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Research Article

Flexural and cracking behavior of reinforced lightweight self-compacting concrete beams made with LECA aggregate

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ABSTRACT

In the current research, an attempt was made to examine the flexural and cracking behavior of reinforced lightweight self-compacting concrete (LWSCC) beams incorporating light-expanded clay aggregate (LECA) as a partial replacement for natural coarse aggregate (NCA). Mechanical properties such as compressive strength, split tensile strength, and flexural strength were evaluated, alongside fresh properties assessed using flow table, V-funnel, J-ring, and L-box tests. The study examined six beams, including a control mix, with LECA replacements of 5%, 10%, 15%, 20%, and 25%. The results indicate that compressive strength decreased with higher LECA content, from 44.56 MPa in the control mix to 32.73 MPa at 25% LECA. Flexural and split tensile strengths showed similar trends. Crack width increased with LECA content, from 1 mm in the control mix to 2 mm at 25% LECA, while density decreased. Flexural performance analysis revealed reduced ultimate load capacity and increased deflection with higher LECA proportions. The ductility index improved, suggesting enhanced flexibility. This study concludes that LECA can effectively replace NCA in LWSCC, though with a trade-off in strength and cracking behavior.

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1. INTRODUCTION

Concrete made of lightweight materials weighs less than traditional Concrete. Lightweight Concrete has a unit weight of between 300 and 1900 kg/m^3, compared to 2200 to 2500 kg/m^3 for regular Concrete. Using lighter particles instead of heavier ones is one method for producing lightweight Concrete. The Light Expanded Clay Aggregate (LECA) is used instead of the normal-weight aggregates in the experiment to produce Lightweight self-compacting concrete (LWSCC) using expanded clay aggregate. Expanded clay aggregates have higher compressive strengths than a lot of lightweight aggregates. Structural concrete containing LECA can reduce heating and cooling costs by up to 50% and reinforce steel costs by 20%. Using LECA in self-compacting concrete reduces density and improves flexibility, but challenges include reduced compressive strength and increased cracking, requiring careful balance in mix design. [1–5]. A unique kind of clay that may expand is used to create Light Expanded Clay Aggregate (LECA). The pulverized coal and oil mixture heated the rotary or vertical shaft kiln to about 1200 °C before the clay was blended with an additive to make it bloat. The final product comprises rigid, spherical particles with a honeycomb-like inside and a thick, smooth surface texture. The developed cellular struc-

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ture is held in place as the product cools and is employed as a lightweight aggregate. Lightweight Expanded Clay Aggregate (LECA) uses alternate sources of aggregates, such as LECA in Concrete, which is beneficial in achieving sustainable construction practices [6–8].

The experimental work utilizes LECA instead of normal-weight aggregates. Expanded clay aggregates have more compressive strength than many lightweight aggregates. Structural Concrete containing LECA can reduce heating and cooling costs by up to 50% and reinforcing steel costs by 20% [9–11]. Concrete's strength qualities decreased when LECA alone was used to replace coarse aggregates [12]. Mineral admixtures were employed to boost the strength qualities. The ideal fly ash content is 10% [13]. The importance of utilizing fly ash on higher-strength “lightweight self-compacting concrete” made using “Light Expanded Clay Aggregate."After researching the impacts of silica fume on “lightweight aggregate concrete," [14]. The ten percent silica fume is the ideal substance. [15], The steel fibers included in fractions of 0.0%, 0.50%, and 1.0% improved strength and “unit weight of lightweight concrete” as the steel fiber concentration rose. Lightweight aggregates have been used in place of stable aggregates [16]. The ratio of Lightweight aggregate increased, and Concrete's density and compressive strength dropped. Lightweight concrete boasts a lower weight than traditional concrete, with a unit weight spanning from 300 to 1900 kg/m^3.

The construction industry is expanding quickly worldwide, intending to build structures more efficiently and faster and for less money to boost economics and construction quality. Furthermore, the construction sector is looking into several options for this aim. One way to do this is to emphasize how long it takes for Concrete to cure. This can be done by adequately curing the substance to increase its early strength. There are numerous curative techniques available. Vacuum-cured LECA has a higher compressive strength than partially saturated surface-dried LECA [17]. The slump-flow of self-consolidating concrete made with LC1 (with a density of 1.58 g/cm^3) measured at 667 mm, while for LC2 (with a density of 2.07 g/cm^3), it measured at 608 mm. These findings indicate that when using the exact proportions of lightweight aggregates, the self-consolidating concrete exhibits greater flowability with lower-density lightweight coarse aggregates. This observation applies to both lightweight aggregate and conventional concrete. [18, 19]. The accelerated cure with boiling water has been tested [20]. The structural behavior of lightweight concrete using LECA has been investigated, demonstrating a reduction in concrete weight and cost while maintaining mechanical properties. [21], It can be utilized to increase early development strength. In areas with a water constraint, LECA can be internally cured [22]. In this study, boiling water is used to hasten the curing process. It presents numerous advantages in terms of durability, cost-effectiveness, and productivity at construction sites. Conversely, lightweight concrete can significantly decrease the structural load, reducing member sizes and simplifying construction processes. Consequently, lightweight concrete can lead to overall cost savings in construction projects. Traditionally, lightweight aggregate concrete is produced similarly to conventional concrete. However, this manufacturing approach often faces aggregate segregation issues due to the aggregates' low density. In contrast, by reducing the aggregate content, self-consolidating concrete can be produced with more powders. This typically results in a concrete mix with improved viscosity during the fresh stage and greater compressive strength as it hardens. Therefore, integrating lightweight aggregates into self-consolidating concrete is believed to enhance quality and produce high-strength lightweight concrete while mitigating segregation issues associated with lightweight aggregates [23, 24]. The paper suggests that integrating pumice as a partial replacement in self-compacting concrete beams can enhance flexural properties, potentially leading to more sustainable construction practices by utilizing less conventional, more environmentally friendly materials while maintaining structural integrity and performance [25].

