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Control Strength Lightweight Mortar made by Recycled Concrete Aggregate and Expanded Perlite

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ABSTRACT

The use of recycled concrete aggregate (RCA) in the production of concrete structures in Malaysia is minimal and does not match the amount of recycled concrete waste produced during a similar period. Moreover, there is a growing need to shorten the construction period, which necessitates the use of lighter concrete materials to produce lighter material with a minimal strength that able to act as part of the structures. Hence, this study aims to analyse the physical and mechanical properties of control strength lightweight mortar (CSLM) made from RCA and expanded perlite (EPA). The nominal size of crushed RCA and EPA was 4.75 mm, like the natural sand (NA) used. Several ratios of RCA, NFA, and EPA (fine aggregate) were employed to determine the optimal ratio of fine aggregate to cement. The CSLM underwent testing for its uniaxial compressive strength at 3, 7, and 28 days, while flexural strength was tested only at 28 days. It is found that the ideal proportion of RCA and EPA in CLSM is 40% and 20% of the total fine aggregate content, respectively. Meanwhile, the optimal mix ratio for CSLM consists of 40% RCA, 40% NFA, and 20% EPA. Hence, it can be concluded that the presence of residual mortar in RCA increased the water absorption rate, resulting in lower compressive and flexural strength when higher proportions of RCA and EPA were used. Studying CLSM using RCA and EPA offers the benefit of creating more sustainable construction materials by reducing waste and conserving natural resources.

Keywords: Recycle concrete aggregate; lightweight cement mortar; compressive strength; flexural strength; expanded perlite

INTRODUCTION

Recycled concrete waste sourced from the demolition of old structures and construction projects has increased over the years, particularly in Malaysia as stated by Umar, Shafiq & Ahmad (2021). Nagapan et al. (2013) stated that the waste originating from construction sites, which typically includes concrete, asphalt, brick, timber, glass, plastic, metal, and cardboard. All these waste materials have the potential for recycling or reuse in various forms (Umar et al. 2021a). While timber is often reused on construction sites as formwork, concrete, and brick, unfortunately, are not. Many construction projects choose not to recycle or reuse concrete and brick due to the associated costs, thus the management of construction and demolition waste remains a critical issue in Malaysia, primarily due to the lack of standardized operating procedures and weak enforcement by authorities (Umar et al. 2021b; Moh & Abd Manaf 2017).

Concrete waste from construction sites or demolished structures, such as old buildings, roads, and drainage systems, holds the potential for recycling or reuse in alternative forms (Barhmaiah et al. 2020; Corinaldesi, 2010; Tabsh & Abdelfatah, 2009; Zheng et al. 2018). Concrete and brick waste can be repurposed as recycled concrete aggregate (RCA) by further crushing the waste into finer particles, adhering to the nominal size of natural aggregates. Several studies conducted by numerous researchers have investigated the effectiveness (Zheng et al. 2018), mechanical properties (Barhmaiah et al. 2020; Bui et al. 2018; Corinaldesi 2010; Tabsh & Abdelfatah 2009; Zheng et al. 2018), effect of curing time (Abdel-Hay 2017; Gholampour & Ozbakkaloglu 2018; López Gayarre et al. 2014), durability (Kou & Poon 2012) and application on structures (Fathifazl et al. 2011; Tang et al. 2017; Tareq Noaman et al. 2021; Wang et al. 2016; Xiao et al. 2012) of RCA obtained from various sources, including demolished structures, construction sites, concrete batching plants, pre-mixed concrete cubes, and factories.

While numerous studies have focused on the suitability and effectiveness of incorporating RCA in the place of coarse and fine aggregates to produce concrete (Abdel-Hay, 2017; Asteray et al. 2018; Barhmaiah et al. 2020; Bui et al. 2018; Kim et al. 2016; López Gayarre et al. 2014; Tabsh & Abdelfatah, 2009; Zheng et al. 2018) and mortar (Braga et al. 2012; Jochem et al. 2020; Li et al. 2019; Mardani-Aghabaglou et al. 2019; Zhang et al. 2015; Md Nor et al. 2024: Ruslan et al. 2023; Md Nor et al. 2023), specifically containing various percentages of fine RCA. It has been noted that the water absorption and open porosity of mortar containing RCA are higher compared to those made with lightweight concrete aggregate (LCA) (Jochem et al. 2020). Braga et al. (2012) state that the fine form of RCA has been found to decrease the rate of water absorption, consequently increasing the compressive strength of mortar by nearly 15% as the hardened fine RCA fills the water capillaries. However, the workability of mortar containing RCA at the same water-to-cement ratio is lower when the percentage of RCA is higher, primarily due to the presence of residual mortar which elevates the water absorption rate, necessitating additional water in the design mix to maintain workability (Braga et al. 2012; Jochem et al. 2020; Mardani-Aghabaglou et al. 2019).

