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Innovative Approach to Foam Concrete Production by Utilizing Recycled Foam Concrete as a Sustainable Alternative

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ABSTRACT

Foam concrete, distinguished by its lightweight properties and versatility in construction, is a porous material produced from cement, water, fine aggregate, and foam. It contains numerous voids and lacks coarse aggregate, which accounts for its lightweight and low density. It has been widely used in roofing, partition walls, and insulation applications. This study explores an innovative approach to foam concrete production by investigating the effect of using recycled foam concrete waste, processed into various sizes of lightweight aggregate. The water-to-cement and cement-to-aggregate ratios were maintained at 0.45 and 1:1.3, respectively. The research involved replacing 50% of the aggregate volume with recycled waste from foam concrete, using specified aggregate sizes of Gradation levels of four aggregate sizes (12.5-9.50) mm, (9.50-4.75) mm (4.75-2.36) mm, and (2.36-1.18) mm. Results showed that the optimal size for use was 9.50-4.75 mm, which enhanced compressive strength, and tensile strength while increasing water absorption at 28 days by percentages compared to traditional FC mix. The study aims to minimize the use of natural aggregate resources and reduce construction waste. Through a comprehensive experimental program including material characterization, and mechanical performance testing, the findings are expected to provide valuable contributions to sustainable construction practices.

Keywords: Foam concrete, Recycle foam concrete, Lightweight concrete.

1. INTRODUCTION

Concrete is one of the most extensive materials used worldwide. Approximately twelve billion tons of concrete are manufactured every year. All over the world, requiring the consumption of around (1.6, 10, 1) billion tons of (Portland cement, rocks, and water) respectively **(Shah and Wang, 2004)**. However, the consumption of natural aggregates nearly exceeds 26.8 billion tons per year there has been growing concern about

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environmental justification **(Busari, 2022)**. With the increasing global demand for concrete production, more than 31,000 tons of demolition waste are generated every year **(Cook et al., 2020).** On the other hand, large quantities of demolished waste require a huge space for disposal, which is harmful environmentally, demolition Waste is made up of debris that was produced from the tearing down or dismantling of buildings, roads, bridges, and other structures. This waste commonly includes materials like concrete, bricks, wood, metals, glass, plastics, and other construction components highlighting an important aspect of advancing sustainable construction practices involves tackling the challenge of managing demolition waste at the end of a material's lifecycle **(Kalpavalli and Naik, 2015; Bravo-German et al., 2021).** This situation leads to a question about the preservation of natural aggregate sources, the annual increase in industrial waste is the largest problem that threatens the environment and is difficult to control. Therefore, recycling constriction waste and management methods are highly efficient in reducing problems. And reduce its impact, while at the same time preserving natural resources. The most essential challenge among all future development trends is how to make concrete more sustainable, Lightweight concrete has long been utilized effectively in building construction **(Hachim and Fawzi, 2012; Abdalla et al., 2022; Ali and Awad, 2023; Fawzi and Awad, 2023; Kazem and Fawzi, 2024).** One of these solutions is Cellular aerated concrete, also known as foam concrete (FC), distinguished by its lightweight properties and adaptability in construction, which presents an opportunity to significantly advance sustainable building practices. There are several factors, for instance, constituents, cement quality and quantity, supplementary cementations materials, aggregates, admixtures, mix design, procedures of mixing and manufacture, foaming agent (type, amount, preparation manner), which considerably influence foam concrete properties **(Koksal et al., 2020; Cheng et al., 2021; Ali and Fawzi, 2021; Al–Hail and Fawzi, 2024).** The usual range of unit weight of foam concrete is (400–1600) kg/m3, its compressive strength varies from (1–25) MPs, additionally, thermal conductivity coefficients vary from (0.2- 0.8) W/m.k, thereby being of great application **(Ahmad et al., 2019; Hashim and Tantray, 2021).** Based on numerous studies conducted on materials thus far, the pore structure and mechanical properties of foam concrete can be significantly affected by the performance of the foam **(Hajimohammadi et al., 2018; Hussian and Aljalawi, 2022).**

