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Eco-Friendly Roller Compacted Concrete: A Review

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ABSTRACT

Sustainable evolution is vital to address miscellaneous issues, and experts are currently exploring the possibilities of Eco-Friendly concrete (Green concrete). This type of concrete involves using environmentally and economically viable substances that can act as entire or partial replacements for conventional materials. By doing so, it can assist in reducing the consumption of natural resources and energy, as well as minimize pollution. For example, several researchers have performed on incorporating sustainable approaches in roller compacted concrete RCC by replacing certain substances with eco-friendly alternatives. That is a favorable step toward devising more sustainable construction practices. Therefore, this study resorted to reapplying recycled plastic garbage (sustainable plastic) to construct environmentally eco-friendly concrete (green concrete). First, examine the possibility of using plastic as a partial substitute for fine-aggregates in RCC mixtures. Second, examination of the possibility of using plastic as a partial substitute for coarse-aggregates in RCC mixtures to enhance the performance of RCC. In early periods, a suitable RCC mix was designed in the lab to test the concrete strength, freezing-thawing, permeability, durability, erosion, and porosity of set concrete. The findings confirmed that RCC can maintain the same properties as traditional concrete using the known mixtures. Trial tests were designed and organized to evaluate the quality of pouring and compaction operations, suitable mix composition, and void specimens to accomplish testing on the constructed RCC. It has shown that RCC with prime ingredients and proper ratios can be performed with similar strength and durability as conventional concrete. However, RCC differs from ordinary concrete pavements. This technology provides a favorable economical alternative for many branches of civil engineering installations.

Keywords: Roller-Compacted Concrete (RCC), Eco-Friendly concrete, Recycled plastic, Concrete

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الخرسانة المرصوصة بالحدل الصديقة للبيئة: مراجعة

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الخلاصة

التنمية المستدامة ضرورية للتغلب على العديد من المشاكل لذلك يبحث العلماء عن خرسانة صديقة للبيئة (الخرسانة الخضراء) تشتمل على مواد بيئية واقتصادية لها خصائص ويمكن استخدامها كبدائل كاملة او جزئية للمواد الطبيعية. تتميز الخرسانة الخضراء القادرة على البناء المستدام بتطبيق المخلفات الصناعية لتقليل استهلاك الموارد الطبيعية والطاقة وتلوث البيئة لذلك حاول عدد من الباحثين غرس الممارسات المستدامة في خلائط RCC عن طريق استبدال المواد وهو ما يجعل الخرسانة أكثر صداقة للبيئة. لذلك لجأت هذه الدراسة الى اعادة استخدام النفايات البلاستيكية المعاد تدويرها (البلاستك المستدام) لأنتاج خرسانة صديقة للبيئة (الخرسانة الخضراء) عن طريق: (اولا) استخدام البلاستك كبديل جزئي للركام الناعم في خليط RCC (ثانيا) فحص امكانية استخدام البلاستك كبديل جزئي للركام الخشن في مخاليط RCC لتحسين اداء RCC . في وقت سابق تم التخطيط لوصفة مناسبة لخليط RCC في المختبر لأختبار خصائص القوة، مقاومة الانجماد والذوبان نفاذية الماء، التآكل وخصائص الفراغ الهوائي للخرسانة الصلبة. اثبتت النتائج التي تم الحصول عليها ان الخرسانة RCC لها نفس الخصائص (الجودة) مثل الخرسانة التقليدية باستخدام الخلائط المتاحة , تم تخطيط وتنظيم قسم اختبار تجريبي من اجل تقييم جودة عمليات التنسيب والضغط من اجل ضبط تركيبة الخليط بشكل دقيق وتحمل العينات الاساسية لاجراء الاختبار على RCC ولقد اثبت ان RCC مع المكونات الاساسية والوصفة المناسبة (نسب الخليط) يمكن صنعها بنفس القوة والمتانة مثل الخرسانة التقليدية ولكن على عكس الارصفة التقليدية , توفر هذه التقنية بديلا اقتصاديا مناسبا لانواع عديدة من منشات الهندسة المدنية .