Several studies have also focused on producing lightweight and super lightweight concrete, utilizing a variety of methods, including autoclaving, foaming, no-fines, and the use of lightweight aggregates (Bui et al. 2018; Jian & Wu, 2021; Jamaludin et al. 2024). These include the utilization of industrial and agricultural by-products as supplementary cementitious materials or substitute aggregates. Additionally, artificial lightweight aggregates, such as expanded perlite (EPA), expanded clay, expanded polystyrene, pumice, and metakaolin, are options that can be considered for producing lightweight concrete. The residual mortar present on the RCA can adversely affect the bonding of the aggregate and binder material. Treatment of the residual mortar with sodium silicate has been proposed to increase the surface area of the RCA (Bui et al. 2018). Moreover, the presence of residual mortar in RCA leads to a reduction in the mechanical properties and durability of the resulting mortar due to its porous structure (Jian & Wu, 2021). This statement is aligned with the findings by Shi et al. (2016) which indicate that residual mortar on RCA has higher porosity and water absorption rates and lower compressive strength compared to natural aggregates, necessitating further surface treatment to enhance its mechanical properties.

It is found that from the review that investigation on production of CLSM using RCA and EPA is still limited. The main aim of this study is to investigate the performance of CLSM mortar containing EPA and RCA at various percentages. This study contributes to the development of sustainable building materials and improves the understanding of how recycled and lightweight aggregates can be used effectively in construction industry.

METHODOLOGY

This study was conducted with the intention of producing CSLM using EPA and RCA at various percentages, and as such, the selection of materials was meticulously planned to meet the objectives. The mixture of cement, aggregate, and water used is illustrated in Figure 1. Only fine aggregate was utilized to minimize the density of CSLM, while the incorporation of lightweight aggregate (LWA) was employed to further create lighter materials.

CEMENT

The materials utilized in this laboratory-based experimental study were as follows. The binder used is ordinary Portland cement (ASTM type 1), comprising a compound of lime (CaO), silica (SiO2), alumina (AL2O3), iron (Fe2O3), sulphur trioxide (SO3), and magnesium (MgO). The fineness, with a specific surface measured at 334 m^2/kg, and the soundness is 1.3 mm. Table 1 presents the chemical composition of the cement employed in this study. The concrete cement mortar was designed with a mix ratio of 1:4, representing the ratio of cement to aggregate, with no specific target strength. The water-to-cement ratio (w/c) utilized in the study was 0.65, given that the RCA initially used a mixture of aggregate and mortar, thereby leading to a higher water absorption rate in comparison to normal aggregate, as confirmed by Zheng et al. (2018).

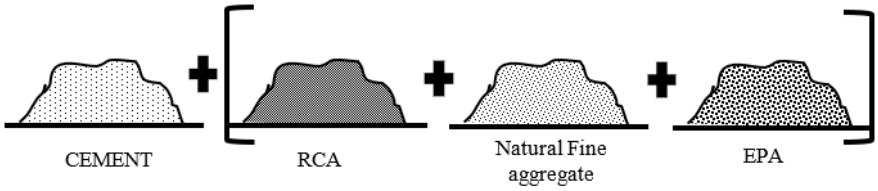

FIGURE 1. CLSM proportionate materials mix

TABLE 1 Cement chemical composition

SiO_2 (%)	AL_2O_3 (%)	Fe_2O_3 (%)	CaO (%)
20.27	5.54	3.42	64.07
Loss of ignition LOI (%)	SO_3 (%)	MgO (%)	Others (%)
1.16	2.32	2.89	0.33

FINE AGGREGATE

River sand with a maximum nominal sieve size of 4.75 mm was used as natural fine aggregate (NFA). No coarse aggregate was used in this study as the aim was to reduce the density of the concrete mortar. The water used is tap water. The density of NFA is 1625 kg/m^3, with an average water absorption of 1.92% and a specific gravity of 2.62. The concrete waste to be reused as RCA was collected from the local concrete batching plant where the control test cube is used for each batch of concrete mix. The cubes with a target strength of 25 MPa were selected for this study to maintain the consistency of the mix. The cubes were then taken to the laboratory where they were first crushed using a hacker and then a jaw crusher machine. A similar method used by Ruslan et al. (2023) was also used for this study to produce RCA. After the cubes were crushed to the desired fine particles, they were washed, oven dried and graded using screening tools to obtain the fine RCA passing the standard nominal aggregate size of 4.75 mm. Figure 1 shows the physical appearance of the RCA, NFA and EPA used in this study after crushing and sieving. The EPA was type C (construction grade) and has a density of 80 to 135 kg/m^3. The EPA was sieved to perform particle size distribution analysis and the maximum nominal size of the EPA used was 4.75 mm.

As the gradation of RCA, NFA and EPA affects the performance of the mortar mix, these materials were thoroughly sieved before use. This process ensured that the aggregates were properly graded, which contributed to the overall strength and workability of the mix. To achieve optimum distribution of the NA, the sieves were carefully selected and adjusted in different sizes. This step was crucial to ensure that the mortar mix had the desired consistency and performance characteristics. Table 2 represents the physical properties of the fine aggregate used in this study. Figure 2 shows the physical appearance of the well-sorted fine aggregate, including RCA, NA, and EPA.