One of the most important benefits is its lightweight (FC) reduces the self-weight of the structural concrete, thereby, minimizing the dead load members such as foundations, columns beams, or load bearing resulting in more economic structural design. The design will reduce the amount of material used and eventually cut down the cost of the construction project, it has unique properties such as minimal consumption of coarse aggregate, high flow ability, fire attack, good sound and heat insulation, in addition, lower concrete density ranging between (400 – 1850) kg/m^3. The standard lightweight concrete **(Xiao et al., 2012; Mydin et al., 2018; Nensok et al., 2021; Song et al., 2022; Salih et al., 2023).** The advantages of foam concrete extend beyond its fire and seismic resistance. Foam concrete blocks are highly favored for constructing walls due to their excellent thermal and acoustic insulation properties. Additionally, they can also be used for a variety of other applications. for filling voids behind archways and refurbishing damaged sewerage systems, as well as for producing masonry units **(Nandi et al., 2016; Harith, et al., 2017; Bishir et al., 2018; Raj et al., 2019).** The properties of foamed concrete are highly dependent on the quality of the foam. There are two types of foaming agents: synthetic, which is suitable for densities around 1000 kg/m^3, and protein-based, which is suitable for densities ranging from 400 to

1600 kg/m^3 **(Liu et al., 2024)**. As its own to enhance some properties, mechanical and durability of foamed concrete. Researchers need to make use of construction and demolition waste to meet the increasing demand for aggregates for concrete manufacture **(Saleh et al., 2023).** Study concluded that foam concrete can provide an excellent means of combining different types in large quantities, due to the low strength requirements of foam concrete. **(Shah et al., 2021).**

The expansion of uses of foamed concrete (FC) as alternative concrete and not just use it as a filler material. The aim of this is to reduce the global warming phenomenon that arises from the production and use of traditional concrete. Through the development in the use of) FC) as an alternative to traditional concrete, and because of its low density which leads to reduced production and transportation costs and the number and effort of workers, thermal conductivity **(Rahardjo et al., 2024**). Generally, foamed concrete (FC) is prepared by preparing pre-made foam and adding it to the cement mortar by mixing cement and aggregate. In this study, coarse aggregate was used and the foaming agent was in certain proportions. A recent study investigated the production of sustainable Foamed Concrete by using recycling waste materials as an example Recycling waste materials is considered the most visible solution to protect the environment. Using scraps in concrete production is a proper method for getting rid of waste, improving the characteristics of concrete, and reducing the consumption of natural aggregates **(Helmy et al., 2023).** Furthermore, recycled coarse aggregate accounts for (60) % of all crushed concrete **(Ghorbani et al., 2019).** Since it is necessary to develop the preparation process of FC by adding coarse aggregate. On the one hand, the application of coarse aggregate in foamed concrete is to add LWCA. **(Guo et al., 2021).** However, it found that with the increase in FC density, the compressive strength and absorption capacity of FC are significantly improved **(Gholampour et al., 2017**). A significant amount of WC is generated through the reconstruction of ancient cities. To reuse recycled concrete materials in lightweight construction, a new preparation method for FC is proposed. single-factor tests, the effects of (RCA) gradation were examined, RCA volume ratio, water-cement ratio, and foam content on the preparation process and performance of recycled coarse aggregate foamed concrete (RCAFC) were investigated. The findings revealed that RCA gradation significantly affected on performance of RCAFC. Gradation comprising a mass ratio of five aggregate sizes (9.5–16) mm, (16–19) mm, (19–26.5) mm, (26.5–31.5) mm, and (31.5–37.5) mm in proportions of (2:4:8:3:3) It has been found to reduce water absorption by (4.6) %, increase compressive strength by 6.0%, and simplify sample preparation compared to natural grading. In addition, an increase in recycled concrete aggregate volume fraction will be proportional to compressive strength **(Han et al., 2023).**

In general, many studies have been undertaken to study the production FC, Fresh properties, Hardened properties, thermal, and durability properties also applications of FC, it was observed that Foam concrete strength has a relationship with its density, where a reduction in the density leads to a reduction in the concrete strength. This reduction is attributed to many factors, including foam volume, Water to cement ratio, sand grading and type, cement-to-sand ratio, and curing method, Examples of materials replaced by aggregates are rubberized concrete is a type of sustainable concrete material that contains rubber particles from used tyres as a partial replacement of its mineral aggregate. Rubberized concrete has attracted researchers' **(Eltayeb et al., 2020)**.

