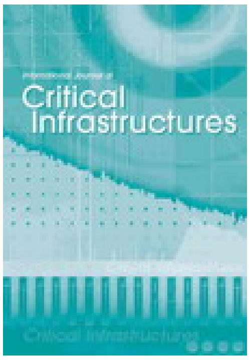

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C. Anish, R. Venkata Krishnaiah, K. Vijaya Bhaskar Raju

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Application of silica fume, pumice and nylon to identify the characteristics of LWC after critical infrastructure analysis

C. Anish*, R. Venkata Krishnaiah and K. Vijaya Bhaskar Raju

Department of Civil Engineering,
Bharath Institute of Higher Education and Research,
Chennai, Tamil Nadu, India
Email: anishdavidpaul@gmail.com
Email: venkatapec@gmail.com
Email: raju.kvb@gmail.com
*Corresponding author

Abstract: Finding lucrative building designs has been the major problem the construction industry has been experiencing lately. This issue can be fixed by dramatically lowering the structural part's self-weight and sizing it down. Lightweight concrete (LWC) is the sole material that can be used to achieve this. In earlier tests, various lightweight aggregates were utilised to lower the density. The primary benefits of LWC columns are that they do not require a reinforced cage or forms because their steel tubes can be used just as well as scaffolding and are fireproof. Based on the numerous research projects undertaken, it can be concluded that circular poles should be favoured over a square LWC to boost stability and satisfy various design needs. This study defines LWC while considering strength component development. Thus, this experiment examines silica fume and pumice stone as entire substitutions. After moulding samples with the desired mix ratio, compression, tensile, and bending capacities are assessed. This specially designed LWC mix of M30 grade concrete has 0.6 to 0.7 times the strength of regular concrete, according to tests. The strength measures dramatically increased by adding 20% silica fume and 1.5% nylon fibre.

Keywords: critical infrastructure; lightweight concrete; LWC; pumice; silica fume; nylon fibre; waste rubber powder; mechanical properties; thermal properties.

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Biographical notes: C. Anish is an Assistant Professor in the School of Civil and Infrastructure. Additionally, he is a part-time research scholar specialising in structural and concrete materials. Furthermore, he has ten years of teaching experience in concrete technology and structural engineering.

R. Venkata Krishnaiah is currently employed as a Professor at the Department of Civil Engineering at the BIHER in Chennai. He has been teaching for nearly 25 years and has been instrumental in completing a few doctoral degrees.

K. Vijaya Bhaskar Raju has been working as the Vice-Chancellor at the Bharath Institute of Higher Education and Research, Chennai. He has published ten textbooks and over 65 technical papers and has received numerous awards. He has completed his BE in Civil Engineering from the Dayananda Sagar College of Engineering, Bengaluru and obtained his PhD in Civil Engineering from the Indian Institute of Science, Bengaluru. He has held various teaching and administrative positions throughout his career.

1 Introduction

Lightweight concrete (LWC) is a type of concrete that has a lower density and weight than normal-weight concrete. It is achieved using lightweight aggregates such as natural or artificial materials with low specific gravity or by incorporating air-entraining or foaming agents into the concrete mix (Anish and Krishniah, 2022). LWC has various advantages, such as reduced dead load, improved thermal insulation, enhanced fire resistance and sound absorption properties. It also has disadvantages, such as lower strength, durability and stiffness than normal-weight concrete (Li et al., 2022a). LWC can be used for various civil engineering and construction applications, such as building structures, bridges, precast elements, floating structures, etc. Several research journals have published articles on the development, characterisation and performance of different types of LWC, such as cellular LWC, sawdust concrete, perlite concrete and coconut shell concrete (Zeyun and Dawood, 2016). These articles provide valuable insights into the properties and behaviour of LWC under various conditions and loading scenarios (Li et al., 2022b). Ordinary concrete (OC) M30 (IS 10262, 2009) grade is a common construction material that consists of cement, water and aggregates (sand and gravel). It has high strength, durability and thermal mass but also high density, thermal conductivity and environmental impact (Murugan and Arumugam, 2014).

LWC is a type of concrete that has a lower density than OC by using lighter aggregates (natural or artificial), foamed concrete (FC) or aerated concrete (AC) (Murugan and Vimala, 2013). It has lower thermal conductivity, better fire resistance, better sound insulation and lower environmental impact than OC, but also lower strength, higher water absorption, higher shrinkage and higher cost than OC.

More and more often, innovative concrete is used in construction projects. High-strength concrete has several advantages, such as reducing the number of structural element pieces needed, increasing construction room occupancy, and extending the lifespan of structures (Rao et al., 2013). However, high-strength concrete frequently has a lower water-to-binder ratio than standard toughness concrete (Siva and Murugan, 2005). Because more binders are used, and more conventional concrete is produced while making high-strength concrete, there is a greater requirement to limit the emissions of conventional concrete. Basic studies have been conducted to compare the outcomes of larger concrete to conventional concrete. Ultra-high-performance concrete may offer more benefits than conventional concrete design claims (IS 10262, 2009). The use of slag in producing ultra-high-performance concrete was recommended by IS 383 (1970a) and Suraya Hani et al. (2019) to reduce outputs and building energy while reducing life cycle costs (Yogaraj et al., 2020). According to Compione and Mindess (1999), who examined the life cycle emissions of typical concrete produced at different compressive strengths, service life waste increased linearly with strength characteristics. Using stronger concrete and standardising the mixing process may help reduce emissions of OC during the construction phase, according to a method given in Banthia and Trottier (1994) for assessing the emissions of OC from the concrete supply chain (Murugan et al., 2012). A concrete desire index that considered the effects of mechanical characteristics, longevity, emissions from normal concrete, and price was proposed by IS 516 (1959). Several variables, including aggregate type and size, cement type and content, water-cement ratio (w/c), admixtures, and curing conditions, affect the qualities and performance of LWC. LWC's quality and durability can be increased by adopting the right mix of design and production techniques (IS 383, 1970b).