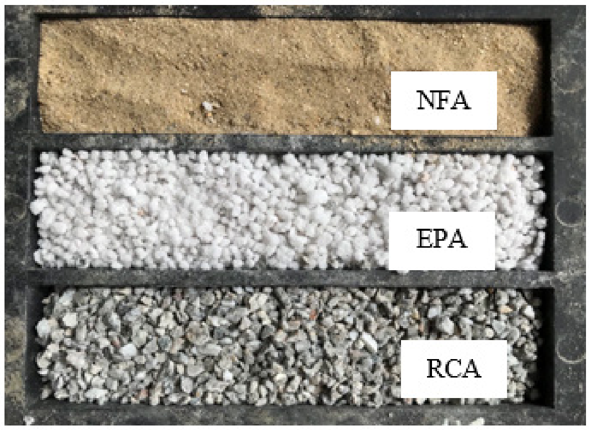

FIGURE 2. Physical appearance of well-sorted NFA, EPA and RCA

ADMIXTURE

Sika Viscocrete-20HE was used as a superplasticiser with a maximum dosage of 1.0% of the total cement mass. The residual mortar in fine RCA and the high-water absorption capacity of EPA required an increased amount of water to maintain the workability of the mortar. The addition of the superplasticiser not only increased the workability of the mortar, but also improved the mechanical properties of the CSLM.

Sika Viscocrete-20HE was selected as a water-reducing agent primarily because of its effectiveness in promoting high workability and producing an impermeable mortar under conditions of significant water reduction. In addition, its use enabled the early strength development of the mortar through surface absorption effects.

DETAIL COMPOSITIONS OF THE DESIGN MIX FOR CLSM

The composition of each material for preparation of CLSM was determined based on a 1:4 weight ratio, with the total of the ratio representing cement to fine aggregate (NFA, RCA and EPA). Although the total composition was calculated based on weight, the quantity of each aggregate was based on the various percentages corresponding to the volume of fine aggregate.

Two types of CLSM were prepared, namely control and LWA materials. The control CLSM was prepared with a single type of fine aggregate, i.e. NFA, RCA or EPA, without combination with other materials. These samples served as the basis for comparison. For the CSLM with LWA materials, different percentages of NFA and RCA were used, with the percentage of EPA serving as a reference based on volume. The percentage of EPA was initially set at 5 % without superplasticiser and then adjusted to 5 %, 10 %, 20 % and 30 % with the superplasticiser.

Table 3 provides a detailed breakdown of the volume percentages for each material composition, including the corresponding w/c ratio. This table was used as an important reference for understanding the variations in mix composition and their effects on the properties of the CSLM samples.

TABLE 2. Physical properties of sand and RCA

Aggregate	Max dry density (kg/m^3)	Water absorption (%)	Specific gravity	Aggregate Impact Value (%)
Sand (NFA)	1625	1.92	2.62	-
RCA	1575	6.2	2.52	24.23
Expanded Perlite (EPA)	100	34.07	-	32.65

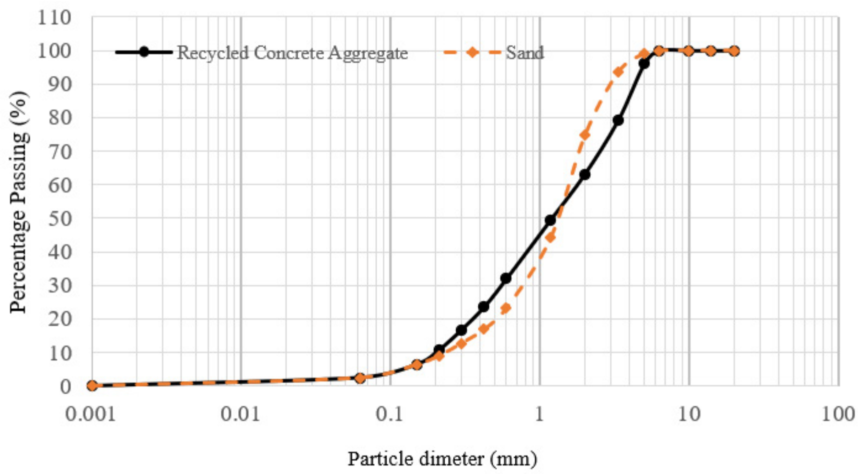

FIGURE 3. Particle size distribution of fine aggregate

TABLE 3. Material compositions

Sample	NFA (%)	RCA (%)	EPA (%)	w/c	Sample	NFA (%)	RCA (%)	EPA (%)	w/c
RNEA1	25	70	5	0.65	RNEC1	10	70	20	0.65
RNEA2	35	60	5	0.65	RNEC2	20	60	20	0.65
RNEA3	45	50	5	0.65	RNEC3	30	50	20	0.65
RNEA4	55	40	5	0.65	RNEC4	40	40	20	0.65
RNEA5	65	30	5	0.65	RNEC5	50	30	20	0.65

continue ...

... *cont.*

RNEA6	75	20	5	0.65	RNEC6	60	20	20	0.65
RNEA7	85	10	5	0.65	RNEC7	70	10	20	0.65
RNEB1	20	70	10	0.65	RNED1	0	70	30	0.65
RNEB2	30	60	10	0.65	RNED2	10	60	30	0.65
RNEB3	40	50	10	0.65	RNED3	20	50	30	0.65
RNEB4	50	40	10	0.65	RNED4	30	40	30	0.65
RNEB5	60	30	10	0.65	RNED5	40	30	30	0.65
RNEB6	70	20	10	0.65	RNED6	50	20	30	0.65
RNEB7	80	10	10	0.65	RNED7	60	10	30	0.65

MIXING PROCESS OF THE CLSM

The mixing process for the materials was carried out with a controlled mixture, as shown in Figure 4. Mixing began with the thorough mixture of NFA and RCA to ensure that these aggregates were properly mixed prior to the addition of cement and EPA. This step was critical to achieve an even distribution of the cementitious material throughout the mix.