Experimental studies on the properties of foam concretes, made with a, containing fly ash (FA) as aggregate and granulated blast furnace slag as fine aggregate **(Oren et al., 2020).** As an example, using thermostone blocks and ceramic tiles as the raw materials to produce

foamed concrete is a great way to promote economic growth by preserving natural resources, and lowering waste constriction by recycling waste into useful materials. **(Shareef et al., 2023).** sugarcane bagasse ash provides economic sand replacement in foam concrete without degrading its mechanical properties **(Khawaja et al., 2021).** Using pozzolanic materials and palm oil fuel ash on the engineering properties of lightweight foamed concrete It was observed that the incorporation of palm oil fuel ash into foamed concrete as part of the aggregate led to an increase in compressive strength, splitting, flexural tensile strength, **(Lim et al., 2013; Al-Shwaiter et al., 2022).** Furthermore, the research explored the effect of replacing sand with waste glass powder in foam mechanical and microstructural properties of foamed concrete (FC). Replacement ratios ranging between (0– 50) % were examined. The results revealed that at a 20% glass powder replacement, the mechanical properties improved, compressive strength, splitting strength, and flexural strength increasing by (18, 40, 33) %, respectively. However, increasing the replacement ratio beyond (20) % did not lead to additional major advancements. Additionally, porosity, absorption, and sorptivity were reduced with the incorporation of glass powder. These findings underscore the potential advantages of utilizing glass powder in FC to improve its overall performance **(Maglad et al., 2023).**
Therefore, the objective of this research is to investigate the use of different sizes of recycled foam concrete (RFC), as a partial replacement of aggregate, reduce the consumption of natural aggregate resources, and minimize construction waste

2. EXPERIMENTAL WORK

2.1 Materials

2.1.1 Cement

Ordinary Portland cement type (I- 42.5R), was used the physical and chemical requirement composition has been tested according to the Iraqi standard specification **(IQS No.5, 2019).**

2.1.2 Aggregate

Natural sand was used in this study, which confirmed Standard Specifications **(IQS No.45, 1984).**

2.1.3 Crushed Recycle Foam Concrete (RFC)

The recycled Foam concrete from manufacturer waste collection (casting–cutting) as replaced as an alternative. used was Factory waste Foam concrete. The steps for preparing the recycled foam concrete were as follows:

1-The concrete samples were crushed by crusher and hammer into small particles with the required sizes

2-The crushed concrete then was sieved to get particles similar to that of the natural coarse and fine aggregate used as shown in **Table 1**, and **Fig.1**

After collecting waste, prepare four groups of it by crushing then sieving it to the required size as shown in **Table 2**, which presents the physical properties of the recycled foam concrete (RFC), and specific gravity (mm) is measured according to **(ASTM C188-95, 2001).** Loose bulk density (kg/m^3) according to standard specification **(ASTM C29, 2001).** Water absorption according to **(ASTM C127, 2013).**

Table 1. A single size of crushed RFC by using different sieves

NO	Sieves size. (mm)	Passing. (mm)	Retained. (mm)
1	(12.5-9.5)	12.5	9.5
2	(9.5-4.75)	9.5	4.75
3	(4.75-2.36)	4.75	2.36
4	(2.36-1.18)	2.36	1.18

A B

Figure 1. (A) Sieve sizes and (B) Sieves used for producing different sizes of RFC.

Table 2. Physical properties of (RFC)

Particle size of aggregate (mm)	Specific gravity (mm)	Loose bulk density (kg/m³)	Water absorption (%)
RFC (12.5-9.5)	2.54	560	17.23
RFC (9.5 - 4.75)	2.59	602	14.53
Natural (Sand)	2.65	1689.2	1.21
RFC (4.75-2.36)	2.62	710	27.97
RFC (2.36-1.18)	2.70	1220	33.61

2.1.4 Foaming Agent

The protein-based surfactant used in this study is an under the name (PA-1). The foaming agent is diluted in water at a rate of (1:30). The mixed solution is then aerated to produce stable foam with a density between (65-68) kg/m^3. It was provided by **(Al-mulali et al., 2015).**

2.1.5 Water

Drinking water was used for mixing and curing purposes according to standard specifications **(IQS No.1703, 2018)**.

2.2 Preparing Concrete Mixtures

As shown in **Table 3** below, four mixtures were prepared: for reference mixture, cement content was 352.16 kg/m^3, coarse aggregate to cement ratio 1:1.3, Water to cement ratio 0.45.

Table 3. Mixes details.