الكلمات المفتاحية: الخرسانة المضغوطة بالأسطوانة، خرسانة صديقة للبيئة (الخرسانة الخضراء)، النفايات البلاستيكية المعاد تدويرها، خرسانة

1. INTRODUCTION

Green concrete represents a form of eco-friendly concrete produced using waste substances from various industries to substitute part of the content **(Ahmed et al., 2022)**. Green concrete needs low energy for production and minimizes cement content in the mix, which leads to lowering pollutants. Also, the new type of concrete would be inexpensive and more durable because it pollutes little carbon dioxide into the atmosphere **(Tarrad and Abbas, 2023).** The objective of this research was to investigate the use of plastic as a partial substitution for natural aggregates in Roller Compacted Concrete Pavement (RCCP), reducing the use of nonrenewable resources has been the primary focus of efforts to integrate sustainability into the roadway business in recent years **(Shamran and Abbas, 2024)**. A more sustainable pavement could be achieved by optimal mix design, innovative paving processes, and a decrease in the demand for virgin materials. You can use recycled materials as an alternative to virgin ones, or even all of them **(Shamran and Abbas, 2023)**. RCCP used in paving roads is widespread in numerous states worldwide **(Abed et al., 2023)**. The heavy steel drum rollers are the cause of calling this type of concrete roller-compacted concrete **(ACI 327, 2015)**. They work to compact the concrete into its final form, making it a durable and long-lasting option for various construction projects. It has several benefits. However, its procedure differs from the method of traditional cement concrete pavement **(Khan and Abbas, 2021).** The RCC contains equal components to conventional concrete. However, it has a more increased proportion of sand, which makes it rigid and steady beneath compaction. It also has adequate water to spread the paste without segregation **(Abbas, 2022).** RCCP can be performed without skeletons, dowels, or rebar steel **(Gáspár and Bencze, 2020).** The carriage carrying the instrument of RCCP is quite various from the traditional concrete pavements; the hydration grade mostly controls the intensity boosting in traditional concrete pavements, while it relies on both the grade of compaction and hydration technique in RCCP **(ACI PRC-309.5, 2022)**. A mixture of various rollers is utilized to arrive at the entire compaction in the field, prime pressure by fixed drum, then by vibratory-pneumatic drums and last access by fixed drum to clear the roller imprints. Several techniques are adopted to affect a similar compaction degree brought in the laboratory. **Table 1** shows that the most standard ones to manufacture RCCP samples in the lab are a vibrating table VT, vibrating hammer VH, modified proctor MP, and gyratory compactor GC compared with the field specimens FS **(Selvam and Singh, 2023). Table 2** The behavior of RCCP upon manufacturing with various compaction mechanisms determines the multiple advantageous laboratory compaction processes that could affect the in-site situations **(Selvam and Singh, 2023).** The main variations between RCCP mixtures and conventional concrete pavement mixtures are as follows: RCCP mixtures usually lack air entrainment, have descending water content, descending cement paste content, and require a bigger amount of fine aggregate to produce a blended aggregate that is well-graded and stable under the action of a vibratory roller **(Sarsam et al., 2013). Table 3** explains some previous studies of RCC.

Table 1. Mechanical Properties of RCCP at Different Compaction Efforts **(Selvam and Singh, 2023).**

Compaction Technique	Testing age	FS	VH	MP	VT	GC
Compressive Strength (MPa)	7-days	30 (1.5)	36 (1.5)	23 (2.1)	22 (3.5)	16 (0.5)
	28-days	40 (3.3)	47 (1.6)	39 (1.8)	35 (2.2)	33 (2.9)
Flexural Strength (MPa)	7-days	3.8 (0.24)	3.6 (0.23)	3.1 (0.26)	3.7 (0.26)	-
	28-days	4.6 (0.17)	4.7 (0.33)	4.2 (0.15)	4.5 (0.3)	-
Indirect Tensile Strength (MPa)	28-days	3 (0.23)	3.3 (0.58)	2.9 (0.65)	2.6 (0.15)	2.4 (0.13)
Elastic Modulus (GPa)	28-days	35.44 (1.70)	39.14 (3.31)	37.32 (2.30)	32.19 (1.28)	24.29 (2.33)

Table 2. Consistency and attrition coefficients for various compaction works **(Selvam and Singh, 2023).**

Compaction Technique	Cohesion (MPa)	Coefficient of friction
FS	5.48	1.69
VH	6.23	1.75
MP	5.32	1.70
VT	4.77	1.70
GC	4.45	1.72

RCC has been used since 1975, and 342 projects have been finished. Since 2000, 13.9 million square yards of SY have been used in 271 projects **(Zollinger, 2016). Figs. 1** and **2** show the history of RCC.

