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Studying Sustainable Concrete Block Efficiency Production: A Review

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ABSTRACT

Worldwide, enormous amounts of waste cause major environmental issues, including scrap tires and plastic, and large waste, a consequence of the demolition of buildings, including crushed concrete, crushed clay bricks, and crushed thermo-stone. From that point, it's possible to consider that the recycling processes for these materials and using them in the manufacturing field will reduce the adverse effects on the environment of these wastes and the consumption of natural resources. Sustainable concrete blocks can be considered as one of the products produced by using these materials as partial volume replacement of the coarse, fine aggregate, or cement content, considering their dry density, workability, absorption, compressive strength, and thermal conductivity tests evaluate their performance- and conformity with specifications. The results of tests on samples of sustainable concrete blocks showed the feasibility of using demolished building waste as aggregates instead of natural materials for their production.

Keywords: Waste clay bricks, Demolished building wastes, Recycled concrete, Recycled aggregate, Sustainable block.

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دراسة كفاءة إنتاج البلوك الخرساني المستدام:مراجعة

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الخلاصة

على الصـــعيد العالمي، هناك مشـــاكل بيئية خطيرة ، بســـبب الكميات الهائلة من النفايات ، والتي تشـــمل الإطارات الخردة ، والبلاســتيك ، بالإضـــافة إلى كميات كبيرة من النفايات ، نتيجة هدم المباني ، والتي تشــمل الخرســـانة المســحوقة ، والطابوق المســحوق ، و الحجر الحراري المكســر. من هذه النقطة ، يمكن اعتبار أن عمليات إعادة التدوير لهذه المواد واســتخدامها في مجال التصـنيع سـتقلل من الآثار السـلبية على البيئة لهذه النفايات بالإضـافة إلى تقليل اسـتهلاك الموارد الطبيعية. يمكن اعتبار الكتل الخرسـانية المسـتدامة أحد المنتجات التي يتم إنتاجها باسـتخدام هذه المواد كبديل جزئي من حجم الركام الخشـن اوالناعم أو محتوى الأسمنت ، مع الأخذ في الاعتبار التأثير المحتمل لها على الخصـائص الفيزيائية والميكانيكية للكتل الخرسـانية. تسـتخدم فحوص الكثافة الجافة وقابلية التشـغيل والامتصـاص وقوة الانضـغاط والتوصـيل الحراري لتقييم أدائها ومطابقتها للمواصـفات. أظهرت نتائج الاختبارات على عينات من الكتل الخرســـانية المســـتدامة جدوى اســـتخدام نفايات المباني المهدمة كركام بدلاً من المواد الطبيعية لإنتاجها.

الكلمات المفتاحية: مخلفات الطابوق الطيني، مخلفات البناء المهدمة، الخرســـانة المعاد تدويرها، الركام المعاد تدويره، الكتل الخرسانية المستدامة.

1. INTRODUCTION

The pollution of the environment and energy waste are receiving more attention these days **(Li et al., 2020)**. The investigation for ways to reduce waste and CO_2 emissions in the building supply chain has gained attention in recent decades. Large quantities of natural resources are required to manufacture cement and aggregate concrete **(Soares and Tavares, 2022).** The construction industry accounts for 39% of yearly worldwide CO_2 emissions, with building materials accounting for 11%. Concrete production is expected to be 12 billion tons annually, making it the second most consumed commodity globally. As a result, the concrete industry requires enormous amounts of natural resources, posing considerable environmental issues. The contemporary linear economy and worldwide population increase are accountable for outpouring trash into the environment. To alleviate this burden, the European Commission set a goal of reducing 90% of emissions from the construction industry by 2050 **(European Commission, 2019)** and promoting resource efficiency and circular economy models. This will imply the reformulation of several building materials and products, where conventional materials could be replaced by reused or recycled ones, with economic, technical, and environmental benefits, also in line with the goals for sustainable development set by the United Nations. Indeed, the use of wastes as secondary construction materials can channel by-products back into the value chain **(Bonoli et al., 2021).** This can reduce waste, landfill disposal, and the exploitation of primary resources while providing cleaner manufacturing pathways and increasing market competitiveness. Several by-products from various sectors now discarded as trash have been the subject of study on reuse prospects in concretes in this context **(Naran et al., 2022)**.

On the other hand, the construction sector is having difficulty owing to a lack of building supplies. Utilizing plastic waste in diverse applications, such as concrete aggregate, is essential since plastic trash's low recycling rate greatly contributes to environmental degradation. **(Alqahtani et al., 2017).** The production of plastic for industrial usage began in the 1920s, and since then, the world has consumed an enormous amount of plastic. According to some estimations, 299 million tons of plastic were manufactured globally in 2013. The frequent burial of plastic trash endangers the ecology. Consequently, several researchers have concentrated on incorporating plastic waste into concrete for various reasons. **(Babafemi et al., 2018)**. Exploiting plastic waste is a partial answer to environmental challenges. Using plastic waste in construction components may reduce concrete costs and environmental pollution.

Non-direct advantages include lower landfill trash costs and energy savings. Various research has been conducted on the mechanical characteristics of concrete using polyethylene terephthalate (PET) bottles. It has been shown that using plastic may reduce the weight of conventional concrete by (2–6) % and the compressive strength by 33%. **(Mohammed and Hammadi, 2018)**. The compressive strength and unit weight were measured after 30 days in a study that investigated the addition of plastic as a partial component of the coarse aggregate in concrete for the design of ecological concrete blocks and to establish a linear equation to estimate compressive strength for those blocks, varying cement, sand, gravel, and plastic volume. The results demonstrated that for the mixing ratio 1:1:1, the unit weight decreased by (36 and 45.43) % for the sections of plastic that were (25 and 50) %, respectively, and the compressive strength decreased by (27.99 and 41) % for those portions **(Velazco et al., 2021).**

This study investigates whether it is feasible to recycle construction and demolition debris into concrete blocks for use in building construction instead of throwing it away or utilizing it for less important purposes like fixing potholes or backfilling foundations. These recycled aggregate concrete blocks must fulfill the (local) construction material norms and criteria for load-bearing capability.