Mix Symbol	Mix Description
MR	Control Foam concrete mix
M1	Foam concrete mix with 50% RFC size (12.5-9.5) mm replaced as aggregate
M2	Foam concrete mix with 50% RFC size (9.5-4.75) mm replaced as aggregate
M3	Foam concrete mix with 50%RFC size (4.75-2.36) mm replaced as aggregate
M4	Foam concrete mix with 50% RFC size (2.36-1.18) mm replaced as aggregate

2.3 Mixing Procedure

The mixing was applied according to the method stipulated in **(ASTM C 796, 2001).** Mixing was carried out by using a special foam concrete paddle mixer operating at a speed of about 40 rpm, with a maximum capacity of 0.25 m^3. Before starting mixing, it is necessary to prepare foaming agent at a first using machine stable foam is product with a density of between (62-68) kg/m^3.

- The inner part of the mixer has been cleaned and moistened before use.
- prepared the mortar from half the amount of natural sand is added and the rest is replaced with the single size of RFC as aggregate (depending on its density) were added to the mixer and mixed firstly in the mixer for 2 minutes.
- After the RFC with natural sand were mixed, directly followed by the addition of the cement and water, for 3 minutes, then add water. Hence, mixed until they were completely distributed,
- The water must be added gradually to achieve and lead to the required consistency. The limitation of consistency mortar fixed to a value between (220- 240) mm is determined by the use method **(Al-mulali et al., 2015).**
- Then calculate the density of the slurry by weighing the mortar using one-liter cup, the density and amount of foam are determined and gradually added to the base then, the components are mixed to obtain a homogeneous foamed concrete mixture with wet density ±3 % of the design density of foam concrete, which is 1000 kg/m^3, It is taken by the weight of one cup of concrete mix (fresh mix) Once the required density of foam concrete is obtained.
- the foam concrete is directly cast into the molds were cast in cubic molds with dimensions (100×100 ×100) mm, and prism with dimensions (400×100×100) mm, Hanes, Lubricate the molds using vegetable oil non- react with foamed concrete. Without any compaction, leave to dry air for 24 hours the formwork is removed.

2.4 Mixing Proportion

Many trail mixes were made to choose the appropriate proportions of the mixing components. In this research, five concrete mixes were studied; the reference mix and four other mixes that contained a different size of RFC aggregate were replaced with recycled aggregate in the proportions 50% by volume, the chosen water-to-cement ratio and cement-to-aggregate ratio were maintained at 0.45 and 1:1.3, respectively. For mixed design purposes. It is important to ensure that the base mortar mix has a sufficient amount of water. A dry mortar base mix will lead to the cement extracting the water therefore it is very necessary for the hydration process, from the foam side the compressive and flexural strength and water absorption tests were conducted at two different curing ages, 7 and 28 days. The mixes used in this study included one without any replaced material, four mixes with varying sizes of Gradation level of four aggregate sizes 12.5-9.5 mm, 9.5-4.75 mm, 4.75-2.36 mm, and 2.36-1.18 mm. replacement in proportion (50%) by volume of recycle foam concrete (RFC)

3. TESTS

3.1 Fresh Test

3.1.1 Flow Test

The Flow test the consistency of the mortar base mix showed be fixed to a value between (220- 240) mm**,** See **Fig .2** was identified by measuring the spread diameter of the mixture filled a cylinder of diameter of (75) mm and height of (150) mm **(Al-mulali et al., 2015).**

Figure 2. Flow test.

3.2 Mechanical Test

3.2.1 Compressive Strength

The compressive strength is conducted according to a standard specification **(BS EN 12390-3, 2019)**, and the dimensions of cubes (100×100×100) mm, are used for the determination of the compressive strength. The cubes were tested at the age of 7, 28 days, see **Fig. 3**

Figure 3. Compressive strength

3.2.2 Flexural Strength

The flexural strength was determined using a sample with a dimension of (100×100×400) mm. The test is conducted according to standard specifications **(BS EN 12390-5, 2009)**. The test is conducted at 7 and 28 days, see **Fig. 4**

Figure 4. Flexural strength

3.3 Water Absorption

The absorption characteristics of the foamed concrete samples examined in this study have been thoroughly investigated, the water absorption readings are taken according **to (BS 1881-122, 2011)**. For this test, the average of the cubic samples tested with dimension (100×100×100) mm at the age 28 and 90 days.