Several research works conducted experimentation with various mixes with an unchanged proportion of cement or with a different amount of cement and ratio, which were mixed with industrial leftovers such as steel slag, fly ash, silica fume, and lightweight aggregate to study the effectiveness infilled building material in the LWC stub column under axial the compressive loading (Sandeep Kauthsa Sharma, et al., 2021). The number of rubber tires being thrown away has grown due to the increasing number of automobiles, and environmental contamination has been made worse by the low recovery rate of recycled tires. Tire waste should never be burned, buried, or piled up in landfills since it is inefficient and bad for the environment. Few looked around the analytical analysis of a trio of bigger diameter LWCs under tension and compared it with forecasts. LWC is a promising material for various applications in the construction industry where thermal insulation is important, such as residential or office buildings. However, more research is needed to overcome some of the challenges and limitations of using LWC.

Following is how the paper is organised: the material on which Section 2 is based describes many types of LWC and reviews of literature. In Section 3, there is a brief discussion of the objectives and methodologies. Section 4 of the study is devoted to analysis. Section 5 of the study provides key tests and findings. Section 6 discusses concluding remarks and future directions.

2 Review of literature

2.1 Types of lightweight

Different types of LWC have different properties and uses. Some of them are:

- Lightweight aggregate concrete: As aggregates, this concrete is constructed of porous and light substances like clay, shale, slate, volcanic pumice, ash, or perlite. Its density ranges from 400 kg/m^3 to 2,000 kg/m^3.
- Aerated or FC: Due to the substantial air holes within it, this concrete is also known as gas concrete or FC. It is made by incorporating air bubbles into the mortar or concrete mix. Between 300 kg/m^3 and 1,800 kg/m^3 is its density.
- No-fines concrete: Sand or other fine particles are not present in this concrete. Only coarse particles, held together by cement paste with tiny holes, are present. It has a density between 1,600 kg/m^3 and 2,000 kg/m^3.

The poor connection between latex and cement, which prevents the creation of concrete with a high rubber content, is why concrete made with rubber loses strength over time. As a result, techniques that increase the rubber content while limiting concrete's loss of strength have been investigated. The effects of LWC solution on enhancing the bond between the rubber and cemented concrete were explored by Deyyala (2014) and Janardhan and Venkata Krishnaiah (2022).

The results show that adding LWC solution did not significantly increase the resilience of modified rubber concrete, but it did give the concrete good tenacious and impact resistance. Slag, nanosilica, and silica fume have all been employed to enhance the region of interfacial transition between rubber and mortar and grout to counteract rubber's detrimental effects. Adams Joe et al. (2013) and Rao et al. (2013) discovered that nanosilica might reinforce the interface LWC, optimise the pore structure, and improve the adhesive action, partially reversing the elasticity loss of rubber concrete. The best option in terms of cost and utility is silica fume. Banthia and Trottier (1994) discovered that silica fume boosts strength in compression and dynamic and static parameters while reducing the quantity of cement used in viscoelastic concrete mixes (Sharma and Sharma, 2023).

In these situations, silica fume application also decreases water permeability and chloride distribution. Concrete's impact resistance is boosted by 20–25 times when steel and plastic fibres are added (Compione and Mindess, 1999). According to research, using natural fibres such as coir, sisal, jute, and hibiscus boosts the impact protection of the slabs by 7–10 times on cement-based slabs reinforced with these fibres. According to Dayakar and Mohan (2019), concrete with 16% rubber has a five-fold boost in impact resistance. Dayakar and Mohan (2019) upgraded the test procedure for determining the impact and inability to respond of fibre-reinforced concrete structures to dynamic loads and demonstrated that the impact and inability to respond of the organised steel fibre-reinforced concrete is six times greater than that of the original concrete, as measured by the total number of blows in first fractures to failure. In the IS 456 (2000) test, impact energy remained constant, while steel fibreglass-reinforced concrete beam shock energy dropped with rising ball size and increased with rising ball height (Li et al., 2019).

- Lightweight structural concrete: For structural uses, such as piers, beams, panel walls, and bridge decks, this concrete is employed. Its density ranges from 1,400 kg/m^3 to 2,000 kg/m^3, making it stronger than other LWC forms.
- Lightweight decorative concrete: Aesthetic uses for this concrete include ornamentation, sculpture, and landscaping. Its density ranges from 800 kg/m^3 to 1,400 kg/m^3, making it weaker than other varieties of LWC.

3 Objectives and methodology

3.1 Objective

- Pumice aggregate can be used instead of coarse aggregate to make the concrete lighter.

- Silica fume can be added to concrete as an extra material, up to 20% of the weight of cement, although the usual amount is 7%–10%. This can make the concrete very strong with a 20% addition.
- Concrete's tensile strength can be increased by adding nylon fibre.