2. WASTE MATERIAL CONCRETE

Incorporating waste as aggregate for concrete has been demonstrated to be a suitable option for mitigating the effects of the building sector. Over the last several years, the technical community has been examining the impact of utilizing recycled aggregates from structural parts on concrete, but little has been investigated concerning the effect of using masonry as aggregates for concrete **(Soares and Tavares, 2022).** Fly ash is used instead of some of the cement while creating hollow concrete blocks. In addition, various waste materials, including plastic, glass, and chopped wood, are substituted between 0 and 5 mm with polyester fibers. A non-load-bearing stone wall was built using hollow blocks made of unconventional concrete (**Hanuseac et al., 2021)**.

2.1 Using Demolished Waste Materials in Concrete Block Units

The building sector contributes to 39% of the annual global CO_2 released, of which 11% is embodied in building materials. This would need the reformulation of various construction materials and products, in which conventional materials might be substituted by reused or recycled materials, with economic, technological, and environmental benefits, in line with the United Nations Sustainable Development Goals. Using trash as secondary building materials might reintroduce byproducts into the value chain. Innovations in solid waste management and product development have resulted in novel concrete mixes, blocks, tiles, aggregates, and binders. When comparing solutions that differ in terms of materials, methods, components, or applications, life cycle assessment (LCA) can demonstrate environmental benefits.

Nonetheless, studies are scarce focusing on mapping LCA research in specific building industry subjects with a comprehensive understanding. During the construction, demolition, and brick manufacturing operations, enormous volumes of waste clay bricks are generated. Because these contaminants are discharged, they cause a slew of environmental problems **(Salam and Khalil, 2022**).

Several studies have examined the functional performance and possible environmental benefits of using recycled aggregates (RA) to replace natural aggregates in new concrete mixes made from construction and demolition waste (CDW). The difficulty in comparing the results of life cycle assessment (LCA) studies was also identified due to different approaches taken by other authors, namely regarding the system boundaries, functional units, allocation procedures (i.e., if avoided landfilling is considered, physical or economic allocation), transport distances between RA and concrete producers, and including (or not) the carbon absorption in the concrete life cycle or its end-of-life stage. Some concrete hollow block qualities, like thermal resistance and thermal conductivity, may be positively impacted by the recycled materials. (Pavlu et al., 2019). Concrete produced with CBA has a compressive strength between 21 and 31 MPa at 28 days, which indicates that the substitution rate is under 50%. However, When CBA in concrete is replaced, the compressive strength may decrease by more than 50% **(Li et al., 2021)**.

The process of Demolishing Waste Materials (DWM) can affect the properties of concrete block units by:

A- Mix preparation and replacement ratio in DWM.

The possibility of working using the DWM as a partial replacement for the concrete containing cement has been displayed by previous research. **Table 1** shows some of these research's mixed preparation and replacement ratios.

Table 1. Mix preparation and replacement ratio of DWM.

Reference	Replacement ratio %	Remark
(Zena and Abbood, 2021)	– Nano powder brick with 0, 5, and 10% has been used as an alternative for cement weight. – Sand from the river with bricks as an alternative to 10, 20, and 30% weight of cement.	The mixed proportion was approximately 1 (cement): 2.1 (river sand): 3 (crushed gravel) by weight.

(Keshavarz and Mostofinejad, 2019)	Porcelain tiles and red ceramic are used With percentages of 25%, 50%, 75%, and 100%, an alternative by volume of coarse aggregate weight.	The weight of mixing for The cubic meter was: Cement (400 kg/m^3), Water to cement ratio (0.54), Water (216 kg/m^3), Fine aggregate (802 kg/m^3).
(Hussen, 2016)	– Crushed concrete coarse aggregate was used instead of natural coarse aggregate in increments of 10, 20, 30, and 50% (by weight). – Fine aggregate was substituted with crushed concrete sand at 10, 20, 30, and 50% (by weight). – The natural coarse aggregate was replaced with crushed (concrete and bricks) coarse aggregate in increments of 10, 20, 30, and 50% (by weight). – Fine aggregate was substituted with crushed (concrete and bricks) sand in proportions of 10, 20, 30, and 50% (by weight). – Fine aggregate and coarse aggregate were substituted with crushed concrete aggregate in proportions of 10, 20, 30, and 50% (by weight). – Fine and coarse aggregate were substituted with crushed (concrete and brick) aggregate in proportions of 10, 20, 30, and 50%, respectively.	The control mix had 1 (cement): 2 (sand): 3 (coarse aggregate) by weight and didn't contain either crushed concrete or crushed bricks.
(Hussein, 2021)	– The replacement percentages for coarse cellular concrete aggregates were 35, 50, and 75%. – The silica fume was added to three mixes, including coarse cellular concrete aggregates at a constant replacement value of 6% by weight of cement.	The control mix had a mixed percentage of (1: 1.5: 3: 0.45) by weight. It had been prepared using ordinary aggregate and no silica fume (0% SF).