The primary goal of this study is to review lightweight aggregates (LWA) used to make lightweight self-consolidating Concrete. In addition to identifying the physical qualities, LWA is compared. The effects of LWA usage on the characteristics of freshly poured and hardened Concrete will be investigated. Additionally, the LWSCC mix design procedure is examined. After evaluating the currently available material, the LWSCC material goods and mix design can be significantly improved. Incorporating LECA as a lightweight aggregate in self-compacting concrete is crucial for advancing sustainable construction. LECA reduces the concrete's overall weight, enhancing its workability and reducing structural load. This innovation allows for more efficient material use, lower transportation costs, and improved thermal insulation, aligning with modern demands for environmentally friendly and energy-efficient building materials. This study's novelty lies in its comprehensive analysis of reinforced lightweight self-compacting concrete (LWSCC) beams incorporating varying proportions of LECA. By evaluating mechanical properties, flexural performance, and cracking behavior, this research offers new insights into optimizing LWSCC mixes for enhanced structural efficiency, sustainability, and practical application in modern construction practices.

2. MATERIALS AND METHODS

2.1. Materials

The present study utilized 53-grade ordinary Portland cement (OPC). Furthermore, ordinary physical cement attributes were evaluated according to IS 12269-2013 [26]. The specific surface area of the cement, measured at 329 m^2/kg, was determined using Blaine's air permeability method. Additionally, the specific gravity of the cement was found to be 3.09 by IS 4031-1996 [27]. River sand, locally available and sieved up to 4.750 mm, was used as the "fine aggregate (FA)." Sand characteristics were evaluated using IS: 2386-1963. Coarse Aggregates (CA) with a maximum size of 12.5 mm and a specific gravity of 2.45, held at 10 mm, were locally sourced, employed, and conformed to Zone-II as per IS 383:2016 [28–39]. To examine the characteristics of light-expanded clay, ranging in size from 8 to 12 mm, evaluated according to IS-2386-PART-III-1963 [40] as shown in Tables 1 and 2. Superplasticizer, specifically a sulfonated naphthalene-based polymer, was employed as an agent for significant water reduction in compliance with ASTM C 494:2019 [41].

The present research considers lightweight expanded clay aggregate (LECA), a coarse aggregate formed of clay. At roughly 1200 °C, lightweight expanded clay aggregate (LECA) can be created within a rotary kiln. Burnt clay is broken down into tiny, airy, swollen particles that make up LECA. The LECA used in this study featured an 8–12 mm particle size distribution, a 332 kg/m^3 bulk density, and an approximately 14.5% water absorption rate. These properties were crucial for achieving the concrete's desired lightweight and self-compacting characteristics, ensuring proper workability, reduced density, and enhanced thermal insulation for structural applications. A picture of a light-expanded clay aggregate is shown in Figure 1.

An unwanted consequence of burning pulverized coal in thermal power plants is fly ash, also known as fuel ash. Fly ash is composed of small siliceous and aluminous pozzolan particles. We used Class C fly ash for this experiment. Subbituminous coals create Class C fly ashes containing mostly free lime, tricalcium aluminate, quartz, and calcium alumino-sulfate glass (CaO). Class C fly ash, which includes more than 20% CaO, is often called high-calcium fly ash. Utilizing fly ash has several advantages, including producing dense concrete with a smooth surface, excellent strength, workability, and reduced CO_2 emissions and hydration heat. Two downsides are the increase in salt scaling and the use of air-entraining admixtures. Fly ash, which had a specific gravity of 2.1, was used to replace 10% of the weight of the cement. The CONPLAST SP 430 was employed in this investigation. It is used to make concrete more workable and is carefully formulated to provide significant water reductions of up to 25% without sacrificing workability. It also minimizes permeability, resulting in high-quality concrete.