3.2 Materials and specification

Grade 53 (IS 10262, 2009) infilled round composite uprights are entirely cast with two distinct widths of locally accessible, crushed blue granite stones with an input size of no more than 20 mm (IS 383, 1970a). The infill materials included a standard concrete mix and a silicon dioxide concrete matrix mix (Zannah et al., 2023). The specimens were selected based on height and thickness (Sharma and Sharma, 2021). Three clay layers were stacked within the matching thin steel tubular columns, with one end covered by a thin film sheet on the flat bottom plate and the other end left exposed. The experimental procedure setup with two dial gauges to measure the specimen's lateral rotation is shown in Table 1. The mix ratios for the values of infilled concrete columns are provided in detail.

- *Ordinary Portland cement:* Grade 53 (IS 10262, 2009).
- *Coarse aggregate:* Blue granite stones readily available nearby that have been crushed and meet a maximum aggregate size of 20 mm (IS 383, 1970a).
- *Pumice:* From Astra Chemicals.
- *M-sand:* Made from crushed rock or gravel, this material is utilised to make aggregate less than 4 mm in size (Adams Joe et al., 2013).
- *Silica fume:* Collected from Elkem Industry, Mumbai.
- *Nylon fibre:* Collected from Sri Sai Krishna Fibre Products, Chennai.
- *Superplasticiser admixture:* Conplast SP430 from Fosroc Chemicals Limited, Chennai.

4 Analysis

By eliminating the need to transfer traditional building supplies from the mainland, crystal concrete built of coral particles has received substantial consideration in building beachfront or unimportant island buildings. Nevertheless, oyster concrete's uses are severely constrained by flaws such as extreme permeability, fracture toughness, and low strength (Murugan and Shanmugam, 2016). In order to meet the needs of both sustainable and economic development in coastal and island construction and development, this paper creates an entirely novel coral concrete digital image using coral debris to consider replacing sand and aggregates, seawater, cementations waste materials, namely pumice, nylon and silica fume, and modified polypropylene fibre. The technical and endurance of the new reef concrete are assessed, and it is also described how pumice, nylon, and silica fume work in concert to improve LWC coastal concrete's efficiency. It has been discovered that adding nylon and silica fume to LWC concrete can greatly increase its qualities and lower its nitrate issue.

4.1 Concrete proportioning

M30 grade mix design of concrete proportioned in Table 1 (IS 10262, 2009).

Table 1 Cement properties

Cement	*FA*	*CA*	*Water*
432.55	580.26	405.61	186

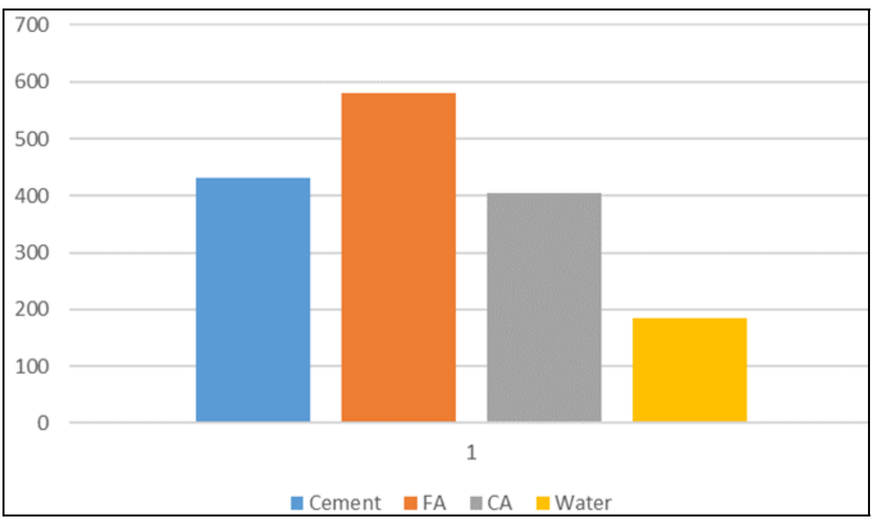
To express the proportion in the usual way,

$$Cement : FA : CA : W$$

$$1 : 1.3 : 0.9 : 0.43$$

Figure 1 depicts the concrete-filled FA, CA, and water of composite columns utilised in contemporary engineering systems. Also, thorough computational as well as experimental research has been done.

Figure 1 Mix design of concrete proportion in terms of FA, CA and water (see online version for colours)



4.2 Material testing

Table 2 gives the various properties of the cement, and it can be seen that the initial setting time has a value of 30. The final setting time has a value of 300. Specific gravity is 3.13, and the fitness of cement by sieve is 90%. It can also be noticed in Figure 2.