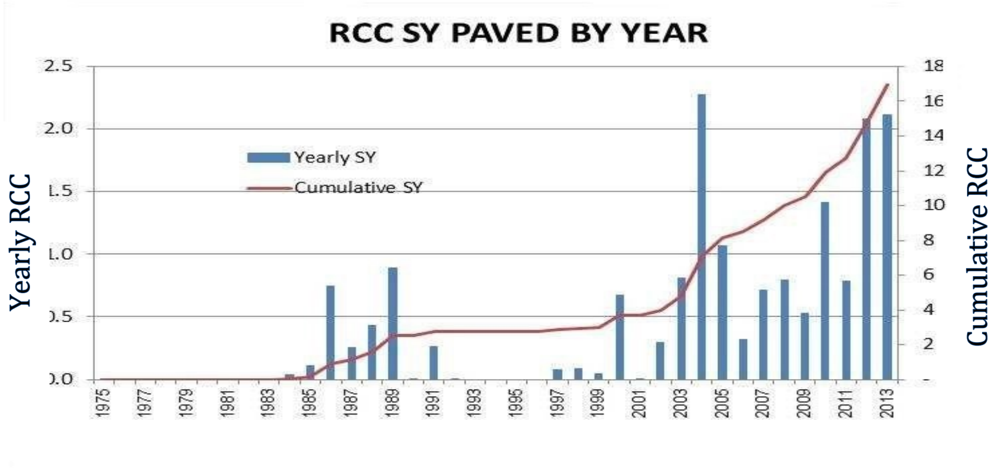


Figure 1. Summary of RCC Projects in the United States **(Zollinger, 2016).**

Figure 2. Improvements in RCC paving structure **(Harrington et al., 2010).**

Operating plastic in concrete is a sustainable explanation from economic, social, and environmental standpoints (notice **Fig. 3**)**(Tarrad and Abbas, 2023).**

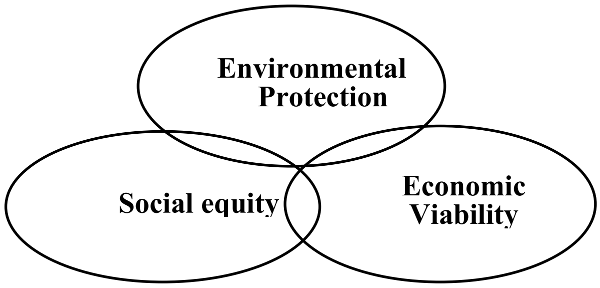


Figure 3. Three globes of sustainable growth **(Tarrad and Abbas, 2023).**

Table 3. RCC literature review summary.

NO.	Author	Study	Conclusion
1	**(Abbas, 2022)**	examined the effects of using recycled (brick, thermos stone, granite, and ceramic) powders as fillers on the mechanical Properties of RCC.	The mechanical properties of the RCC have improved.
2	**(Khan and Abbas, 2021)**	Study the durability of an RCC convenient for road paving using specified percentages of silica sand powder (SSP) as a partial replacement by weight of sulfate-resisting cement.	As the exposure time increases, the deterioration also increases, e.g., the fc decreased by 17.0% and 19.4% after 30 and 60 cycles (60 and 120) days in $MgSO_4$ solution. It was found that the cyclic wetting and drying exposure regimes exhibited the most severe deterioration effect, especially (cyclic W and D in MgSO4).
3	**(Khalid and Abbas, 2023)**	investigate the mechanical proprieties of RCC mixes appropriate for roadway paving with feasible prices and more suitable engineering properties by employing recycled concrete aggregate.	The partial replacement of natural aggregate (coarse or fine) with recycled aggregate has the best mechanical properties (compressive, tension, flexural strength) results.
4	**(Salih and Abed, 2016)**	The study examines how different curing methods, such as air curing, emulsified asphalt (flan coat) curing, 7-day water curing, and permanent water curing, affect the properties of RCC. Additionally, the use of porcelain, a regional material	Replacing 5% of fine aggregate with porcelain improves RCC compared to conventional methods. Air curing for RCC with 5% porcelain is compared to permanent conventional curing. It has an improvement by percentages for bulk density, compressive strength, flexural