2.2. Mix Design

The LWSCC mix proportions are essential for its application since the suggested proportions may alter the necessary qualities in both the fresh and hardened stages. To satisfy the self-compacting requirement, LWSCC must develop the requisite fresh features, such as filling capacity, passage ability, and segregation resistance. The Concrete's filling or flow ability refers to its capacity to move freely, fill the formwork, and support its weight. On the other hand, the capacity to travel through dense steel reinforcement sections without harming them or cluttering the area with formworks is called passage ability. Segregation resistance is the capacity to maintain homogeneity during transportation, placement, and subsequent placement without bleeding or separating. “The composition of the raw materials, the quantity of chemical and mineral admixtures, the types of aggregate utilized, packing density, water-to-cement ratio (W/C)," and design methods significantly impact LWSCC performance. Presently being used as per the curves given in the rational mix design procedure by Rao et al. [42].

Table 1. Cement physical properties

S. No.	Test performed	Test values
1	initial setting time	42 min
2	Specific gravity	2.79
3	Soundness of cement	5 mm
4	Standard consistency	32%
5	Fineness of cement	3.7%

Table 2. Physical characteristics of gravel, LECA, and coarse aggregates

S. No.	Name of the test	Test values		
		Gravel	LECA	Fine aggregates
1	Fineness modulus	6.39	5.82	3.11
2	Specific gravity	2.45	0.606	2.59
3	Bulk density	1415.6 kg/m^3	332 kg/m^3	1638.7 kg/m^3
4	Water absorption	0.7%	14.5%	1.1%

Figure 1. Lightweight expanded clay aggregate (LECA).

2.3. Test Methods

2.3.1. Compressive Strength

According to BS 12390-3: 2009 [43], the compressive strength of red mud concrete was assessed using samples sized 150 × 150 × 150 mm. These samples were meticulously prepared and subsequently tested for their compressive strength in a specialized compressive testing machine, ensuring precise and reliable results.

2.3.2. Flexural Strength

The procedure for evaluating the flexural strength adhered to BS 1881-118: 1983 [44]. Samples measuring 100 × 100 × 500 mm were meticulously crafted and tested on a flexural testing machine. This method effectively determined the concrete's bending resistance, offering critical insights into its structural capabilities under load.

Table 3. Mix proportions of control mic and LWSCC

Mix designation	Cement	Fly ash	Fine aggregate (sand)	Normal coarse aggregates	Light-expanded clay aggregate (LECA)	Water	Super plasticizer
Control mix	428	182	885	700	0	192	9.44
LECA 5	428	182	885	664.8	11.65	192	9.44
LECA 10	428	182	885	629.8	23.30	192	9.44
LECA 15	428	182	885	594.8	30.80	192	9.44
LECA 20	428	182	885	559.8	46.60	192	9.44
LECA 25	428	182	885	594.8	58.25	192	9.44

Table 4. Nomenclature and detailing of LWSCRC beams

S. No.	Beam designation	Average cube strength (MPa)	B (mm)	Height D (mm)	d (mm)	Length (mm)	Ast (mm^2)
1	Control mix	28.28	200	230	200	1000	314.20
2	LECA 5	30.24	200	230	200	1000	314.20
3	LECA 10	31.65	200	230	200	1000	314.20
4	LECA 15	33.17	200	230	200	1000	314.20
5	LECA 20	31.89	200	230	200	1000	314.20
6	LECA 25	28.28	200	230	200	1000	314.20

2.3.3. Split Tensile Strength

The split tensile strength was assessed following BS 1881-117: 1983 [45]. Cylindrical samples with dimensions of 150 mm diameter and 300 mm height were prepared and examined using a tensile testing apparatus. This testing was crucial for understanding the concrete's tensile strength, highlighting its ability to withstand tensile forces, which is vital for structural applications.

2.3.4. Load Frame Machine

A load frame setup consisting of parameters such as hydraulic loads and deflection measurements via Linear Variable Differential Transformer (LVDT) sensors is needed. The setup includes vertical and lateral loads of 1000 and 20 kN, respectively, and measures deflection and strain at multiple points on a specimen, ensuring comprehensive data collection during testing.

2.4. Preparation of Specimens

Selected lightweight self-compacting concrete mixes with various percentages of LECA aggregate replacement—such as the Control Mix, LECA 5, LECA 10, LECA 15, LECA 20, and LECA 25 combinations, and NC discussed in the previous section—were used to create RC beams of different depths, incorporating fly ash and natural and synthetic lightweight aggregates. All beams were cast in wooden molds. The compressive strength of the concrete in each beam was measured using cube samples. Three concrete cubes were cast during the casting of each beam. All beam and cube samples were de-molded after 24 hours and cured in a water tank for 28 days. The beams were made from different mixtures of natural and lightweight aggregates, fly ash, and HYSD steel bars of various diameters (8 mm for stirrups and 10 mm for primary reinforcement in compression and tension). After assembly, the reinforcing cages were placed in beam molds before the concrete was poured. The names of the beams are displayed in Table 3. Beam mold size and other details are shown in Table 4. The width of all six beams was 150 mm. The molds were cleaned before pouring concrete into the cast iron molds, and oil was applied to all surfaces. The molds were positioned on a flat surface. After the molds were filled with concrete, it flowed and settled. Excess concrete was removed with a trowel, and the top surface was leveled. Beams of size 200 x 230 x 1000 mm were cast. as shown in Figure 2. The beam dimensions, 200x230x1000 mm, 200 mm, and 230 mm, are the is the standard width and depth of beam popularity used in the construction industry, 1000 mm is the unit length and reinforcement details were chosen to simulate real-world structural elements closely, ensuring accurate evaluation of flexural, cracking, and load-carrying behaviors.