B- Compressive Strength of Concrete and Concrete Masonry Unit Block

The most important block of concrete mechanical property is its compressive strength. This may be significantly enhanced by using reused components. A minimum compressive strength of 7 MPa is required for load-bearing wall blocks. **(Neville, 2011)**. The concrete's compressive strengths, including the 20% crushed brick aggregate, were roughly 10.19% lower than the reference mix's compressive strength at 28 days but somewhat higher than the objective strength of 38.75 MPa. Although the compressive strength of concrete with 30% crushed brick aggregate reduced across all ages, reaching 26.73% in 150 days. Compressive strength was increased at all ages with the 5% and 10% inclusion quantities of powder made of Nano-bricks combined with Nano Brick Powder. The mixture with a 10% substitution of Nano Brick Powder (NBP) exhibited the greatest growth of up to 26.15% after 150 days. **(Abdullah et al., 2022).** To conduct a compressive strength test, they employed Perlite, control polyethylene, rubber, and other hollow concrete blocks available. Findings from this investigation on hollow concrete blocks are shown in **Table 2** and **Fig. 1 (Al-Tamimi et al., 2020).**

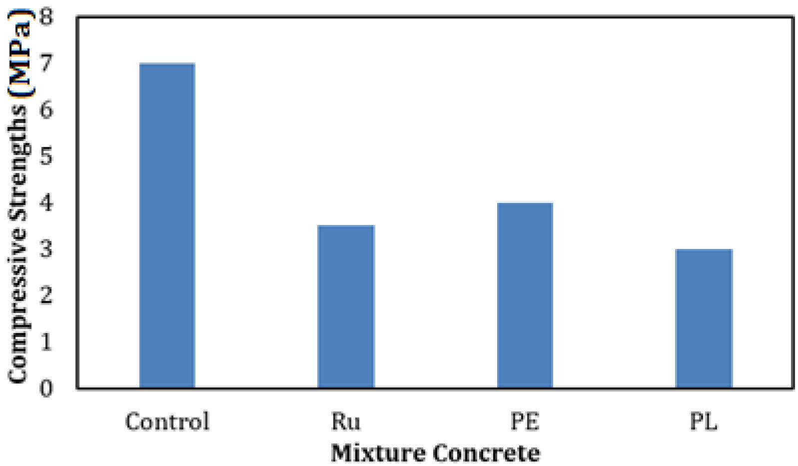

Figure 1. Compressive strengths (MPa) of concrete masonry hollow blocks **(Al-Tamimi et al., 2020)**

Table 2. Compressive Strength for the concrete hollow blocks **(Al-Tamimi et al., 2020).**

Mix Concrete	Hollow Block Strength (MPa)	Observation of Failure of Blocks
Control	6.91	Longitudinal cracks
Pl-HP (perlite Hollow Block)	3.52	Longitudinal cracks
Ru-HB (Rubber Hollow Block)	3.65	High flexibility Absorbed load
PE-HB (polyethylene Hollow Block)	3.85	Medium flexibility Small cracks

Due to the porcelain's hardness, concrete made with coarse aggregate employing it has compression strength greater than 41% that of control concrete made with standard aggregate. **(Keshavarz and Mostofinejad, 2019).** Furthermore, as shown in **Table 3 and Fig. 2,** the concrete with 25% and 50% Recycled Masonry Aggregate (RMA) had an average strength decrease of 10.35% at 7 days of age, while the concrete with 75% RMA had a strength reduction of 35.4% and the concrete with 100% RMA had a strength reduction of 50.5%. Analyzing the compressive strength development reveals that the difference in strength between concrete with 25% RMA was decreased to 2.8%, concrete with 50% RMA stayed constant over time, and concrete with 75% and 100% RMA revealed an average loss of 37.3% **(Soares and Tavares, 2022).** Hollow concrete blocks (8 x 8 x 8 in) and (16 x 8 x 8 in) had compressive or crushing strength rates of 28 kg/cm^2 and 35kg/cm^2, respectively. Brick units separately of dimension (22 x 11 x 8 cm) have a compressive or crushing strength rate of 113.33 kg/cm^2 **(Ahmad et al., 2014).**

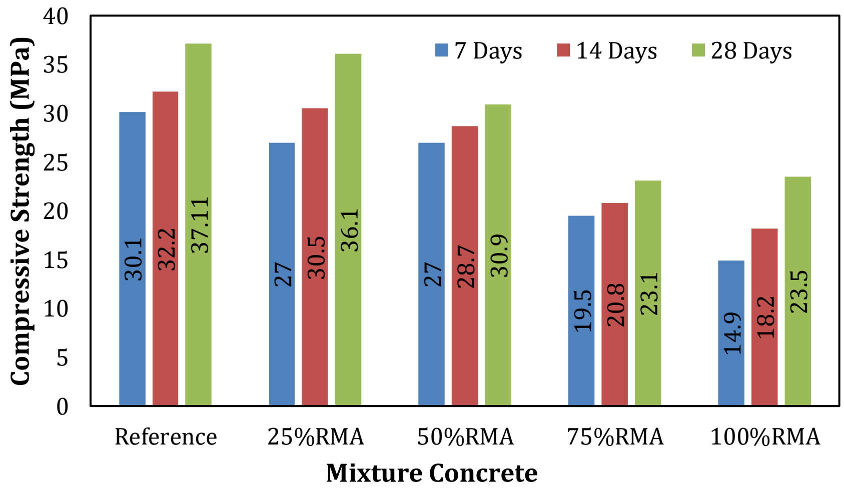

Figure 2. Compressive strength (MPa) of concretes produced **(Soares and Tavares, 2022)**

Table 3. Compressive strength (f_{cm}) reduction as a function of replacement content **(Soares and Tavares, 2022)**