Following the initial mixing, water was gradually added to the mixture to prevent crumbling of the materials, which could negatively affect the properties of the CSLM. The slow addition of water ensured that the mixture retained its integrity and allowed for optimal hydration and workability. EPA was incorporated at a later stage of the mixing process, which facilitated its thorough integration into the NFA and RCA already coated with cement paste. The w/c ratio was kept well within 0.65.

In the final stage of the mixing process, when the admixture was added, the rotation speed of the mixer was increased. This adjustment during mixing was made to ensure that the admixture was evenly distributed throughout the CSLM, resulting in a homogeneous mixture with improved performance characteristics.

IDENTIFICATION THE PROPERTIES OF FRESH MORTAR

A flow test was performed to evaluate the flowability of CSLM with different proportions of RCA and EPA in the mixture. The flow table test was carried out in accordance to ASTM C230. This workability test was critical in assessing the amount of water required in the mix to achieve the desired consistency. In addition to the workability assessment, the fresh density of CSLM was measured to analyze the density variations resulting from the different material compositions. This analysis provided insight into how the addition of different proportions of RCA and EPA affected the overall density of the CSLM, which is a key factor in determining the performance characteristics of the material.

IDENTIFICATION OF THE MECHANICAL PERFORMANCE OF HARDENED CLSM MORTAR

In order to determine the mechanical performance of the hardened CLSM mortar, the compressive strength test and the flexural strength test were carried out. For the compressive strength test, 50 mm x 50 mm x 50 mm cubes were produced. Prisms measuring 40 mm x 40 mm x 160 mm were prepared for the flexural strength test. The hardened CSLM mortar cubes and prisms were cured for 3, 7 and 28 days before being tested for mechanical properties. The compression test was carried out in accordance with BS EN 12504-4 (2004) at a constant compression rate of 1.0 mm/s. The bending properties of CSLM were determined by a three-point bending test using a 100 kN universal testing machine.

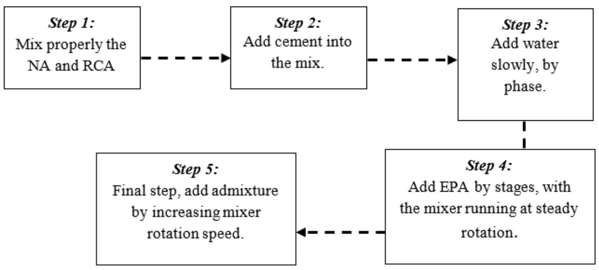

FIGURE 4. CSLM mixing process

RESULTS AND DISCUSSION

DENSITY OF THE CLSM

Figure 5 shows the results of CSLM density with different percentages of RCA, ranging from 10% to 70%. The density was measured at the age of the CLSM mortar of 28 days. The density of CSLM decreased almost linearly as the percentage of RCA decreased, with the lowest density of CSLM achieved at 30% EPA. The density of the mixture was mainly controlled by the presence of EPA and the percentage of NFA in the mixture. A low percentage of EPA contributes to a high density of the mixture, while a high percentage of NFA results in a denser CSLM mixture. Therefore, an optimum mix percentage for each fine aggregate used is required to produce a CSLM with a minimum allowable strength and a dry density of less than 2000 kg/m^3.

From Figure 5 shows that both materials, RCA and EPA, directly influenced the density of the mixes. At an RCA content of 70%, the density of the mixtures is the lowest, while at an RCA content of 10%, the density of the mixtures is the highest, with the highest density being 2245 kg/m^3. The presence of RCA as a substitute for the NFA has made a significant contribution to the reduction in density. However, the reduction in density significantly reduces the compressive strength and flexural strength of the mixture.

On the other hand, the percentage of EPA also shows a significant effect on the reduction of the hardened density of the mixtures. The replacement of 30% EPA reduced the density of the mixture by almost 30% compared to the replacement of 5% EPA. At 70% RCA and 30% EPA, the mixture has reached a density of 1847 kg/m^3, while at 5 % EPA the density of the blend is 2028 kg/m^3. The density of EPA has contributed to the reduction in mix density which has resulted in significant void content in the CSLM due to the presence of voids in the EPA. Therefore, EPA is very favourable for use as a substitute material in the production of lightweight materials.

COMPRESSIVE STRENGTH OF CLSM MORTAR

The compressive strength of CSLM, as shown in Figure 6, shows an increasing trend reflecting the ability of the mix to withstand higher compressive loads at lower proportions of RCA. The adherent mortar contained in the RCA has developed a weak structural layer with a high-water absorption capacity, limiting the ability of CSLM to support the applied axial load. In addition, the results indicate that the EPA content reduces the compressive strength of CLSM. This is consistent with the properties of EPA, which are characterised by low density, high porosity and low compressibility. The considerable number of pores within the EPA structure directly reduces the compressive capacity of the mixture to carry the axially imposed load. The compressive strength is lowest at 70% RCA. The lowest strength was found to be 3.89 MPa and the highest strength 29.81 MPa at 10% RCA as a partial replacement of the NFA.