Figure 2. Mould with casted beam specimen.

2.5. Details of Reinforcement Bars for Beams

As is common knowledge, concrete is strong in tension yet fragile in compression. Therefore, adding reinforcement

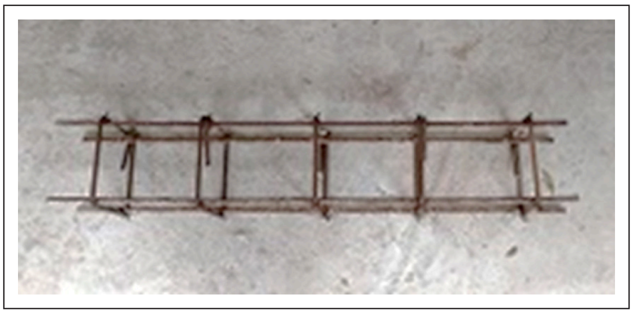

Figure 3. Reinforcement bars.

to Concrete makes a composite material with the "strength of concrete against compressive stress and the strength of reinforcement" against tensile stress. The reinforcement provided in the top and bottom is 2 bars of 12 mm diameter and 8 mm diameter stirrups at 200 mm center to center, as shown in Figure 3.

3. DISCUSSION ON RESULTS

3.1. Compressive Strength

According to the recommendations from EFNARC, the fresh properties of M40-grade concrete were successfully achieved. Extensive testing revealed that the compressive strength of this concrete grade at 28 days varied with the percentage of coarse aggregate replaced by Light Expanded Clay Aggregate (LECA). Specifically, the compressive strengths recorded were 44.56, 44.6, 45.2, 41.65, 36.1, and 32.73 N/mm^2 for replacement levels of 0%, 5%, 10%, 15%, 20%, and 25% respectively. This data indicates a trend where compressive strength tends to decrease as the replacement percentage of LECA increases beyond 10%. Additionally, it was observed that the rate of water absorption decreased as the grade of the concrete increased. This suggests that higher-grade concretes, likely due to their denser and more refined matrix, exhibit improved resistance to water penetration compared to lower grades. Moreover, when comparing self-compacting concrete (SCC) with lightweight self-compacting concrete (LWSCC), it was found that SCC exhibits significantly lower water absorption rates, indicating better performance in density and impermeability [1, 3, 15, 16]. The document further details the compressive strength of concrete using light-expanded clay aggregate, presenting results for five different replacement ratios in Figure 4. The methodology for determining the compressive strength involved calculating the maximum compressive load a specimen could withstand and dividing this value by the cross-sectional area of a 150 mm cube. This rigorous approach ensures an accurate assessment of the concrete's structural capabilities under compression, providing vital information for practical applications in construction.

Kumar et al. [46], found that the compressive strength of concrete using 100% lightweight coarse aggregate was 20% lower than that of the control concrete, which had an aggregate density of 2.07 g/cm^3. Additionally, the strength was 31% lower when the aggregate density was 1.58 g/cm^3.

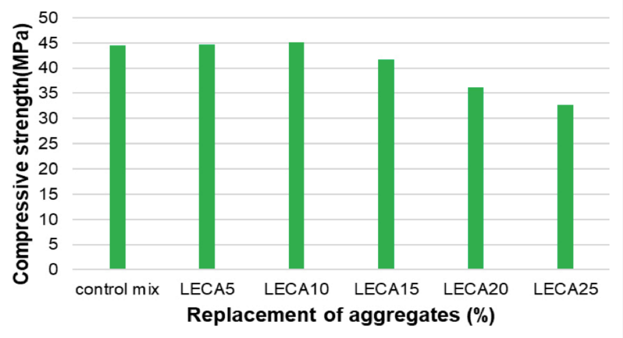

Figure 4. Compressive strength of LWSCC concrete of changed replacements.