Concrete	f_{cm} (%) 7 days	f_{cm} (%) 14 days	f_{cm} (%) 28 days
25%RMA	10.3	5.3	2.8
50%RMA	10.4	11.0	16.6
75%RMA	35.4	35.5	37.8
100%RMA	50.5	43.6	36.8

C. Modulus of Rupture of Concrete and Concrete Masonry Unit Block

The Modulus of Rupture decreased as the crush stone aggregate (CSA) to tile chip aggregate (TCA) replacement ratio increased. The maximum strength reduction of the Modulus of Rupture was determined to be 39% for the mix with a 100% aggregate replacement ratio. The Modulus of Rupture decreases by 5% when 25% CSA is replaced with TCA **(Mohan et**

al., 2018). The kind and dose of waste affected flexural strength. Flexural strength decreased when type 0-4 mm aggregates were substituted compared to the control mix, including polyester fibers raising When the proportion of replacement in ceramic is raised, the Modulus of Rupture increases by 65% over the reference concrete. It will rise to 100% after the replacement is complete. This rise in the Modulus of Rupture was caused by a higher fraction of ceramic substitution in the concrete mixture **(Keshavarz and Mostofinejad, 2019)**. With an increase in CBP, flexural strength declines. Clay Brick Powder (CBP) replacements of over 20% are considered in these analyses, and tiny amounts of CBP might not significantly affect the concrete's flexural strength. The variations widened, with losses ranging from 6% to 11% after 90 cure days **(Letelier et al., 2018)**. Flexural strength values rise by (13%) of (30% IF+10%) BP above the control mix value before falling with the increasing mix. With increasing [optimization of iron filings + (5, 10, and 15%) of brick powder] percentages up to (30% IF+10% BP), flexural strength increases (iron filings and brick powder) **(Rasool et al., 2020)**.

D. Dry Density of Concrete and Concrete Masonry Unit Block

The greater the concentration of RCA in concrete, the reduced the Recycled Concrete Aggregate (RCA) density. The reduced specific gravity and attached old mortar on Recycled Concrete Aggregate (RCA) contribute to the decreased density of RCA-containing concrete. Concrete densities incorporate varied amounts of coarse Recycled Concrete Aggregate (RCA) **(Verian et al., 2018)**. Because the specific weight of waste ceramics tile is low, the density decreases as the amount of replacement increases. As a consequence of the lower density of the masonry blocks, the dead load of the building will be reduced **(Ravindra et al., 2015)**. Nanomaterials impact the characteristics of limestone dust used in green concrete by raising the dry density as the fraction of nanomaterials from Al_2O_3 increases. The reference mixture's dry density comprises a quantity of silica sand powder and plastic. Waste clay brick powders (WBP's) reduce specific weight and density to minimize the density of the final product utilized. As a result, it will minimize the origin's dead loads, which is a positive consequence **(Abbas and Abbas, 2022)**. Dry density decreased by approximately 1.73, 3.31, and 4.61%, respectively, when 10%, 20%, and 30% of CBA were substituted for the reference mix. Due to the coarse brick aggregate's reduced specific weight and dry-rodded density compared to natural coarse aggregate, the reduction may be explained **(Abdullah et al., 2022)**.

2.2 Using Plastic Waste Materials in Concrete Block Units

Every year, massive amounts of plastic are manufactured all around the world. The inappropriate disposal of plastic waste causes serious environmental and health issues **(Lokeshwari et al., 2019).** Thousands of dolphins, whales, marine animals, and sea turtles die from ingesting plastic bags tossed into the water each year. The practice of throwing plastic waste pollutes the ecosystem on land and water, with plastic bags decomposing over 1000 years **(Raghatate, 2012).** Plastic manufacture and consumption are increasing drastically as time passes and research occurs. However, since plastic trash does not break down, it presents environmental problems. The use of coarse plastic aggregates in place of natural aggregates is done to reduce consumption because natural aggregates naturally

decompose in the soil, creating environmental issues. Researchers have searched for substitutes for aggregates and cement for the past 50 years **(Tayyab et al., 2018)**. Recycling discarded plastic is costly since it does not dissolve rapidly and requires a long break, resulting in serious environmental pollution concerns. As a result, the landfilling of plastic garbage should be prevented. In the 1990s, research on the effects of various types and sizes on the properties of concrete began, with studies focusing on using polyethylene as coarse aggregate or fine aggregate in concrete **(Abdelmoti and Mustafa, 2019)**.
Plastic is widely produced all around the globe. Plastic is thought to degrade over a thousand years. Inadequate plastic waste management poses several natural world and Medical dangers **(Lokeshwari et al., 2019).** Plastic manufacturing and consumption are increasing drastically as time passes and progress occurs. Nonetheless, since plastic garbage does not decompose, it poses environmental issues when discarded. This implies that it does not break down naturally in the soil, producing ecological matters. Hence, aggregates made of grainy plastic are employed as a replacement for organic aggregates to minimize waste. For the last 50 years, scientists have attempted to identify alternate materials for aggregates and cement **(Tayyab et al., 2018)**.

A. Mix Preparation of Concrete and Concrete Masonry Unit Block

The possibility of working by using the PWM as a substitution in part for the coarse aggregate used in concrete has been displayed by previous research. **Table 4.** presents some of these research mixes preparation and replacement ratios.

Table 4. An overview of earlier research that used plastic aggregate in the concrete mixture.