Figure 6 also shows that the compressive strength of the mixture labelled RNEB7 with 80% NFA, 10% RCA and 10% EPA has the highest compressive strength. Meanwhile, the mix with 15% NFA, 70% RCA and 30% EPA (RNEA1) has the lowest compressive strength with a value of 6.12 MPa. The EPA content contributed significantly to the reduction in strength, with several factors identified. Md Nor et al (2024) found that mortars containing EPA create porosity that reduces particle packing within the mortar matrix, thus reducing cohesion and interlocking between particles.

The presence of NFA contributed to the higher compressive strength. The matrix of natural sand increased the cohesion and interlocking between the particles and improved the ability of the material to withstand the axial load applied to the solid. The compressive strength decreased linearly with decreasing NFA content. The presence of NFA is crucial for increasing the compressive strength of the material. It is equally important to determine the optimum NFA content as it improves the overall performance of the material. However, the optimum NFA content must be determined as a higher NFA content contributes to a higher density of the material. At 40% RCA, where the NFA content is between 30% and 65%, the compressive strength of CLSM has reached the target strength. Further analysis of the density is therefore required.

FLEXURAL STRENGTH OF CLSM MORTAR

The flexural strength of CSLM exhibits a similar pattern to the compressive strength of the mix. However, a higher percentage of NA has contributed to an increase in the mix's density. Figure 7 indicates that the flexural strength reaches its maximum at the 10% RCA content which the flexural strength achieved 8.25 MPa while the lowest flexural strength is at the mix with RCA content is 70%. The flexural strength of respected mix is 1.93 %. The total reduction in strength from the highest to the lowest is almost 50%. This underscores the significant impact of RCA and EPA on the mix, as higher NFA content has led to higher compressive and flexural strength in CSLM.

From Figure 7, the content of EPA plays an equally important role in producing targeted CLSM which has optimum compressive and flexural strength, while the density must be lower than 2000 kg/m^3. The lower the EPA percentage, the flexural strength decreased significantly. The ability of the CSLM to withstand bending deflection due to axially loaded stress is decreased as the presence of void limits the matrix to produce significant interlocking force. At the 40% RCA, the flexural strength has achieved the flexural strength of 4 MPa to 6 MPa. This is the targeted flexural strength of CSLM.