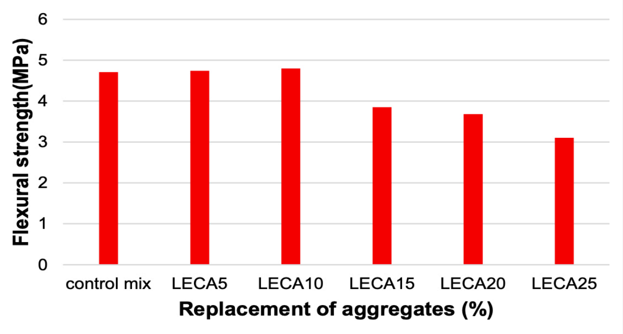

Figure 5. Flexural strength of concrete of different replacements.

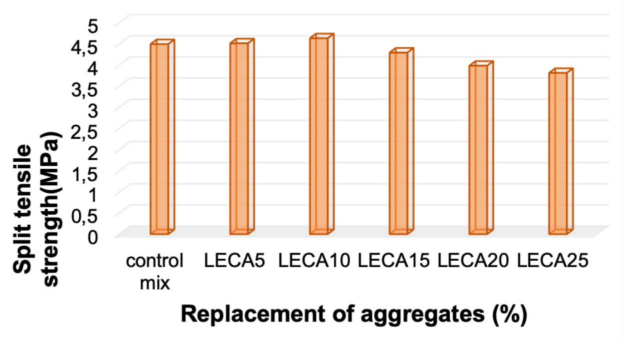

Figure 6. Split tensile strength of concrete of different replacements.

3.2. Flexural Strength Test

This study evaluated the flexural strength of lightweight expanded clay aggregate (LECA) concrete at different replacement levels of coarse aggregates. Beams with 100 mm x 100 mm x 500 mm were used for the flexural test. The replacements considered were 0% (control mix), 5%, 10%, 15%, 20%, and 25% LECA, as shown in Figure 5. The results indicate that the flexural strength of concrete decreases with increasing LECA replacement beyond 10%. The highest flexural strength was achieved at 10% LECA replacement, which is considered the optimum replacement level. This finding is corroborated by the data presented in Figure 5. At 10% replacement, the concrete attained a flexural strength of approximately 5.1 MPa, higher than the control mix and other replacement levels. This sug-

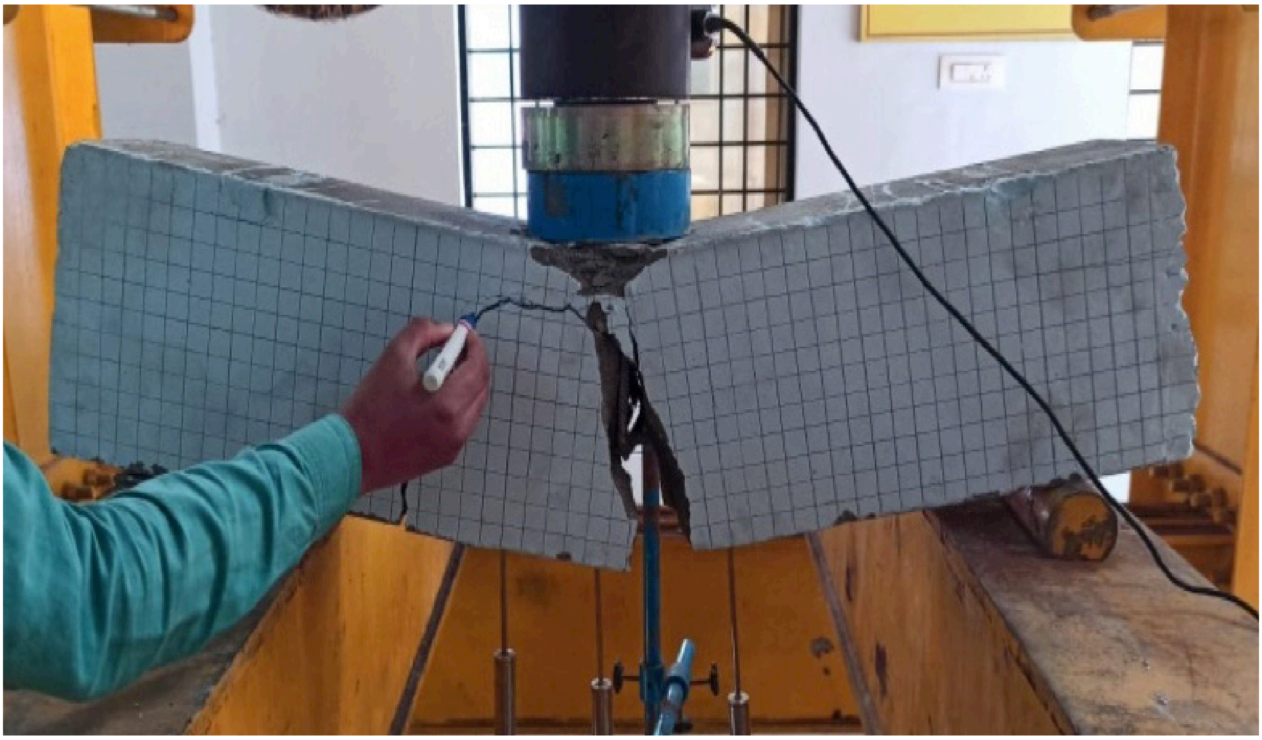

Figure 7. Crack pattern of beam control mix.