Refer.	Substitute ratio %	Remark
(Abdelmoti and Mustafa, 2019)	– Reference mix (M1) – 0%. – Plastic pellets recycled from sand (M2) - 5%. – Plastic pellets recycled from sand (M3) = 10%.	– The mixture proportions were 1:1.87:3.05 and (W/C) 0.47 – The sand was partly replaced with PP plastic pellets to create two different mixes, each comprising (5% and 10%) by volume of plastic pellets.
(Jaivignesh and Sofi, 2017)	Substitution of fine aggregate with (10, 15, and 20%) plastic waste and substitution of coarse aggregate with (15, 20, and 25%) plastic waste	– The mixture proportions were 1:1.79:2.92 and (W/C) 0.45
(Arivalagan, 2020)	-S1 serves as the reference mix, - S2, S3, and S4 use e-plastic instead of coarse aggregate (10, 20, and 30 %, respectively).	- 390 kg/m^3 of cement. - 675 kg/m^3 of fine aggregate - S2, S3, and S4 have e-plastic contents of 30, 55, and 35 kg/m^3 for coarse aggregate content (S1=1150, S2, 1050, S3, and S4 = 650 kg/m^3), respectively.

(Jibrael and Peter, 2016)	-Waste plastic (polyethylene) recycled from the sand was employed in percentages of 1%, 3%, and 5%.	-The proportion of the concrete mixture was 1:1.67:2.5 with a w/c ratio of 0.46

B. Compressive Strength of Concrete and Concrete Masonry Unit Block

Concrete blocks' capacity to resist compression is the most essential mechanical attribute, which may be considerably increased by adding recycled material. Load-bearing wall blocks must have a compressive strength of at least 7 MPa **(Neville, 2011).** The compressive strength decreased by (27.7%, 47.7%, 71.9%, and 81.0%) with a rise in plastic content for varying percentage substitution (0-20%) from both fine and coarse aggregates **(Lokeshwari et al., 2019).** Comparing the compressive strength of the control type with the findings of three different types of hollow concrete blocks (perlite, control polyethylene, and rubber blocks), the outcomes are displayed in **Table 5 and Fig. 3**, indicating that all four kinds of mixes passed the **(ASTM C129-17, 2017)** requirement of 3.45 MPa **(Al-Tamimi et al., 2020)**.

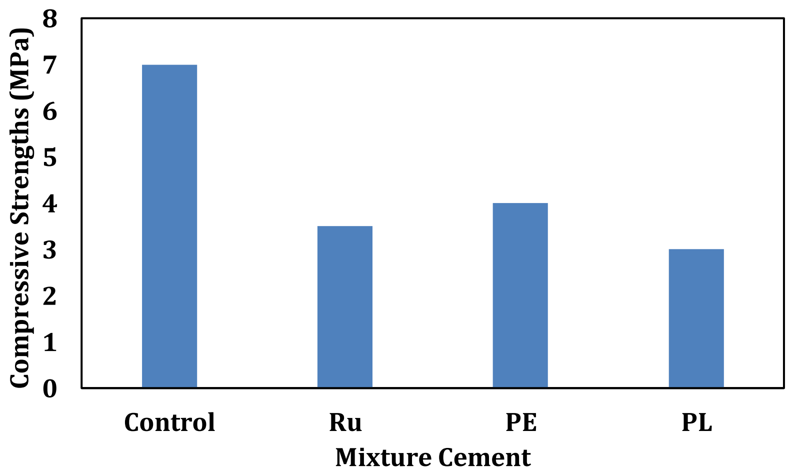

Figure 3. Compressive strengths (MPa) of hollow concrete masonry blocks **(Al-Tamimi et al., 2020).**

Table 5. The hollow concrete bricks' compressive strength **(Al-Tamimi et al., 2020)**.

Mix concrete	Hollow Block Strength's (MPa) (individual units)	Observation of Failure of Blocks
Control	6.91	Longitudinal cracks
Pl-HP. (perlite Hollow Block)	3.52	Longitudinal cracks
Ru-HB (Rubber Hollow Block)	3.65	High flexibility. Absorbed load
PE-HB (polyethylene Hollow Block)	3.85	Medium flexibility. Small cracks

When polyethylene terephthalate (PET) content was increased, the compression strength of the mixtures at the curing stage of 7, 28, and 56 days dropped. In contrast, the compressive strength values of the standard concrete mix made for comparison were 30.6, 35.6, and 35.9 MPa, respectively. After 28 days, compressive strength decreased slightly from 10 and 20 % substitute ratios and significantly from 40 and 50 % to 31 and 60 %, respectively. At a 30% substitute ratio, the stresses were 18.5, 24.6, and 24.7 MPa on days 7, 28, and 56. **(Almeshal et al., 2020)**. The presence of waste plastic aggregate in concrete decreased its compressive strength. The decrease ranges from 9% to 17% **(Jaivignesh and Sofi, 2017)**. Compression, splitting, and Modulus of Rupture all decreased with the proportion of plastic replaced raised **(Qasim et al., 2021a)**. The compressive strength declines with increasing replacement ratios of plastic waste (15, 25, and 45%) of the volume of coarse aggregate, as indicated in Table 6. The drop in compressive strength was caused by a weakening in the bonding strength between the plastic surface and the cement paste, which failed in the zone of the interfacial transition and reduced plastic aggregate strength **(Khalil and Mahdi, 2020)**.