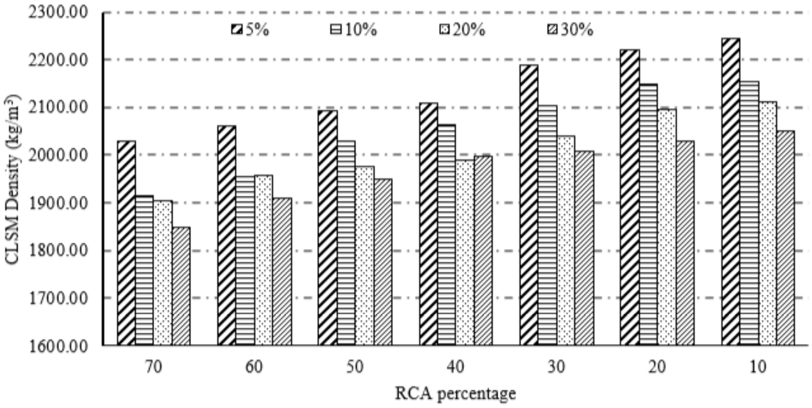

FIGURE 5. Density of the CLSM at different percentages

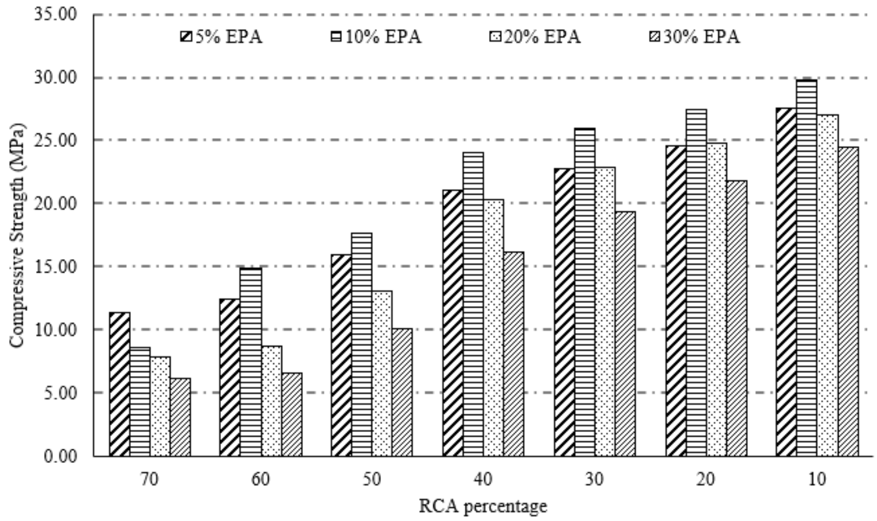

FIGURE 6. Compressive strength of CLSM mortar at 28 days with NFA of 15%

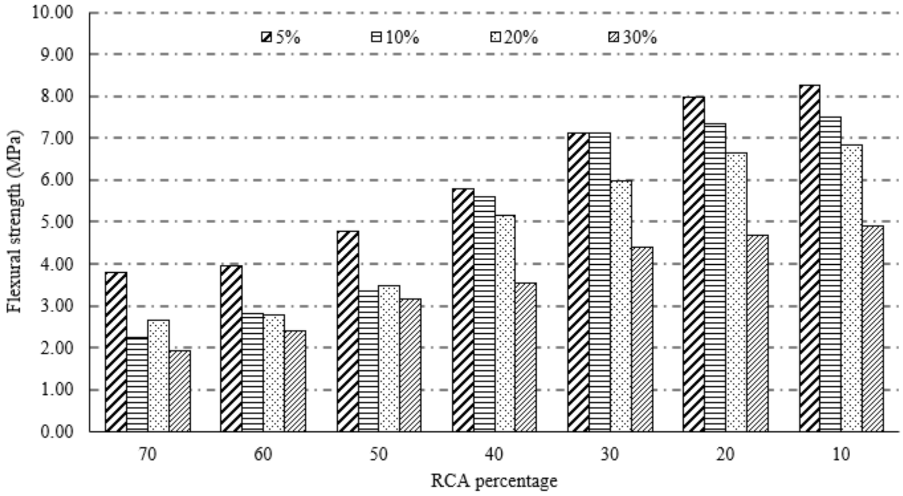

FIGURE 7. Flexural strength of CLSM mortar at 28 days

DENSITY WITH RESPECT TO COMPRESSIVE STRENGTH OF CLSM MORTAR

The CSLM consists of a mixture of RCA, NFA and EPA as aggregates and cement as binder. The CSLM must fulfil two main criteria, namely a strength of more than 20 MPa and a dry density of less than 2000 kg/m³. Figure 8 shows that the mix with 5% EPA has a dry density of more than 2050 kg/m³ for all mixes, with a compressive strength between 11.35 MPa and 27.55 MPa. The mixture with 5% EPA achieves neither the desired strength nor the dry density of CSLM.

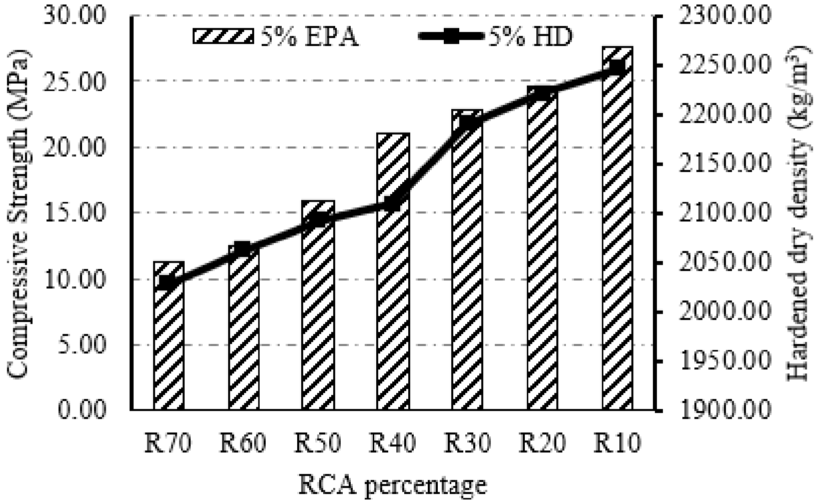

FIGURE 8. Dry density and compressive strength at 5% EPA

The mix with 10% EPA, as shown in Figure 9, had a dry density between 1914 kg/m³ and 2153 kg/m³ with an average compressive strength of 21 MPa. The mixture with a composition of 30% NFA, 60% RCA and 10% EPA (RNEB2) had a low-density of 1953 kg/m³ with a compressive strength of less than 20 MPa. Increasing the EPA content in the mix simultaneously reduced the density and compressive strength of CSLM. Although the mixture with an RCA content of 40 % achieved the desired strength, the density of the mixture was significantly higher than 2000 kg/m³.