		employed as an inner curing agency, with varying volumetric alternate portions of sand is also analyzed.	strength, porosity, absorption, and ultra-pulse velocity, respectively. The results of other percentages of porcelain replacement are lower than conventional and 5% replacement of RCC and decrease with increasing replacement percentage.
5	**(Tarrad and Abbas, 2023)**	The research aimed to create eco-friendly RCC by declining the cement range using waste materials from destroyed buildings such as clay bricks, marble tiles, and glass windows.	The results indicate that RCC mixtures containing these waste materials are a viable option for pavement construction.
6	**(Shamran and Abbas, 2024)**	The laboratory investigations are mainly focused on utilizing disposed scrap material from destroyed constructions and reducing the amount of fine aggregate. The most effective way of disposing of waste materials, such as ceramic tiles, clay bricks, and thermostone hollow blocks, without resorting to a sanitary landfill is to collect them.	According to the study, the use of RCC containing 20% ceramic tiles as fine aggregate improves the durability and strength after 28 days of testing compared to the R.M.On the other hand, the mixture containing 10% ceramic tiles as fine aggregate showed an improvement of up to 3.39%, 1.64%, and 1.42%. Although the clay bricks with 10% aggregate can be implemented, their results were a little down than the R.M but remain within the specification range. However, for the mixtures with 10 and 20% thermostone blocks fine aggregate, the results exhibited a drop in strength likened to the R.M.

2. MATERIALS AND METHODS

2.1. Characterization of Alternative Aggregates

The term eco-friendly concrete or green concrete guides the environmental notion in which garbage is used and thus reclaimed in its exhibition. The exhibition of green concrete is usually inexpensive because of the benefit of scrap as a fractional alternative to cement and aggregate **(Qasim et al., 2021).** The process of producing aggregate has notable environmental impacts **(Tarrad and Abbas, 2023)**. The primary concern is air pollution caused by emissions from mining operations, both from stacks and disturbed areas. Additionally, the depletion of natural aggregate sources poses a threat to the environment and communities **(Ali et al., 2023a).** This depletion can lead to the loss of water retaining layers, bank slides, exposed water supply intake wells, and decreased water table levels, negatively affecting agriculture and aquatic life **(Abbas et al., 2023)**. The concrete initiative primarily contributes to air pollution and an exploiter of raw assets**(Ali et al., 2023b).** As such, it bears a particular responsibility to donate to sustainable development. It can do so by following three objectives. **(Rochman et al., 2013)** it explored aggregate exhibition technologies that are slightly power-intensive and generate less air pollution**(Jebur et al., 2023)**. Since such technologies will not be public in the foreseeable future, the more practical method is to decline the necessity for aggregate, mainly by increasing the use of extra aggregate fabrics, specifically waste fabrics. **(Saikia and De Brito, 2012)** replaced concrete ingredients with recycled materials **(Kamaruddin et al., 2017)** by carefully selecting concrete mix design and admixtures, structures can have increased durability and require less frequent replacement**(Dawood et al., 2023)**. Declining the portion of cement used in concrete blends is a good way to decrease decay and improve air quality due to the high carbon dioxide emissions created during the cement exhibition process. Additionally, recycling waste and using waste materials with high-fineness particle measurements can help lower structure costs and reduce the amount of cement content needed. This approach can also contribute towards achieving a clean and sustainable environment **(Abbas et al., 2022).** Concrete is a widely used construction material composed of sand, gravel, cement, and water due to the availability and low cost of its basic materials **(Yin et al., 2015).** Concrete is known for providing better fire resistance than other building materials**(Abbas et al., 2021).** However, it can have weaknesses and flaws if not correctly set**(Xing et al., 2023).** For example, micro-cracks can form under uniform focused loads, reducing concrete's tensile strength. To enhance the performance of concrete structures, closely spaced fibers can be presented to increase tensile and flexural strength. Normally, aggregate makes up (65-85%) of the mass concrete magnitude in a standard compound**(Abdullah et al., 2022)**. In addition, aggregate recreates an important function in concrete resilience results, and their slump matter can indicate compressive soundness, dimensional soundness, and durability. Consequently, substituting partisan aggregate utilization in concrete mixture practice will supply an option key to the further probable usage of plastic waste. Substitute gravel and sand **(Kamaruddin et al., 2017).** The values required to estimate the balances for the RCC test combinations are provided in **Table 4 (Lamond and Pielert, 2006).**