Table 6. Percentage decrease of Compressive, Tensile, and Flexural strengths of plastic concrete **(Khalil and Mahdi, 2020).**

Age and mix symbol	Decrease of Compressive strength %		Decrease of Tensile strength %		Decrease of Flexural strength %	
Age (days)	7	28	7	28	7	28
B (15%)	18.18	29.14	38.23	18.1	22.58	15.29
C (25%)	24.80	33.80	58.82	51.38	40.32	22.35
D (45%)	40.79	49.51	78.43	70.83	64.51	31.76

C. Modulus of Rupture of Concrete and Concrete Masonry Unit Block

The kind and amount of waste impacted the Modulate of Rupture of the concrete. In comparison to the control mixture, the Modulate of Rupture of the concrete decreased when the aggregate between 0-4 mm was replaced with recycled aggregate, and the Modulate of Rupture of the concrete rose by 10% when polyester fibers were added **(Hanuseac et al., 2021)**. The Modulate of rupture for environmentally friendly concrete decreases as the proportion of plastic aggregate content rises (15.3, 22.4, 31.8 %) for concrete with 15, 25, and 45% coarse plastic aggregate, correspondingly. The poor bonding strength between the cement paste and the plastic surface, which results in that decline, leads to the failure at the interfacial transition zone and the low strength of the plastic aggregate. **(Khalil and Mahdi, 2020)**. The results for substitution and addition demonstrate an improvement in flexural strength. The cumulative increases for replacing and adding Nano glass powder are shown in **Fig. 4**. The chart illustrates that 7.5% substitute and 5% mix addition provide the best replacement outcomes **(Abbas et al., 2021)**. Flexural strength improved by (11.1, 11.16, and 11.6%) and (17.78, 19.86, and 18.64%) after replacing the cement with silica sand by 5% and 10%, respectively, at 7, 28, and 90 days **(Qasim et al., 2021b).** The Modulus of Rupture of concrete constructed of RCA will be 11% lower than that of NC. Utilizing recycled concrete aggregate (RCA) will reduce the modulus of rupture of concrete, particularly if the concrete mix includes recovered aggregate **(Verian et al., 2018)**.

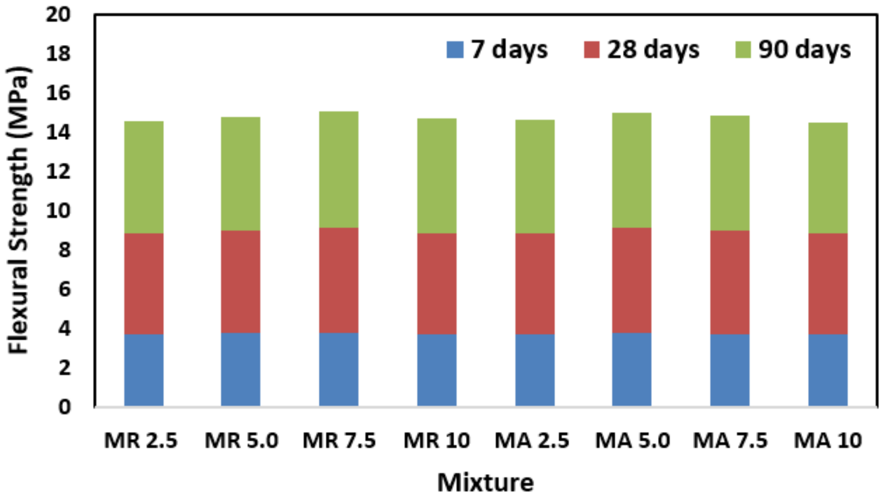

Figure 4. The enhancement in flexural strength by substituting and adding glass powder **(Abbas et al., 2021)**.

D. Dry density of concrete and concrete masonry unit block

The specific gravity of the blended components and the concrete's compactness work together to establish the density of the material. The fresh and dry densities are expected to decrease proportionately to the replacement amount since waste-recovered plastics typically have a lower density than organic aggregates **(Babafemi et al., 2018).** The concrete specimens that were substituted aggregate with waste plastic had a lower unit weight. This is because a coarse aggregate's density is higher than plastic's density. An average of three samples was obtained for each substituted specimen to ensure accuracy. Also, other studies reported similar findings. **Table 7** displays the unit weights of the various specimens **(Lokeshwari et al., 2019)**. The results revealed that the weight of the 7-day samples decreased slightly as the plastic percentage increased; nonetheless, at both 5% (M2, which replaced the sand with plastic pellets 5%) and 10% (M3, which replaced the sand with plastic pellets with 10%), the concrete still contains a significant quantity of water, It contributes to some of the total volumes. Density falls for M2 and M3 after 28 days compared to the control. As the percentage rises, the density decreases due to the considerable variations between the PP plastic pellets and the sand. In general, the density of all mixtures increases with age, which may be ascribed to the reduction of voids as hydration progresses (**Abdelmoti and Mustafa, 2019)**.

Table 7. Dry densities of control mix concrete and plastic-added concrete

Replacement Unit Weight %	**Density (kg/m^3)**
0	2440
5	2263
10	2024
15	1940
20	1770

The results show that the dry density of the environmentally friendly samples was less than that of the control concrete by a proportion of (3.3, 6.7, and 17.5%) for concrete containing (15, 25, and 45%) plastic coarse aggregate, correspondingly **(Khalil and Mahdi, 2020).**

3. CONCLUSIONS

The environmental advantage of utilizing trash as a resource as aggregate replacements in concrete hollow blocks is a reduction in current solid waste and a reduction in organic materials typically used as aggregates. Additionally, making concrete blocks that perform better than expected and adhere to norms is possible because different types of rubbish have unique qualities. The consideration of alternative wastes may lead to the following conclusions :

A. The demolished building waste usage:

(1) Regarding aggregate, recovered concrete, broken brick, discarded ceramic and tile, and plastic waste all partially replace trash in concrete blocks. They may be utilized in significant numbers (50-100%) due to their strength, great hardness, and chemical inertness. As a result, they are some of the most often recovered resources used in concrete blocks, which might reduce the need for organic aggregate in the concrete block industry. However, due to the specific characteristics of each waste, most waste may be valorized to make various types of value-added concrete blocks even at low replacement levels.