4. RESULTS AND DISCUSSION

4.1 Fresh Test

4.1.1 Consistency

The Flow test the consistency of the mortar base mix showed be fixed to a value between (220- 240) mm, it was identified by measuring the spread diameter of the mixture filled a cylinder of diameter of 75mm and height of 150mm. From the laboratory work, it was noticed that adding foam to the un-foamed (mortar) mixture resulted in reducing the spread diameters because of the adhesion between the bubbles of foam and the solid particles**. (Awang and Aljoumaily, 2017).**
the results indicated that the Consistency of mixes increased when replaced with coarse sizes of aggregate of RFC waste leading to an increase in strength compared with fine sizes of aggregate replacement and MR mix. Due to the coarse size of (RFC), it tends to have a higher water absorption capacity compared to natural sand. This absorption decreases the amount of free water available in the mix, resulting in a more viscous consistency and increasing the resistance to flow **(Al-mulali et al., 2015),** as shown in **Fig. 5**

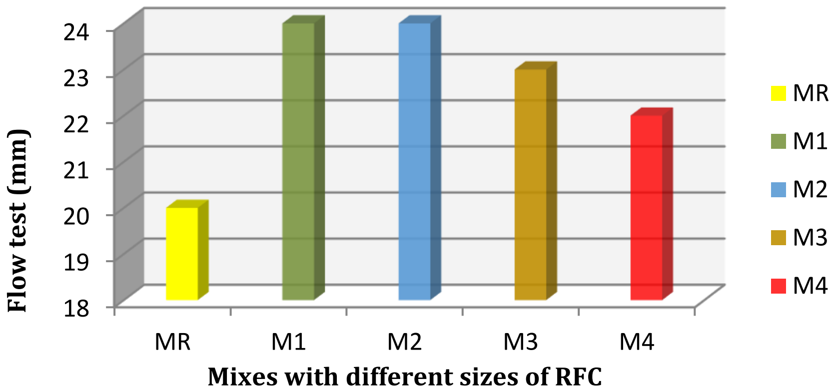

Figure 5. Flow test as a function for different sizes of RFC of FC mixes

The mixes contain fine sizes between (4.75-2.36), and (2.36-1.18) mm of RFC as a partial replacement of natural sand decreased the Consistency value in comparison with MR mix, this is attributed to the combined influence due to increased porosity of the adhered mortar of the RFC, and increases in surface area which led to reduce flow ability

4.2 Mechanical Test

4.2.1 Compressive Strength

Fig. 6 below shows that the compressive strength of the mixes improved with the replacement of coarse aggregates by recycled fine sizes of (RFC) waste. This increase in strength was more pronounced compared to mixes using fine-sized replacements and the MR mix. the major reason for helping in enhancing their strength was Improved Grading The integration of coarse aggregate with natural sand optimizes the particle size distribution, minimizing voids within the mix. This leads to a denser concrete structure, thereby enhancing its mechanical strength, using coarse lightweight aggregate in proportion 50% by volume with natural sand increased Interlocking between practical sizes **(Obaid and Hilal, 2022).**

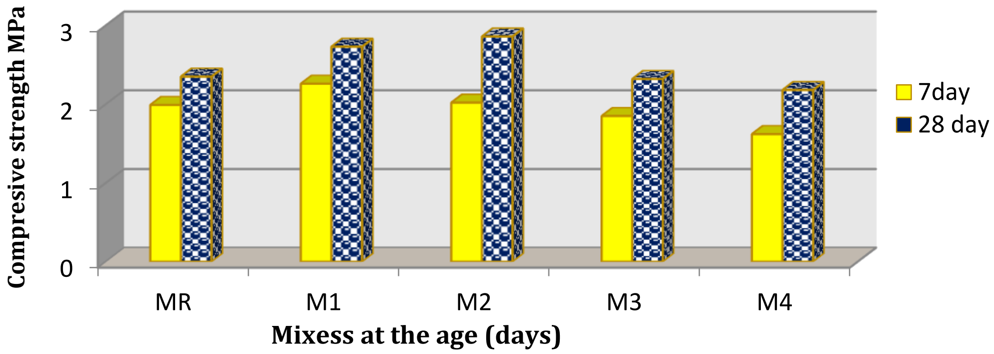

Figure 6. Compressive strength as a function of FC mixes at the ages

Mixes M3 and M4 contain fine sizes of replacement between (4.75-2.36), and (2.36-1.18) mm showing decreased compressive strength readings compared to (MR) mix because it contains the fine size of RFC due to increased specific surface area which can lead to higher water to cement ratio, thereby reducing the compressive strength. and the nature of the replacement is higher water absorption led to created voids compared with natural sand. Thus, reducing strength This condition occurs due to Recycled lightweight material may contain micro-cracks from previous use, which can act as stress concentration points and reduce the overall strength of the concrete **(Zhou and Wang, 2022).**