Table 4. Specific values for Estimating RCC Trial Mixture Balances **(Lamond and Pielert, 2006**).

Contents	Nominal Maximum Size of Aggregate					
	19.0 mm		50 mm		75 mm	
	middle	zone	middle	zone	middle	zone
wet content, kg/m3 a) Vebe < 30 sec b) Vebe > 30 sec	 149 133.5	 132-180.5 109-153.5	 121 118	 106-139 103-126	 106.5 100.5	 84-130 96.9-110
fine aggregate, % a)crushed aggregate b) rounded aggregate	 54.9 42.8	 48.5-58.9 37.4-44	 42.9 40.8	 33-50 35.5-44	 33.5 31.5	 28-34.9 28-33.5
Mortar content, % by magnitude a)crushed aggregate b)rounded aggregate	 69 54.9	 62-72.8 52.3-56	 54.5 50	 42-67.5 46-60	 44.9 42.6	 38-49 38-47
Paste: cannon %, Vp/Vm by magnitude	0.39	0.3-0.49	0.39	0.35-0.6	0.46	0.4-0.6

2.2 Characteristics of Hardened RCC

Specific material properties are important to consider when it comes to stiffened RCC. These Parcels of concrete that are generally calculated contain compressive strength, tensile and shear strength, elastic modulus, tensile strain capability, Poisson's percentage, volume difference, thermal, drying, and autogenous shrinkage, thermal coefficient of expansion, typical warmth, creep, permeability, and durability **(Khalid and Abbas, 2023)**. It's worth noting that the set properties of RCC and traditional concrete are fully alike, with any differences predominantly due to variations in combination with ratios, aggregate grading, and void range **(Tarrad and Abbas, 2023)**. Various RCC mixtures can be proportioned, equal to conventionally set concrete **(ACI 211.3R, 2002).** However, it's challenging to determine specific values for either case. Commonly, RCC has more down cement, paste, and moisture ranges and may have non-plastic fines to load aggregate openings. The physical properties of RCC are greatly affected by the aggregate's quality, grading, and physical properties. **(Lamond and Pielert, 2006).**

2.2.1 Compressive Strength

Compressive strength trials are executed during the setup degree to resolve the optimal combination of cementitious materials, water, and aggregate for RCC. The stability of RCC is influenced by elements such as the water-to-cementitious fabric proportion, rate, and grading of the aggregate, grade of compression, and curing. The grade of compression has a notable impact on the final compressive strength. Because of its arid texture, compression of RCC demands better action than traditional concrete. Without whole compression, improved gaps will arise within the concrete matrix, resulting in declined strength. Pauses in compression may also result in a drop in compressive strength **(Lamond and Pielert, 2006).** Finally, the review should be provided to the truth that most specifications receive 95.9–97.9 % of the highest density as shown in **Fig.4**. As an outcome, compressive strengths of RCC compressed at smaller than the highest density will stand decreased **(Khalid and Abbas, 2023).**