Table 2 Cement properties

SI no.	*Property*	*Values*
1	Initial setting time (min)	30
2	Final setting time (min)	300
3	Specific gravity	3.13
4	Fineness of cement by sieve	90%

Figure 2 Various properties of cement (see online version for colours)

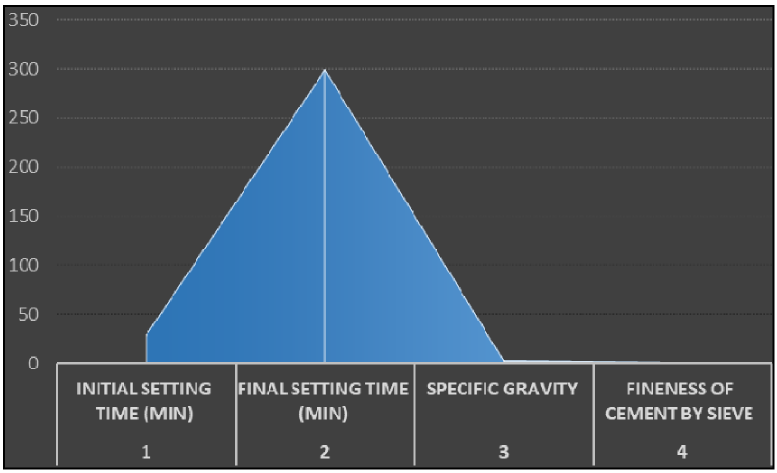


Table 3 Properties of aggregates

SI no.	*Property*	*M-sand*	*Coarse aggregate*	*Pumice aggregate*
1	Specific gravity of coarse aggregate	2.575	2.91	0.945
2	Water absorption	1.192%	0.28%	52%
3	Fineness modulus	2.75	7.17%	-

Source: Muralitharan and Ramasamy (2015), Rao et al. (2013) and IS 383 (1970a, 190b)

Table 4 Properties of silica fume

S. no.	*Property*	*Result*
1	Specific gravity	2.22
2	Fineness	0.23 µm
3	Grain size	0.28 µm
4	Consistency	18.34%

It can be seen from Table 3 that the specific gravity of coarse aggregate is 2.575% of M-sand, 2.91 coarse aggregate, and 0.945 pumice aggregate. Similarly, water absorption has 1.192% M-sand, 0.28% coarse aggregate, and 52% pumice aggregate. Finally, the fineness modulus has 2.75% M-sand, 7.17% coarse aggregate, and 0% pumice aggregate. Fig 3 gives a clear picture of this.

Figure 3 Representation of main properties of aggregates (see online version for colours)

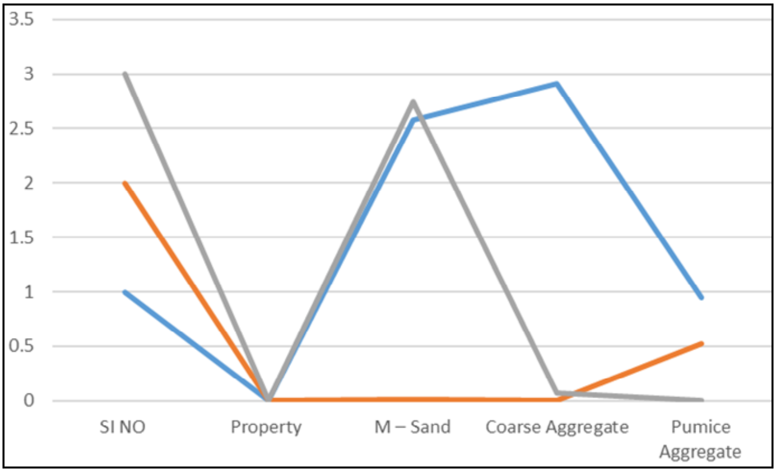


Table 4 gives the properties of silica fume in which specific gravity is found to be 2.22, fitness is 0.23 µm, grain size is 0.28 µm, and consistency is 18.34%. It can also be noticed in Figure 4.

Figure 4 Distribution of various properties of silica fume (see online version for colours)

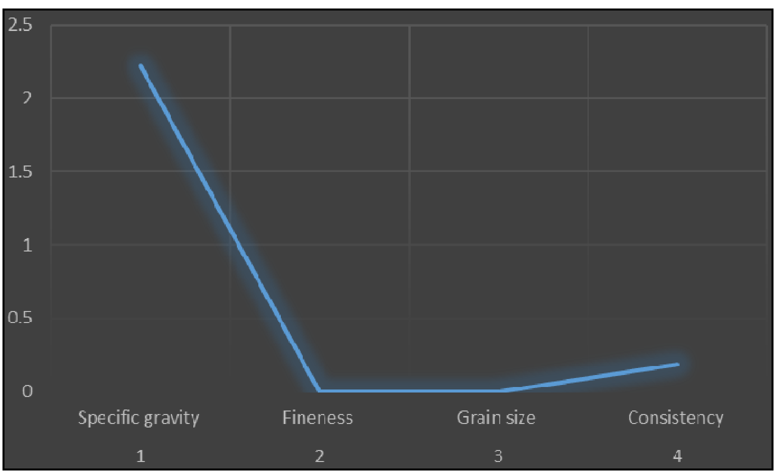


Table 5 Properties of nylon fibre

S. no.	*Property*	*Result*
1	Permeability	The material is less porous
2	Shrinkage	Shrinkage cracks can be eliminated
3	Aspect ratio (I/D)	0.025 or 0.25%

Various mechanics and constructing metrics, such as the compressive strength and the workability for newly produced cement, component contents, part ratios, and pure volume of the concrete mix, were included in the constraints. Concrete mixtures that satisfy numerous performance standards can be obtained once the object's function and restrictions are determined. Contrarily, it should be noted that the formulae for calculating endurance, depression, and material content are derived from mixtures of several elements. It is clear from Tables 5 and 6 that nylon fibre has the permeability property in which the material is less porous. Similarly, in the shrinkage property, cracks can be eliminated. The aspect ratio (I/D) is found to be 0.25%. This is clearer from Figure 5.