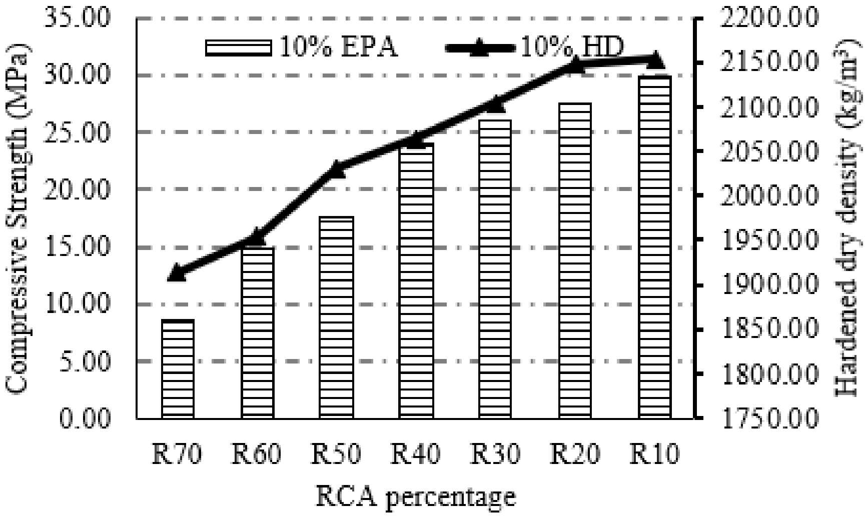

FIGURE 9. Dry density and compressive strength at 10% EPA

Figure 10 illustrates the dry density and compressive strength of CSLM with a 20% EPA replacement. Analysis of the results shows that the 20% EPA gave a balanced mixture. The density and compressive strength of CSLM with 20% EPA show an optimal mix with low density and a good compressive strength value. For example, RNEC4 had a compressive strength of 20.31 MPa and a density of 1980 kg/m³, while RNEC5 with an average strength of 22.8 MPa and a density of 2040 kg/m³ also produced a balanced mix. In comparison, the mixture with an EPA content of 30% (Figure 11) had a low density and low strength values. As the density decreased, the compressive strength of the mix decreased significantly due to the low compressibility resulting from the higher proportion of EPA and RCA in the mix. The overall compressive strength of the mixture with 30% EPA did not exceed 20 MPa. On the other hand, the dry density of the entire mixture fell below 2000 kg/m³. This is largely due to the higher percentage of EPA added to the mix.

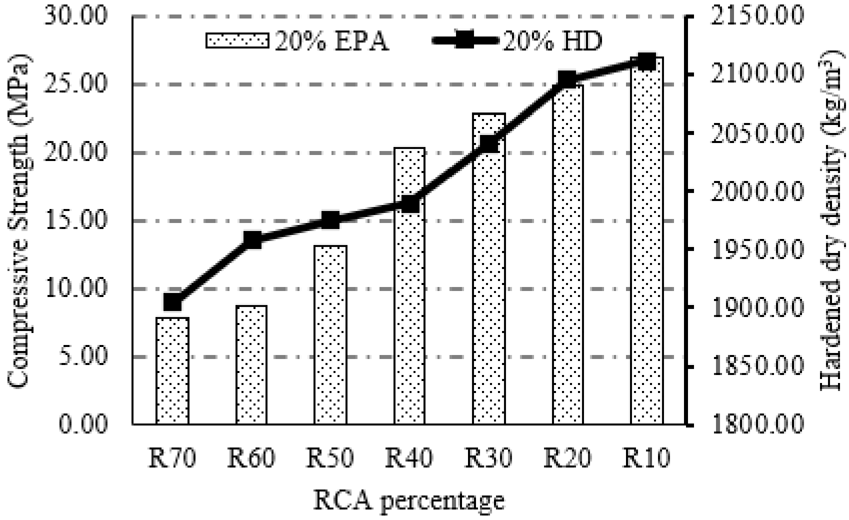

FIGURE 10. Dry density vs compressive strength at 20% EPA

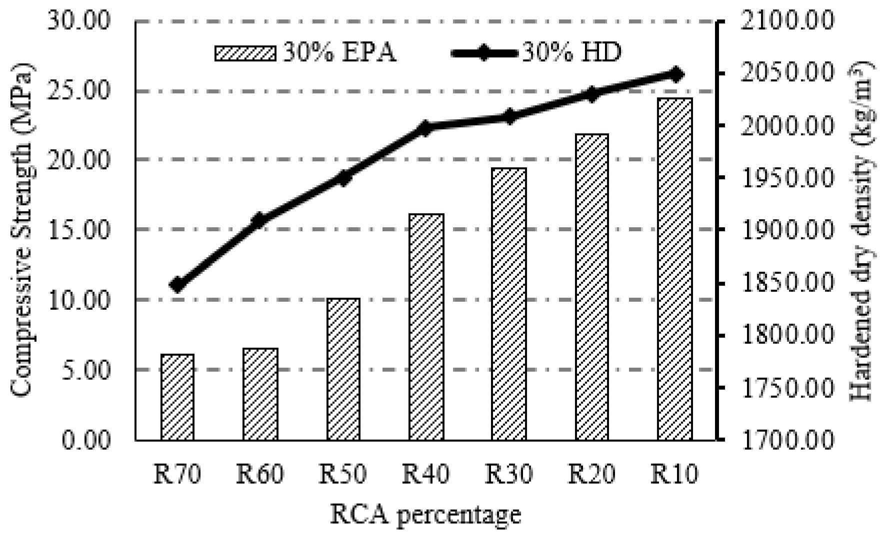

FIGURE 11. Dry density vs compressive strength at 30% EPA

STATISTICAL ANALYSIS OF CLSM MORTAR

Accompanying the strength characteristics, the study places a particular emphasis on the hardened dry density of CSLM. Density is a fundamental property influencing the material's overall structural efficiency, thermal conductivity, and resistance to external factors. The interplay between these properties forms a complex matrix, necessitating a rigorous statistical approach to unravel the underlying patterns and correlations. Through regression and correlation analyses, this investigation aims to elucidate the relationships between compressive strength, flexural strength, and hardened dry density in CSLM. By employing statistical methods, not only to quantify the individual influences of various components but also uncover synergies that may exist within the material. The findings from this analysis are anticipated to contribute valuable insights to the ongoing efforts in optimizing CSLM formulations for enhanced structural performance and durability in diverse construction applications.