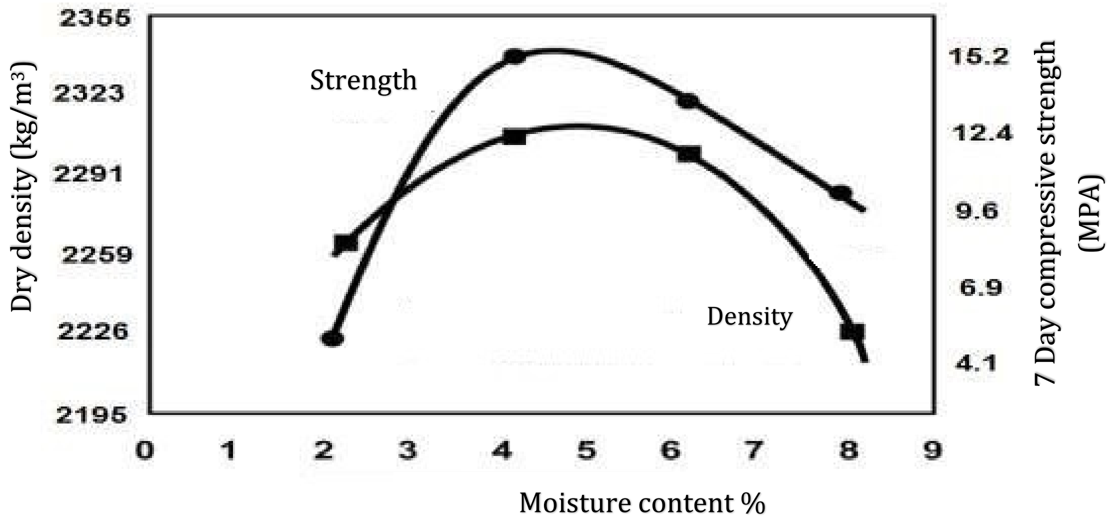


Figure 4. Relation between dry density, 7-day compressive strength, and moisture content of RCC**(Salih et al., 2014).**

2.2.2 Volume Change

When using roller-compact concrete RCC, two main changes in volume occur: drying shrinkage, which mainly affects pavements, and thermal addition and compacting in mass concrete. Drying shrinkage causes less volume change in RCC than traditional concrete because of its descending moisture range. This has resulted in fewer cracks and altered design reviews for RCC pavements. Thermal expansion in massive concrete structures is caused by the chemical reactions of the cementitious material and can lead to heat rise and potential for cracking. However, using less cementitious material in mass RCC construction can lower this potential for thermal cracking. **(Dazko and Constantiner, 2001).**

2.2.3 Permeability

The permeability of RCC relies on the holes in the compressed mass and the porosity of the artillery model. The mix proportioning, placement strategy, and compression capacity largely handle it. The permeability of stiffened RCC is similar to that of traditional concrete, although some studies suggest that it may be higher. The permeability of mass RCC typically ranges from 0.15 to 15, 109 cm. However, the permeability is down for upgraded cementitious blends used in RCCP **(Ouch et al., 2008).**

2.2.4 Durability

Corrosion Opposition Compressive strength and aggregate measure, grading, and grade largely control corrosion opposition. Corrosion examinations in examination flumes have denoted an ideal corrosion fight for RCC. **(ASTM 1138, 2019)** Test Approach for Abrasion fight of Concrete Submerged Approach has been used to estimate the routine of RCC for use as a streambank protector. The examination has shown that the abrasion opposition of RCC has grown with growing strength and greatest aggregate extent. Some analyses showed that aggregates donated better to abrasion resistance than cement range. Remarks of diverse assignments from heavy-duty pavements, such as archives category squares to RCC spillways, have even denoted ideal opposition to corrosion **(Ravindrarajah et al., 2003).**

2.2.5 Freezing and Thawing

Due to their dry consistency, RCC mixtures have not been observed for entraining air. In a study conducted by Piggott, 34 RCCP jobs in the America optical checked, with project ages ranging from 3 to 20 years. The study found that the commission of RCC was excellent. The gravel remains firmly embedded in the RCC matrix, and surface wear is the only noticeable issue. Texture wear commonly appeared within the sooner 1-2 years of benefit but remained stable after. RCC is similar to other non-air-entrained concrete consequences, like concrete pavers and precast concrete tubes, deriving its durability from increased power and lower permeability **(Lamond and Pielert, 2006).** In general, the capacity of a cementitious material to resist freeze-thaw cycles depends on several factors, such as its permeability, the distance between maximum paste and free surface, the amount of freezable water, and the degree of paste saturation RCC is expected that its freeze-thaw resistance will be better than or equal to that of conventional concrete due to its lower water content, higher density, and reduced factors of permeability, degree of paste saturation, and freezable water **(Algin and Gerginci, 2020).**