Figure 5 Representation of important properties of nylon fibre (see online version for colours)

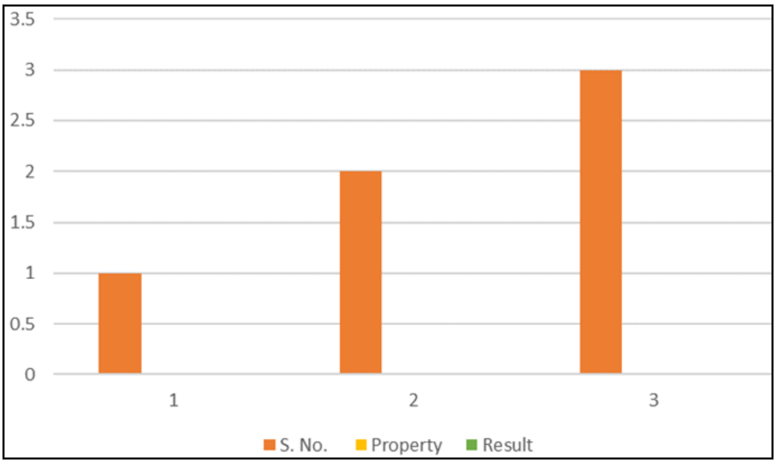


Table 6 Properties of superplasticising admixture (Conplast SP430)

S. no.	*Property*	*Result*
1	Appearance	Brown liquid
2	Specific gravity (BSEN 934-2)	1.2 @ 22°C + 2.2°C
3	Water-soluble chloride	-
4	Alkali content (BSEN 934-2)	Typically, less than 5.3 g Na_2O

5 Results and findings

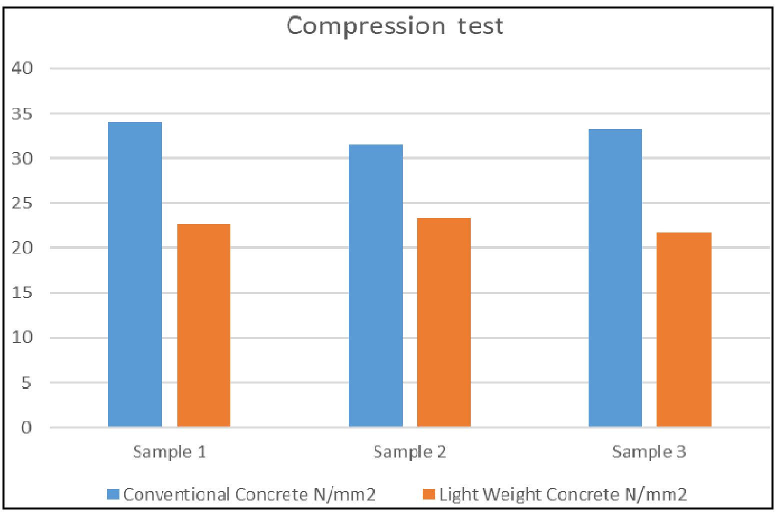
Waste materials recycling and consumption are growing in popularity as individuals become more conscious of the environment. A by-product of the metal processing procedure in the silicon and semiconductor nanoparticles industries is silica fume. This study uses compressive loading to experimentally compare the structural characteristics of a pumice-mixed column filled with regular concrete and silica fume concrete. Variance in steel tube width and columns with a fixed diameter is considered for the investigation. FA, CA, and FA conduct microhardness analyses to investigate the impact of silica fume in concrete. The experiments show that it is possible to substitute cement with silica fume; however, as thickness grows, the strength capacity of the silica fume concrete-filled steel tubular pole is only marginally increased. To assess the workability of new concrete and LWC, slump tests (Compione and Mindess, 1999; Balaguru and Ramakrishnan, 1987; Deyyala, 2014) are carried out (Table 7).

Table 7 Slump value of fresh concretes

Trail	*CC*	*LWC*
	Slump cone (mm)	*Slump cone (mm)*
1	28.1	28.2
2	28.7	28.3
3	27.6	29
Avg.	28.13	28.5

According to IS 383 (1970a) and IS 516 (1959), the compressive strength of hardened concrete after 28 days of curing was evaluated in a concrete lab using UTM (Compione and Mindess, 1999; Balaguru and Ramakrishnan, 1987; Deyyala, 2014).

Figure 6 Compressive strength of CC and LWC (see online version for colours)



We examine the efficiency of LWC and the operational decisions made in two rival characteristics, each of which has a manufacturer that serves a single system and if F_r is the OC, and σ is the corresponding parameter; then the extremital equations are given below (Figure 6):