Figure 8. Crack pattern of beam LECA 5.

gests that a moderate incorporation of LECA can enhance the flexural strength of concrete [2, 4, 15, 16]. At lower replacement levels of 5% and 10%, the flexural strength remains relatively high and comparable to the control mix, indicating that LECA contributes positively to the structural integrity of concrete when used in small amounts. However, as the replacement level increases to 15%, 20%, and 25%, a noticeable decline in flexural strength is observed, with values dropping to approximately 4.2 MPa at 25% replacement. This decrease can be attributed to the increased presence of lightweight aggregate, which may reduce the density and bonding capacity within the concrete matrix. The trend in Figure 5 highlights the critical balance between achieving lightweight properties and

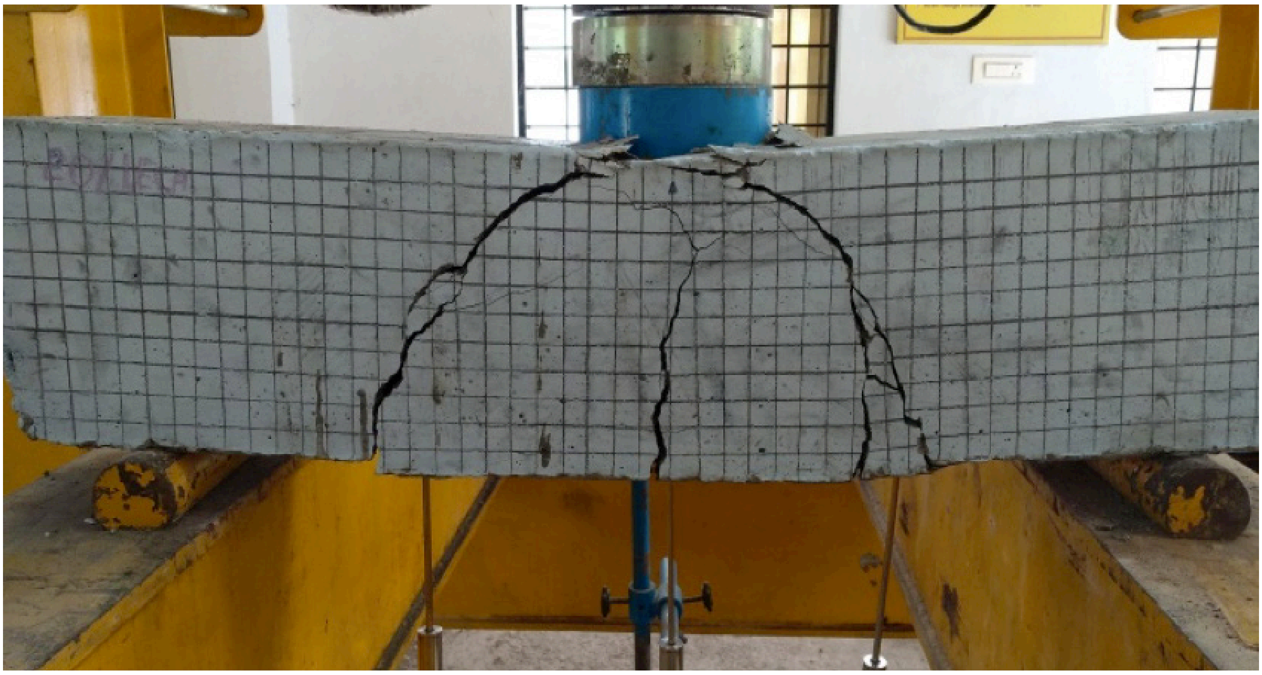

Figure 9. Crack pattern of beam LECA 10.