2.3 Mix Proportioning Strategies of RCC

Mix proportioning designs were used to choose the ideal ratios of soil compaction, moisture content, and dry density for the base layers of a pavement. This involved using a combination of aggregate gradations suitable for the base layers and preparing several concrete mixtures with varying cement and water content. The modified compaction method summarized in **(ASTM D1557, 2002)** was used to prepare the concrete mixtures. To determine the optimum water and cement content for each percentage of cement, the dry density-wet content arc was schemed per mixture, and the combination that resulted in the top dry density was chosen as the premier design combination. The work used 5 separate percentages of cement range (10%, 12%, 14%, 16%, and 18%) by poundage of air-dried aggregate per gradation kind (thick and opening) as shown in **Figs. 5 a** and **b**. To determine the dry density-moisture content relationships, different percentages of moisture content (ranging from 3.5-10.5% of the air-dried aggregate poundage with a 1% increment) were counted for each percentage of cement range. The specimens were compressed employing an altered proctor hammer and steel cylinder mold with a diameter of 9.5cm and a height of 11.6 cm to determine the top dry density. The combination was set in the cylinder mold in 3 coats and compacted with 56 blows of a modified proctor hammer (4500 gm falling from 450mm high) for each layer. Once the compaction was ended, the elongation collar was released, and the texture of the concrete was balanced with the mold **(Sarsam et al., 2014).**

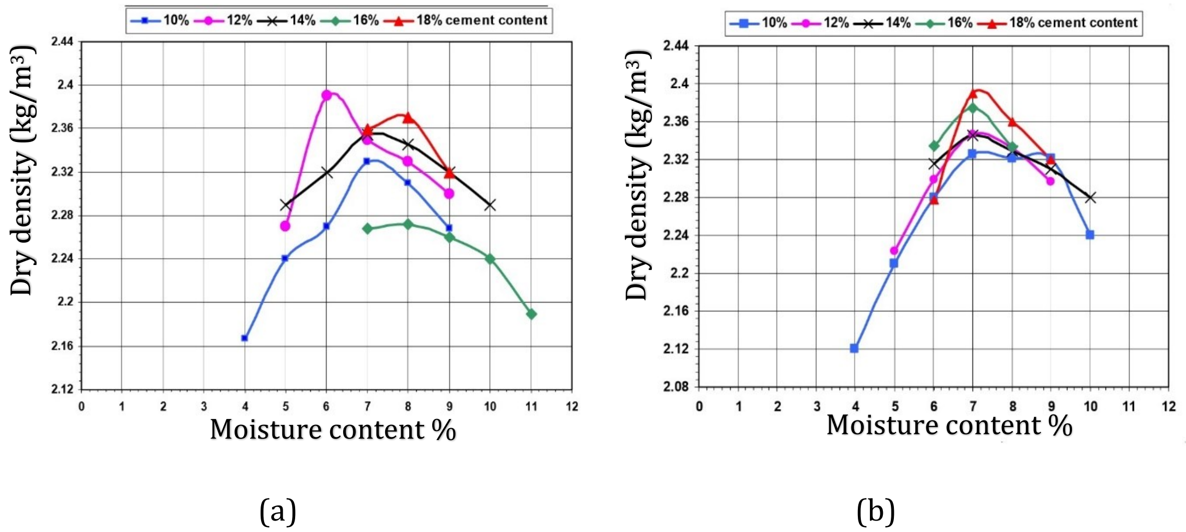


Figure 5. Dry density-moisture content connection of thick and opening-graded mixtures(a) thick graded (b) opening graded **(Sarsam et al., 2014).**

3. ASPECTS INFLUENCING RCCP INCLUDING ALTERNATIVE AGGREGATES

3.1 Sustainable Concrete Having Plastic Scraps

The globe is on the border of plastic trash hazards, which are increasing **(Hussain and Aljalawi, 2022)**. **Fig. 6** discusses the generation of international immediate plastics scrap from 1950 until 2015. Meeting this risk and the fortune of the land counts primarily on collective action and manners in the following years **(Rao and Ravula, 2018).**