4.2.2 Flexural Strength

As shown in **Fig. 7,** Mixes M1, and M2 depict increased flexural strength which contains a coarse size of RFC comparison with MR, this is attributed to the presence of coarse size of lightweight RFC replacement by volume decreased the artificial pores in foam concrete mixes, decreased pores create a stronger mix the volume of the solid components increased than the paste of concrete which, it is effected for reduced amount water demand conducted to less amount of micro-pores in the paste, decreased artificial pores create a stronger mix that requires increased amounts of force to break the specimen provide to improve mechanical strength **(Obaid and Hilal, 2022)**

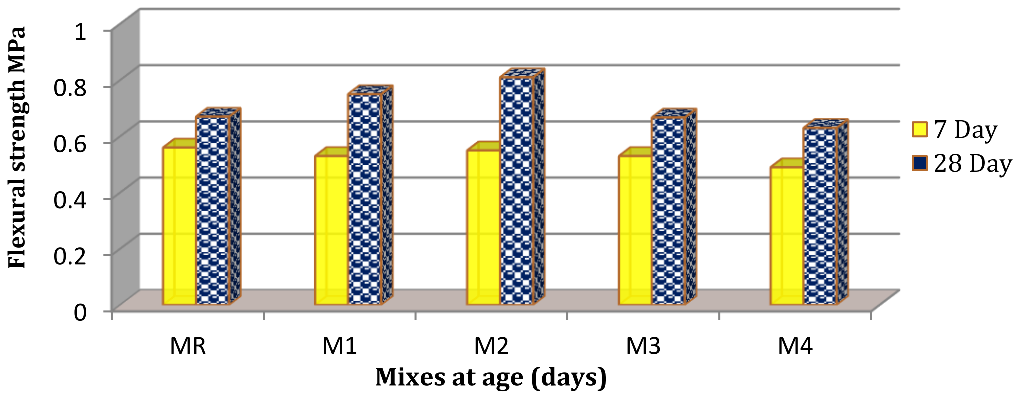

Figure 7. Flexural strength as a function of FC mixes at the ages

4.3 Water Absorption

The results in **Fig. 8** indicated that the Water absorption of mixes containing coarse and fine sizes of aggregate replacement by RFC waste led to an increase in absorption compared with fine sizes replacement and MR. This was caused by to nature of lightweight RFC absorbs far more water than natural sand, and replaced 50%by volume increasing the number of micro-pores, which tend to absorb far more water While decreasing with increased age at 90 days. This is due to the pozzolanic reaction occurring between the silicate oxides present in the natural sand and the calcium hydroxide. calcium silicate hydrate compounds (C-S-H) fill in the voids.

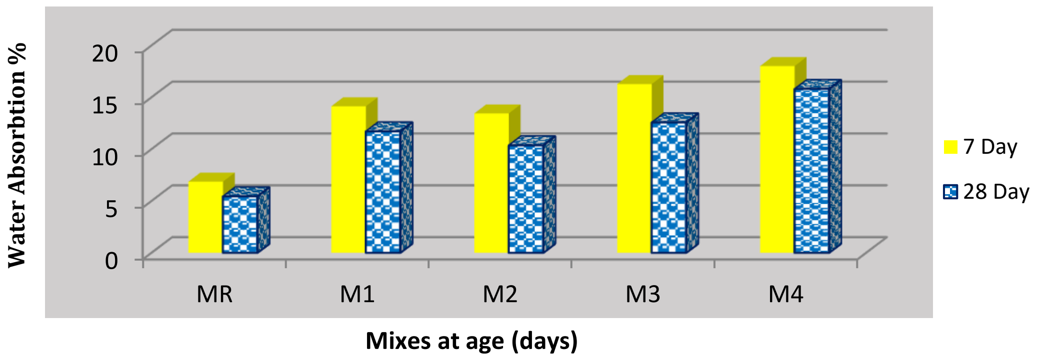

Figure. 8 Water absorption as a function of FC mixes at the ages

Fig. 8 depicts mixes M3 and M4 containing the fine size of crushed RFC between (4.75-2.36), and (2.36-1.18) mm respectively, increased water absorption compared to MR, M1, and M2. Using fine-sized RFC increasing the paste volume in the mix caused to increase in the number of micro-pores, which tend to absorb more water when submerged. It has been demonstrated that a higher paste volume results in increased water absorption. increases the surface area of fine size creates larger voids in the concrete, responsible for higher water absorption. **(Yurdakul et al., 2013).**