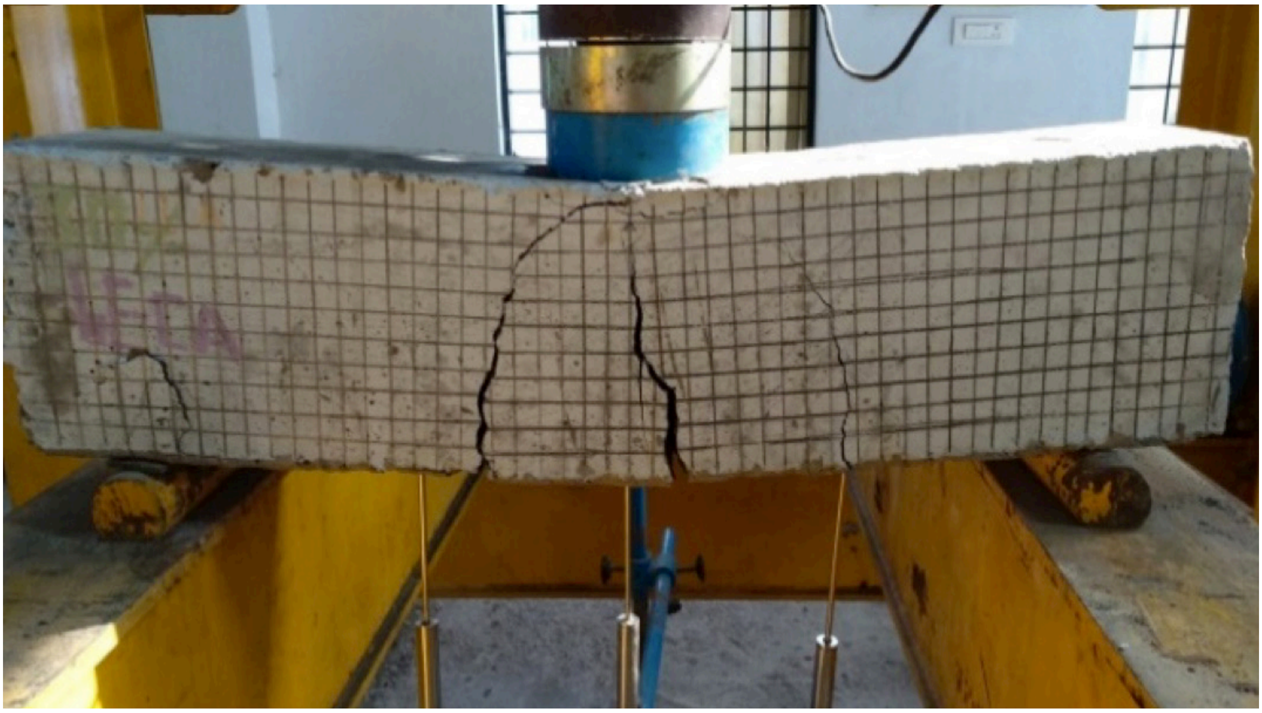

Figure 10. Crack pattern of beam LECA 15.

maintaining structural strength. While LECA is beneficial for reducing the weight of concrete and improving thermal insulation, its proportion must be carefully optimized to avoid compromising mechanical properties. Thus, a 10% replacement of conventional aggregates with LECA is identified as the most effective ratio, providing a good balance between enhanced flexural strength and lightweight characteristics.

3.3. Split Tensile Strength Test

The increase in split tensile strength with specific LECA replacement percentages, such as 10%, can be explained by the optimized strength of lightweight aggregates in the concrete matrix, as shown in Figure 6. The improved particle distribution and interlocking effect between the LECA particles and the cementitious matrix may enhance the overall tensile strength. The highest Split Tensile Strength Test

Figure 11. Crack pattern of beam LECA 20.

Table 5. Flexural performance of reinforced lightweight self-compacting concrete (LWSCC)

Beam designation	Ultimate state		Cracking state		Yielding state		Ductility index	
	Pu (kN)	Δu (mm)	Pcr (kN)	Δcr (mm)	Py (kN)	Δy (mm)	Δu/Δcr	Δu/Δy
Control mix	187.98	1	193.23	1	184.23	1.18	1.00	0.91
LECA 5	179.26	1.25	162.36	1.12	154.89	1.21	1.12	1.03
LECA 10	170.36	1.45	157.26	1.09	149.36	1.12	1.33	1.29
LECA 15	165.36	1.65	149.26	1.04	138.25	1.21	1.59	1.36
LECA 20	152.36	1.75	142.3	1.01	137.25	1.25	1.73	1.40
LECA 25	149.36	2.15	139.25	1	129.25	1.26	2.15	1.71

achieved at LECA 10 replacement is optimum replacement and strength, as shown in Figure 6. On the other hand, the decrease in split tensile strength observed for higher LECA replacement percentages, such as 20% and 25%, could be attributed to the increase in porosity and reduced interfacial bond strength between the aggregate and the matrix [2, 4, 15–17]. The lightweight nature of LECA can lead to increased voids and reduced cohesion, resulting in lower tensile strength values. The flexural and cracking behavior analysis revealed that higher LECA replacement levels increased crack widths and altered crack patterns. Beams with more LECA exhibited broader and more numerous cracks, indicating reduced structural integrity and load-bearing capacity. Overall, LECA contributes to more sustainable construction practices and resource conservation.