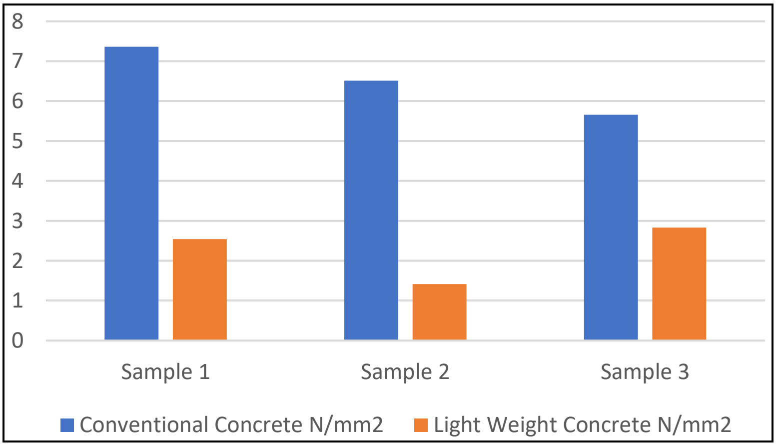
$$F_r = (1-\sigma) + \sqrt{7\sqrt{7\sigma+\sigma^2+5}} + \left(\frac{1}{8}\sqrt{2}\right)\frac{(\sigma)\sqrt{2\sigma+\sigma+2}+\sqrt{2}}{\sigma^2}\frac{6}{11}\left(2\left(\sigma+\sqrt{2}2\sigma+\sigma^2+2\right)\right) \tag{1}$$

$$T_r = \frac{7\sigma^2 4\sqrt{7}\sqrt{7\sigma+\sigma^2+5}+17\sqrt{2}}{12\sigma^5} + 21\sigma + \frac{1}{2}\sqrt{7}\sqrt{-7\sigma+\sigma^2+5} \tag{2}$$

$$E_r = \left(\frac{\sqrt{7}\sigma\left(\sqrt{7\sigma+\sigma^2+5}+\sqrt{2}\right)}{8}\right) - (7\sigma)\left(3\sigma+19\sqrt{7\sigma+\sigma^2+3}\right) \tag{3}$$

After 28 days of cure, concrete cylinder specimens were tested for split tensile strength following IS 456 (2000) and IS 5816 (1999) in the UTM (Compione and Mindess, 1999; Balaguru and Ramakrishnan, 1987; Deyyala, 2014) (Figure 7).

Figure 7 Split tensile test result of CC and LWC (see online version for colours)



5.1 Water absorption test

A procedure like BIS 1881 (Part V) (IS 383, 1970b) was followed to measure the water absorption feature of CC and LWC (Suraya Hani et al., 2019) mixtures on 100 mm cube specimens.

After solving equations (1), (2), and (3), we get

$$L^* = \frac{1}{7}\sigma, \tag{4}$$

$$\Omega^* = \frac{1}{7}\sigma + \frac{1}{2}\sqrt{7}\sqrt{-7\sigma + \sigma^2 + 5}, \tag{5}$$

$$n^* = \frac{1}{5}\left(\sigma + \sqrt{7}\sqrt{-7\sigma + \sigma^2 + 5} + 9\right) \tag{6}$$

and

$$F^* = \frac{1}{11}\left(\sigma + \sqrt{7}\sqrt{-7\sigma + \sigma^2 + 5} + 9\right). \tag{7}$$

The samples were damp-cured for 28 days before being dried in an oven for 24 hours at 110°C. After cooling, the samples were weighed and submerged in water. The mass change was assessed by periodically withdrawing the samples from the water. This went on for three hours till the end of the permitted time. At the end of the time, the amount of water absorbed was calculated by dividing the mass change by the specimen's initial mass. The information was used to calculate each mixture's saturation and 24-hour water absorption. It was regularly measured how much water was absorbed. Researchers could calculate how much water each cube absorbed by weighing the cubes (Figures 8 and 9).

Figure 8 Water absorption of CC and LWC (see online version for colours)

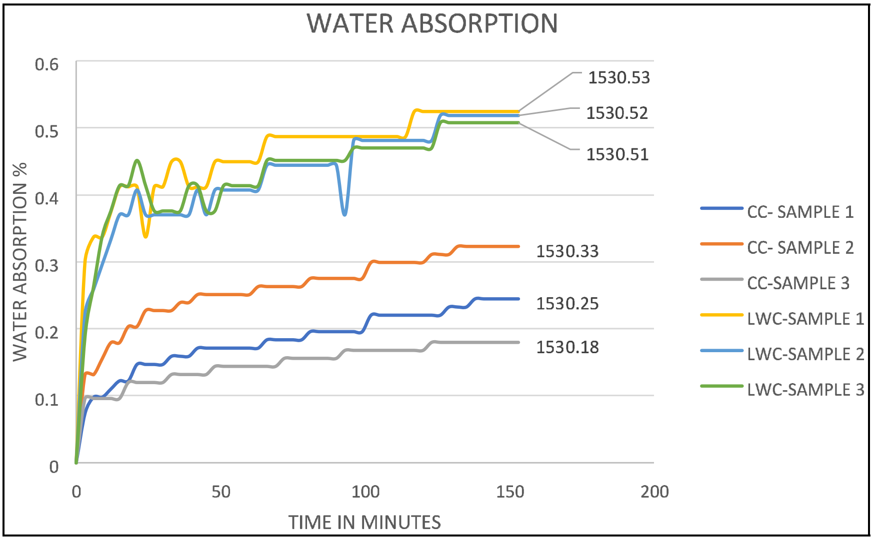
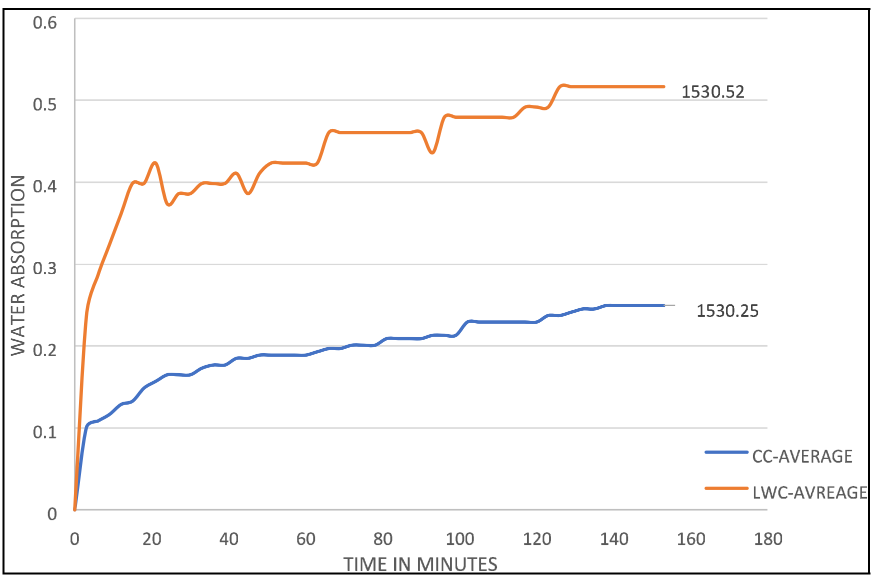