5. CONCLUSIONS

The Effect of using different sizes of Recycled foam concrete RFC as a partial replacement of natural sand by volume (Factory Waste Foam Concrete) on the same properties of lightweight-foamed concrete was discussed and the following**:**

1- The consistency values of FC mixture when use coarse sizes ingratiation level between (12.5-9.5), (9.5-4.75) mm by 2.12 %, increased While, decreased with use fine sizes between (4.75-2.36), (2.36-1.18) mm, by 2.12 % and 6.38 % respectively, compared with MR mix.

2- The investigation results reveal that the optimal size of recycled fine ceramic (RFC) aggregate for foam concrete in the M2 mix is within the range of 9.5–4.75 mm, replacing natural sand. This replacement significantly improved the mechanical properties of the concrete at 28 days of curing. Specifically, compressive strength increased by 21.7%, and flexural strength by 20.89% In comparison with the MR mix.

3- The water absorption value increased for all mixes containing coarse sizes of RFC ingratiation levels between (12.5-9.5), (9.5-4.75) mm, by (105.9 %, and 95.9 %) respectively and fine sizes between (4.75-2.36), (2.36-1.18) mm, by (137 %, 162.5%) respectively at 28 days compared to MR mix. While gradually decreasing over overtime at the age of 90 days of curing.

NOMENCLATURE

Symbol	Description	Symbol	Description
FC	Foam concrete	LWFC	Lightweight foam concrete
RFC	Recycle Foam concrete	OPC	Ordinary Portland Cement

Credit Authorship Contribution Statement

Baraa Zuhair : Writing – original draft, Validation, and Methodology. Mohammed Zuhear Abdul Ameer : Supervision and proofreading.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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نهج مبتكر لإنتاج الخرسانة الرغوية من خلال الاستفادة من الخرسانة الرغوية المعاد تدويرها كبديل مستدام

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الخلاصة

الخرسانة الرغوية، تتميز بخواصها الخفيفة وتعدد استخداماتها في البناء، هي مادة مسامية تُنتَج من الإسمنت والماء والركام الناعم والرغوة. تحتوي على العديد من الفراغات وتفتقر إلى الركام الخشن، مما يجعلها خفيفة الوزن ومنخفضة الكثافة. تم استخدامها على نطاق واسع في أسطح المباني، الجدران الفاصلة، وتطبيقات العزل.تستكشف هذه الدراسة نهجًا مبتكرًا لإنتاج الخرسانة الرغوية من خلال التحقيق في تأثير استخدام مخلفات الخرسانة الرغوية المُعاد تدويرها، والتي تم معالجتها إلى أحجام مختلفة من الركام الخفيف. تم الحفاظ على نسبة الماء إلى الإسمنت عند 0.45 ونسبة الأسمنت إلى الركام عند 1:1.3. تضمنت الدراسة استبدال 50٪ من حجم الركام بمخلفات مُعاد تدويرها من الخرسانة الرغوية، باستخدام أحجام ركام محددة وفقًا لأربع مستويات تدريجية بأحجام 9.5–12.5 ملم، 4.75–9.5 ملم، 2.36–4.75 ملم، و 1.18–2.36 ملم.

أظهرت النتائج أن الحجم الأمثل للاستخدام كان 4.75–9.5 ملم، مما عزز قوة الضغط وقوة الشد، بينما زاد من امتصاص الماء عند 28 يومًا مقارنةً بمزيج الخرسانة الرغوية التقليدية. تهدف الدراسة إلى تقليل استهلاك الموارد الطبيعية من الركام وتقليل نفايات البناء. ومن خلال برنامج تجريبي شامل يشمل توصيف المواد واختبار الأداء الميكانيكي، من المتوقع أن تقدم النتائج مساهمات قيمة في ممارسات البناء المستدامة.

الكلمات المفتاحية: الخرسانة الرغوية، اعادة تدوير الخرسانة الرغوية، الخرسانة الخفيفة الوزن.