3.4. Flexural Behavior of LWSCC Reinforced Beams

Table 5 presents Reinforced Lightweight Self-Compacting Concrete (LWSCC) flexural performance with varying percentages of LECA (Lightweight Expanded Clay Aggregate) replacement. The data outlines several performance metrics across five different LECA replacement levels alongside a control mix. The ultimate state load capacity (Pu) decreases consistently as the LECA content increases. For example, the control mix has a Pu of 187.98 kN, while LECA 25 has a significantly lower value of 149.36 kN. This indicates a reduction in ultimate load-bearing capacity with higher LECA content, possibly due to the lower density and strength of LECA compared to traditional aggregates. Similarly, the cracking state load (Pcr) decreases from 193.23 kN in the control mix to 139.25 kN in the LECA 25 mix, highlighting reduced initial cracking resistance. The corresponding displacements at cracking (Δcr) slightly increase with more LECA, suggesting that higher LECA mixtures tend to have more flexibility before cracking. The yield load (Py) decreases in the yielding state, from 184.23 kN in control to 129.25 kN in LECA 25. Additionally, displacement at yield (Δy) increases, ranging from 1.18 mm to 1.26 mm. This could imply a decrease in stiffness with increased LECA replacement. The ductility indexes, Δu/Δcr and Δu/Δy, generally increase with more LECA content. For instance, Au/Acr rises from 1.00 in the control mix to 2.15 in LECA 25 and Au/Δy from 0.91 to 1.71, respectively. This suggests that higher LECA replacements contribute to increased ductility, which might benefit applications where flexibility and energy absorption are critical despite losing strength and stiffness. The above findings have import-

Figure 12. Crack pattern of beam LECA 25.

Table 6. Crack width values

Beam designation	Width of crack (mm)	Density kg/m^3
Control mix	1	2312
LECA 5	1	1952
LECA 10	1.25	1915
LECA 15	1.55	1902
LECA 20	1.75	1899
LECA 25	2	1890

ant implications for the structural application of LWSCC. While higher LECA levels enhance ductility, they compromise load-bearing capacities and initial cracking resistance, which must be carefully considered in structural design and application. Kavyateja et al. [47]. The load-deflection behavior analysis showed that beams with higher LECA replacement levels had reduced ultimate load-carrying capacity and stiffness but increased ductility. For instance, beams with 25% LECA replacement exhibited lower load capacity and stiffness than the control mix but demonstrated more significant deflection before failure, indicating enhanced ductility. This trade-off highlights LECA's impact on structural performance.

Only flexure cracks and shear cracks, as can be seen from the figures, were created. Beams exhibited no web shear fracture development, as shown in Figure 7, Figure 8, Figure 9. Figure 10, Figure 11, and Figure 12. Because beams have a lower load-carrying capability, the data shows that crack breadth rose when the percentage of Light Expanded Clay Aggregate was replaced. The crack widths observed for the LWSCC beams with different LECA replacements were as follows: 1 mm for 0% replacement, 1 mm for 5% replacement, 1.25 mm for 10% replacement, 1.55 mm for 15% replacement, 1.75 mm for 20% replacement, and 2 mm for 25% replacement. It can be noted that as the LECA replacement percentage increased, the crack widths also increased gradually. Simultaneously, the density values of the LWSCC beams varied as follows: 2312 kg/m^3 for 0% replacement, 1952 kg/m^3 for 5% replacement, 1915 kg/m^3 for 10% replacement, 1902 kg/m^3 for 15% replacement, 1899 kg/m^3 for 20% replacement, and 1890 kg/m^3 for 25% replacement. Table 6 provides the crack width and densities. The density of the LWSCC beams decreased with increasing LECA replacement.

4. CONCLUSION

According to the findings of this investigation, the following conclusions were drawn:

1. The compressive strength of the lightweight self-compacting Concrete (LWSCC) is learned to be decreased by increasing the percentage of lightweight aggregate. In the case of Lightweight aggregate Concrete produced with sintered fly ash aggregate, the optimum compressive strength of LWSCC attained at 40% replacement is 29.46 N/mm^2 of M40 grade concrete.
2. Based on the results, it was discovered that replacing coarse aggregate with Light expanded clay aggregate (LECA) aggregate by control mix, 5%, 10%, 15%, 20%, and 25%, gradually reduced the densities of self-compacting Concrete.
3. As a generalization of these trials, it was found that the maximum load-bearing capacity of lightweight beam flexural elements is reduced by up to 35% compared to conventional beams.
4. The components of the lightweight reinforced concrete beams displayed behavior comparable to conventional concrete beams conventional-lightweight Concrete. At places where the bending moment was most significant, the first cracks appeared perpendicular to the neutral axis.

5. Flexural crack formations started as minute structures invisible to the human eye. The fracture widened as the ultimate stresses approached, but because longitudinal reinforcing was provided by indented steel bars, the crack diameters did not increase excessively.
6. With a percentage replacement of pumice aggregate, fracture width increased; it can be observed that with 15% LECA replacement, P/ reaches its highest value.
7. Load vs. deflection curves show that central deflections are more significant than side deflections. The maximum load values found during beam load frame testing exceeded those predicted by theory.
8. It can also be seen that as the proportion of LECA aggregates increased, the beams' maximum load-carrying capacity decreased.

ETHICS

There are no ethical issues with the publication of this manuscript.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FINANCIAL DISCLOSURE

The authors declared that this study has received no financial support.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

PEER-REVIEW

Externally peer-reviewed.

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