(2) The greatest mechanical attribute of concrete blocks is compressive strength, which may be considerably improved by employing wastes with an acceptable proportion of tiny particles, such as organic aggregate replacement, ceramic and tile waste, and concrete slurry waste. Combining these wastes (fine ceramic tile waste) with fly ash might provide promising effects.

(3) Concrete blocks in partition walls may increase their high-temperature resistance using broken bricks and concrete slurry waste, a value-added application.

(4) Plastic waste may be utilized in pavement applications to improve them by improving compressive strength. Concrete paver blocks can withstand abrasion, skid, and freeze-thaw conditions .

(5) A natural aggregate can be used as a comparison for the characteristics of several of these materials. Natural aggregate is superior to waste concrete aggregate in water absorption, apparent density, and crushing index. This is because there is a substantial amount of porosity in the waste concrete aggregate due to the high proportion of aged mortar. Broken ceramic tile and brick waste aggregate have lower water absorption capacity, apparent density, and crushing indexes than natural aggregate, which has a greater density, crushing index, and apparent density. Ceramic tile aggregate has a dense, smooth glazing without any general bibulousness .

Whatever method is utilized, increasing concrete density increases its compressive strength.

B. For Plastic waste usage:

(1) Using plastic waste in concrete reduces landfill costs and lowers environmental pollutants.

(2) As the amount of plastic replacement increases, so does the fresh density.

(3) The dry density was reduced by increasing the amount of plastic replacement.

(4) Increased plastic replacement lowered compressive, split, and flexural strength.

REFERENCES

Abbas T.F, Abbas Z.K., 2022. Production load–bearing concrete masonry units by using recycled waste crushed clay bricks; A Review. *Journal of Engineering,* 28(10), pp. 13-27, Doi: 10.31026/j.eng.2022.10.02.

Abbas Z.K., Abbood, A. A., Mahmood, R. S., 2022. Producing low-cost self-consolidation concrete using sustainable material. *Open Engineering*, 12(1), pp. 850-858. Doi: 10.1515/eng-2022-0368

Abbas, Z.K. and Abbood, A.A., 2021, February. The influence of incorporating recycled brick on concrete properties. In IOP Conference Series: Materials Science and Engineering, (Vol. 1067, No. 1, p. 012010). IOP Publishing. Doi:10.1088/1757-899X/1067/1/012010

Abbas Z.K., Mahdi H., Tayeh B., 2021. Producing sustainable concrete using nano recycled glass. *The Open Civil Engineering Journal*, 15(1), Doi: 10.2174/1874149502115010236

AbdelMoti H.M. and Mustafaa M.A., 2019. Use of Polypropylene Waste Plastic Pellets as Partial Replacement for Fine Aggregate in Concrete. *University of Khartoum Engineering Journal,* 9(1), Doi: 10.53332/kuej.v9i1.951

Abdullah, D.J., Abbas, Z.K. and Abed, S.K., 2022. Some properties of concrete containing waste brick as partial replacement of coarse aggregate and addition of nano brick powder. In IOP Conference Series: Earth and Environmental Science (Vol. 961, No. 1, p. 012093). IOP Publishing. Doi: 10.1088/1755-1315/961/1/012093

Ahmad R., Malik M.I., Jan M.U., Ahmad P., Seth H., Ahmad J., 2014. Brick masonry and hollow concrete block masonry–A comparative study. *International Journal of Civil and Structural Engineering Research (IJCSER),* 1(1), pp.14-21.

Almeshal I., Tayeh B.A., Alyousef R., Alabduljabbar H., Mohamed A.M., 2020. Eco-friendly concrete containing recycled plastic as partial replacement for sand. *Journal of Materials Research and Technology*, 9(3), pp. 4631-4643. Doi: 10.1016/j.jmrt.2020.02.090

Alqahtani F.K., Ghataora G., Khan M.I., Dirar S., 2017. Novel lightweight concrete containing manufactured plastic aggregate. *Construction and Building Materials*, 148, pp. 386-397. Doi: 10.1016/j.conbuildmat.2017.05.011

Al-Tamimi A.S., Omar S. Al-Amoudi B., Al-Osta M.A., Ali M.R., Ahmad A., 2020. Effect of insulation materials and cavity layout on heat transfer of concrete masonry hollow blocks. *Construction and Building Materials,* 254, pp.119300. Doi: 10.1016/j.conbuildmat.2020.119300

Arivalagan S., 2020. Experimental study on the properties of green concrete by replacement of e-plastic waste as aggregate*. Procedia Computer Science*, 172, pp. 985-990. Doi: 10.1016/j.procs.2020.05.145

Babafemi A.J., Babafemi A.J., Šavija B., Paul S.C., Anggraini V., 2018. Engineering properties of concrete with waste recycled plastic: A review. *Sustainability*, 10(11), p. 3875. Doi: 10.3390/su10113875

Bonoli A., Zanni S. Serrano-Bernardo F., 2021. Sustainability in building and construction within the framework of circular cities and European new green deal. The contribution of concrete recycling. *Sustainability,* 13(4), p. 2139. Doi: 10.3390/su13042139

Hanuseac, L., Barbuta, M., Bejan, L., Rosu, R. and Timu, A., 2021, February. Experimental study on hollow blocks with wastes. *In Proceedings*, 63(1), p. 79.MDPI. Doi: 10.3390/proceedings2020063079

Hussein W.A., 2021. Production of lightweight concrete by using polystyrene (cork) waste. Journal of Physics: Conference Series, IOP Publishing, Doi: 10.1088/1742-6596/1973/1/012128

Hussen S.S., 2016. Influence of incorporating construction building demolition as recycled aggregate on concrete behavior. *Engineering and Technology Journal,* 34(1) Part (A).