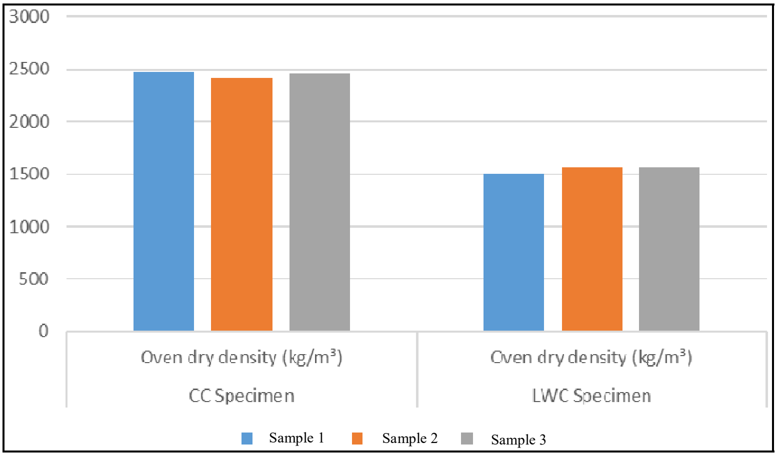
Figure 9 Average water absorption of CC and LWC (see online version for colours)



5.2 Oven dry density

Structural lightweight aggregate concretes an oven-dry density between about 1,200 and 2,000 kg/m^3, while normal weight concretes have an oven-dry density between 2,300 and 2,500 kg/m^3. The weight reduction percentage is 58.64% (Figure 10).

Figure 10 Oven dry density of CC and LWC (see online version for colours)



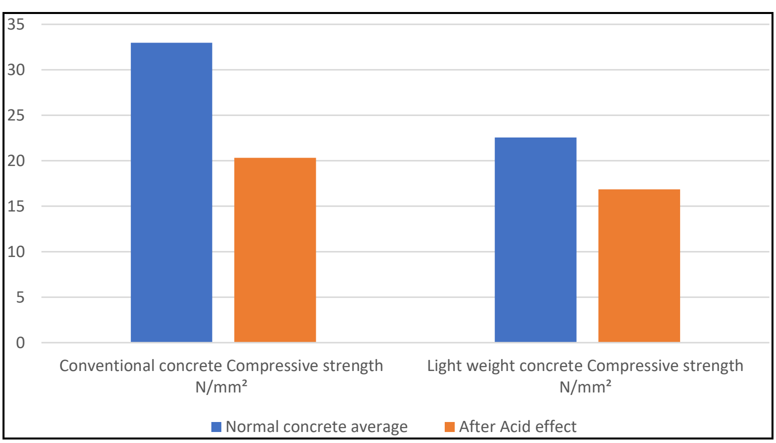
Source: Bakharev et al. (2003)

Every LWC has a predetermined σ, representing the manufacturer's proportional market power. For denoting elements in the r^{th} LWC, we utilise the identical terminology as before but with the addition of a suffix r. In each LWC, we show how the backwards induction method for the $N(\Omega_k, L_r)$ $DN(\Omega_k, L_r)$ model results in the participant's earnings. The optimum negotiating model (5) results in: For an LWC that selects $DN(\Omega_k, L_r)$.

$$\begin{aligned} Min_{(\Omega_r \cdot L_r)}\{\delta_k\} &= Min_{(\Omega_r \cdot L_r)}\left\{\left(E_k^M\right)^{\sigma_1} + \left(E_k^R\right)^{1-\sigma} r\right\} r = 1, 2 \\ &= Min_{(\Omega_r \cdot L_r)}\left\{\left(L_r F_r\right)^{\sigma} r \times \left(\left(n_r + L_r\right) F_r - \frac{\Omega_r^2}{2}\right)^{1-\sigma} r\right\}, \end{aligned} \tag{8}$$

where δ_k modified least element used in concrete.

Figure 11 Acid resistance of CC and LWC (see online version for colours)



The supplier in the r^{th} LWC successively chooses the fire resistance. F_k and merchant pricing n_r in the model that is presented. After that, the service level Ω_k is decided upon through negotiation. The manufacturer of the product ultimately decides on L_r to reduce shrinkage and increase in price (Figure 11).