Figure 13 illustrates the regression analysis of compressive strength and hardened dry density of CSLM, aiming to assess the relationship between these two properties. The graph indicates a linear proportionality between the compressive strength of CSLM and its hardened density, with regression values ranging from 0.8775 to 0.960. It is evident that the primary controlling factor of the mechanical properties of CSLM lies in the physical properties of the aggregates used in the mix. The relationship between compressive strength and hardened dry density of CSLM is outlined as follows: -

$$fc5 = 0.0717\rho - 133.78 \quad (1)$$

$$fc10 = 0.0814\rho - 145.97 \quad (2)$$

$$fc20 = 0.0978\rho - 178.89 \quad (3)$$

$$fc30 = 0.0981\rho - 178.23 \quad (4)$$

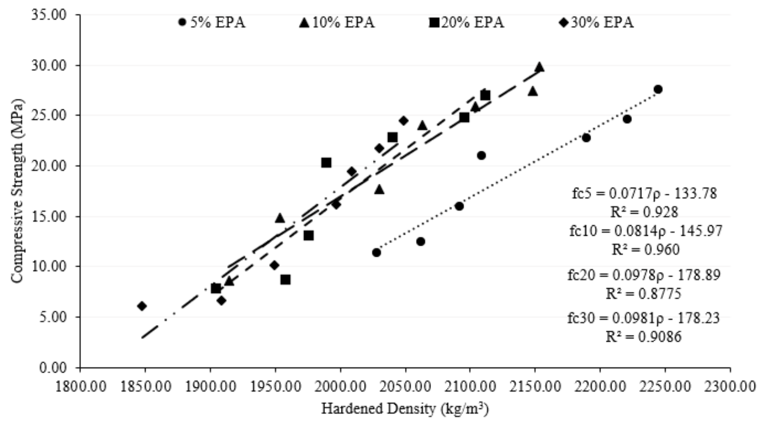

FIGURE 13. Correlation between compressive strength and density of CLSM mortar

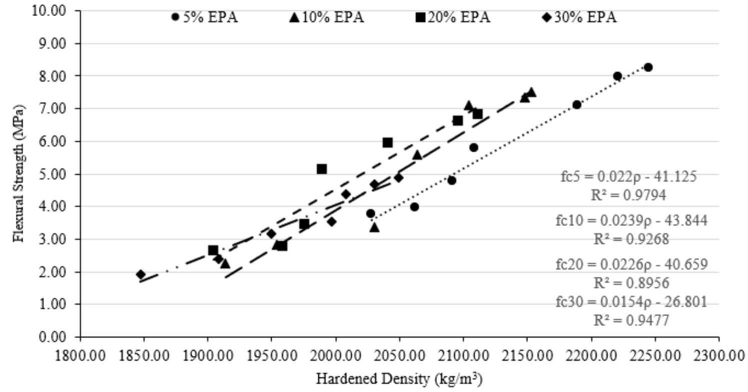

FIGURE 14. Correlation between flexural strength and density of CLSM mortar

Figure 14 depicts the regression analysis of flexural strength and hardened dry density of CSLM. The graph reveals a linear proportionality between the flexural strength of CSLM and its hardened density, with regression values ranging from 0.8956 to 0.9794. The analysis affirms that the primary controlling factor of the mechanical properties of CSLM is the physical properties of aggregates used in the mix. It is observed that the density of the mix decreases with higher usage of RCA and EPA, resulting in weaker CSLM strength. Conversely, an increased proportion of NA in the mix leads to higher CSLM strength but denser density. The relationship between compressive strength and hardened dry density of CSLM is expressed through the following equations:

$$fT5 = 0.022\rho - 41.125 \quad (5)$$

$$fT10 = 0.0241\rho - 44.147 \quad (6)$$

$$fT20 = 0.0226\rho - 40.659 \quad (7)$$

$$fT30 = 0.0154\rho - 26.801 \quad (8)$$

CONCLUSION

Control Strength Lightweight Mortar (CSLM), crafted from recycled concrete aggregate and expanded perlite, exhibits considerable potential for utilization as precast construction materials. The lighter density of expanded perlite, coupled with its capacity to offer effective insulation to buildings, enhances the structure's heat control system. The conclusions derived from this study are summarized as follows:

The optimal percentage of recycled concrete aggregate in CSLM is 40% of the total fine aggregate content. Beyond this threshold, the presence of attached mortar diminishes the bonding contact around the particle skeleton, resulting in CSLM with reduced strength.

The addition of expanded perlite reduces the hardened dry density of CSLM while improving insulation properties. The ideal percentage of EPA is 20% of the total fine aggregate content. Further increments in percentage will eventually compromise the mechanical properties of CSLM.

The optimum ratio for the CSLM mix is 40% RCA, 40% NA, and 20% EPA, or the mix design with the general coding of RNEC4. The compressive and flexural strength of this ratio surpasses the optimum strength values, and the hardened dry density meets the criteria for classification as lightweight material.

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DECLARATION OF COMPETING INTEREST

None.

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