Jaivignesh, B. and Sofi, A., 2017, July. Study on mechanical properties of concrete using plastic waste as an aggregate. In IOP Conference Series: Earth and Environmental Science, (Vol. 80, No. 1, p. 012016). IOP Publishing. Doi:10.1088/1755-1315/80/1/012016

Jibrael, M.A., and Peter, F., 2016. Strength and Behavior of Concrete Contains Waste Plastic. *Journal of Ecosystem and Ecography*, 6(2), pp. 4–7, Doi: 10.4172/2157-7625.1000186

Keshavarz Z., and Mostofinejad D., 2019. Porcelain and red ceramic wastes used as replacements for coarse aggregate in concrete. *Construction and Building Materials*, 195, pp. 218-230, Doi: 10.1016/j.conbuildmat.2018.11.033

Khalil W. and H. Mahdi., 2020. Some properties of sustainable concrete with mixed plastic waste aggregate. IOP Conference Series: Materials Science and Engineering, IOP Publishing, Doi: 10.1088/1757-899X/737/1/012073

Letelier V., Ortega J.M., Muñoz P., Tarela E., Moriconi G., 2018. Influence of waste brick powder in the mechanical properties of recycled aggregate concrete. *Sustainability*, 10(4), p. 1037, Doi: 10.3390/su10041037

Li, J., Chen, Z., Chen, W. and Xu, Z., 2020, April. Seismic performance of pre-cast self-insulation shear walls made by a new type of foam concrete with high strength and low thermal conductivity. In *Structures*, (Vol. 24, pp. 124-136). Doi: 10.1016/j.istruc.2020.01.001

Li J., Xu Z., Chen W., Chen Z., 2021. Mechanical properties of a new type recycled aggregate concrete interlocking hollow block masonry. *Sustainability*, 13(2), p. 745, Doi:10.3390/su13020745

Lokeshwari M., Ostwal N., Nipun K. H., Saxena P., Pranay P., 2019. Utilization of waste plastic as partial replacement of fine and coarse aggregates in concrete blocks. *International Research Journal of Engineering and Technology,* 6(9), pp. 378-382 .

Mohammed, A.M., and Hammadi, A.A., 2018. Effect of adding the plastic waste as fibers on mechanical properties of concrete. *Journal of Engineering and Sustainable Development*, 22(2), pp. 86-95. Doi:10.31272/jeasd.2018.2.85

Mohan, A., Thomas, J. and Joseph, N., 2018, August. Use of clay Tile Chips as Coarse Aggregate in Concrete. In IOP Conference Series: Materials Science and Engineering (Vol. 396, No. 1, p. 012002). IOP Publishing. Doi: 10.1088/1757-899X/396/1/012002

Naran, J.M., Gonzalez, R.E.G., Del Rey Castillo, E., Toma, C.L., Almesfer, N., van Vreden, P. and Saggi, O., 2022. Incorporating waste to develop environmentally-friendly concrete mixes. *Construction and Building Materials,* 314, p.125599. Doi: 10.1016/j.conbuildmat.2021.125599

Neville, A., 2011. Properties of Concrete, Fifth and Final Edition, Longman Group Ltd, United Kingdom.

Pavlu T., Fortova K., Divis J., and Hajek P., 2019. The utilization of recycled masonry aggregate and recycled EPS for concrete blocks for mortarless masonry. *Materials*, 12(12). P. 1923, Doi: 10.3390/ma12121923

Raghatate Atul M., 2012. Use of plastic in a concrete to improve its properties. *International Journal of advanced engineering research and studies,* 1(3), pp. 109-111.

Rasool D.A., Abdulkarem M.A., Abdulrehman M.A., 2020. The effect of adding recycled waste on the mechanical properties of concrete. Defect and Diffusion Forum, *Trans Tech Publ*, Doi: 10.4028/www.scientific.net/DDF.398.83

Ravindra R., Kumar BG A., Santhosh N., 2015. Behavior of Concrete Masonry Blocks with Ceramic Waste. *Recent Trends Civ. Eng. Technol,* 5, pp. 35-40 ,

Salam N. and Khalil W.I., 2022. The Effect of Scrap Tires Recycled Steel Fibers on Some Hardened Properties of Green SCC. *Engineering and Technology Journal*, 40(5), pp. 810-818, Doi: 10.30684/etj.2022.132605.1133

Soares A.C.M., and Tavares M.E.d.N., 2022. Concretes with Recycled Masonry Aggregates. Available at SSRN 4252430

Standard Specification for Nonloadbearing Concrete Masonry Units, ASTM C129-17, A., 2017.

Tayyab S., Ullah A., Shah K., Mehmood F., Gul A., 2018. Influence of reduced water cement ratio on behaviour of concrete having plastic aggregate. *Civil Engineering Journal,* 4(12, pp. 2971-2977, Doi: 10.28991/cej-03091213

Velazco D.J.M., Pirela, M.C.P., Eduardo, M.R.R., and Montero, S.A.O., 2021. Concrete masonry blocks with scrap HDPE as aggregate. *Technical Journal of the Faculty of Engineering,* University of Zula, Vol. 44. N°1, January - April 2021, pp. 04 – 58 ,

Verian K.P., Ashraf W., Cao Y., 2018. Properties of recycled concrete aggregate and their influence in new concrete production. *Resources, Conservation and Recycling*, 133, pp. 30-49, Doi: 10.1016/j.resconrec.2018.02.005