The vendor finds the best pricing by resolving the resulting model using the backwards inference technique:

$$Min_{n_r} = \left\{ E_r = (n_r + L_r)(1 + n_r - \Omega_k - bn_k + |\langle \Omega_k) - \frac{\Omega_k^2}{2} \right\}. \tag{9}$$

If the quality of service Ω is not included, it should be noted that our answers for both quantity and price are nearly comparable to the given parameter. The reaction function that results from the light concrete to n_r is as follows:

$$\Omega_k - 2n_k + L_r - |\langle \Omega_k - bn_k + 1 = 0 \; r = 1, 2; \; k = 3 - r. \tag{10}$$

When the reaction function is solved, the ideal cost results:

$$n_r = \frac{-b - 2\Omega_r - 2L_r - b\Omega_k + 2|\langle \Omega_k - nL_k + b|\langle \Omega_r - 2}{(b-2)(b+2)} r = 1, 2; \; k = 3 - r. \tag{11}$$

Using equation (11) as a starting point, the logarithm function yields:

$$\begin{aligned} Min_{(\Omega_r \cdot L_r)} \{H_k\} &= \sigma_r \log\left(L_r \left(1 + n_r - \Omega_k - bn_k - |\langle \Omega_k)\right)\right) \\ &+ (1 - \sigma_k) \log\left((n_r + L_r)(1 + n_r - \Omega_k - bn_k - |\langle \Omega_k) - \frac{\Omega_r^2}{2} \right). \end{aligned} \tag{12}$$

The product level reaction's function is obtained by replacing equation (10) with equation (11) while retaining the LWC to Ω_r. The best answer to L_r is obtained by solving the reaction functions and adding the resulting Ω_r into the maker's profit function (4), and then applying LWC. Since mathematical solutions are not attainable, we thus conduct a numerical hunt for the quasi-perfect optimal equilibrium. The program arrives at its ideal answer after about a minute of operation. We provide equilibria approaches for the symmetrically conflicting LWC effectiveness and characteristics.

We perform a numerical search for the nearly ideal best equilibrium because it is impossible to arrive at mathematical solutions. After roughly thirty seconds of operation, the program finds the best solution. For the asymmetrical opposing LWC efficacy and features, we offer equilibrium techniques. Concrete loses strength and fluidity as its rubber component rises. It has been discovered that when all of the coarse gravel in asphalt gets replaced with rubber, up to some of the compressive strength of the material and up to less of the tensile strength needed for splitting are decreased; likewise, up to some of the compressive strength and up to less of the splitting bending strength are lost when all of the small stones are replaced with rubber. It is outlined that earlier research and the development of the characteristic function LWC led to the quantification of the strength loss for rubberised concrete mixes and the usefulness of this characteristic function in defining the strength of concrete with a high rubber component. Some others also said that the amount of rubber allowed in the finished product should not be more than a small portion. Notably, rubberised concrete exhibits good tenacity despite a significant drop in strength.

6 Conclusions

LWC was developed by completely replacing the pumice aggregate with a different composition of 20% silica fume and 1.5% nylon fibres by cement weight. The following conclusions are drawn from the experimental investigation in this study. The compressive strength of the LWC cubes was 22.59 N/mm^2 on average at 28 days, as opposed to 32.96 N/mm^2 for the conventional concrete cubes. This is particularly true when creating artificial coasts because moving common building supplies from the mainland can be expensive and damaging to the environment. The earth is home to many atolls, reef reefs, and islands; however, these material deposits are considered garbage and take up a lot of room, utilising resources that are close by to build cheaply and sustainably. The pumice concrete's structural compressive strength was 45.90% lower than conventional concrete. The average split tensile strength of the LWC was 2.26 N/mm^2, while the average split tensile strength of the control concrete was 6.51 N/mm^2. The structural tensile strength of LWC was 65.28% greater than that of control concrete. At 28 days, the average water absorption for the lighter concrete was 0.516 instead of 0.249 for the heavier concrete. The water absorption test after 28 days showed a percentage reduction of 51.74%. The two types of concrete had oven-dry densities of 2,446.61 kg/m^3 for conventional concrete and 1,542.22 kg/m^3 for LWC after 28 days. The oven dry density test after 23 days showed a percentage loss of 58.64%. At 15 days, typical concrete had an average acid resistance of 38.35%, while LWC had an average of 25.26%.

6.1 Future work

In future experimentation, which was done in this study on the effects of varying silica fume and rubber amounts on concrete's unit weight, compressive property, breaking tensile strength in durability against impacts, and energy absorption can be extended. The unit weight of concrete is significantly reduced when tiny rocks are replaced with an equivalent volume of rubber particles, although it is somewhat increased when silica fume is added. The future study can modify the suggested design process by substituting their equations for the ones for strength, slump, and various limitations. Despite some differences in the calculation equations, the fundamental calculating process is relatively similar. As a result, the suggested approach can be seen as a generic approach to the design of low LWC concrete with excellent strength. On the other hand, durability factors like effervescent or chloride ingress were not considered because this study focused on the mix design of high-strength concrete. These durability characteristics might be seen as additional restrictions on the discrepancy in the concrete mixture. As the amount of rubber in concrete grows, its compressible strength and fracture tensile toughness decline, but the introduction of silica fume can somewhat compensate for the loss in strength. Greater rubber content causes the concrete to break down ductility at final fracture under tension rather than bitterly.

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