The growth of concrete that includes plastic extras like aggregate is one of the considerable necessary analyses currently carrying location to help from plastic and its parcels in making fresh concrete **(Falih et al., 2020).** This concrete with adequate specifications alleviates the risk of plastic collection across the globe and keeps biological resources **(Qasim et al., 2021).** This garbage is revealed to the components of the atmosphere, such as mud, wetness, and air decay, and therefore guides the drought of raw aid **(Jaber et al., 2021)**. At the exact moment, the lack of accurate forms to accumulate, transfer, and process plastic garbage confused this issue. The cities of Iraq met the issue of collection of stable garbage in a huge, unexpected marvel **(Dawood and Adnan, 2019).**

The significant advantages of acquiring divested plastic by using it in concrete from the reference factor in sustainability spans are defined in the next topics: 1- Receding and maybe preventing the accretion of plastic garbage in character. 2- Maintaining the crude materials used in concrete and lowering its lack of structure functions. 3- Reusing plastic scrap in concrete is better than further recycling strategies in an elongated and perhaps last period **(Geyer et al., 2017).** Some previous studies of plastic waste are explained in **Table 5.**

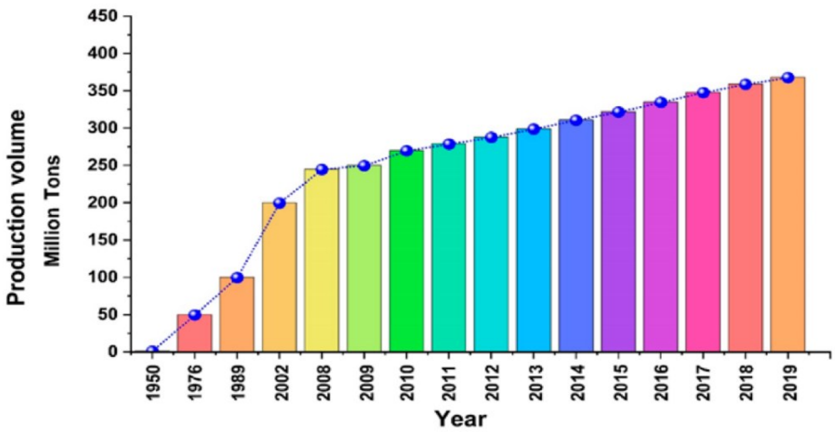


Figure 6. Generation of global plastic waste from 1950 to 2019 **(Khadke et al., 2021).**

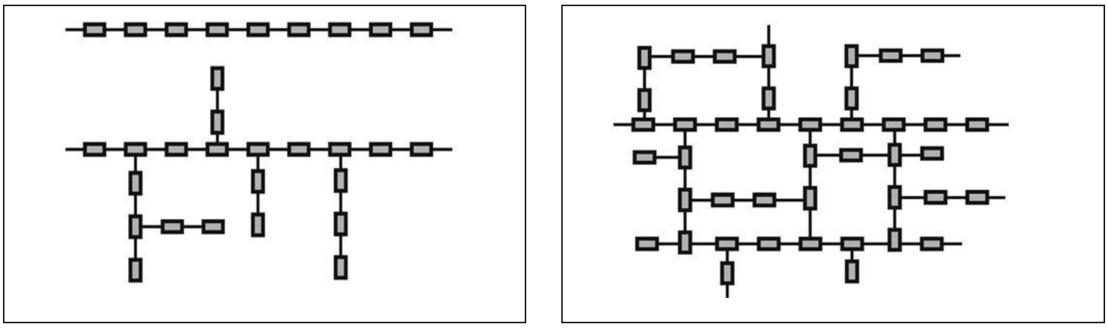
Table 5. Plastic waste literature review summary.

NO.	Author	Study	Conclusion
1	**(Qasim et al., 2021).**	Using plastic scrap as coarse aggregate in green concrete lowers carbon dioxide emissions by lowering cement consumption.	When plastic waste is used to substitute coarse aggregate, it results in a reduction of compressive, flexural, tensile strength, and dry density.
2	**(Radhi et al., 2022)**	The high-strength concrete employed a plastic coarse aggregate rather than coarse aggregate at varying ratios.	Achieving promising results while minimizing environmental impact.
3	**(Khalil et al., 2020)**	The study examined the impact of waste brick powder, crushed waste	At both 7 and 28 days, replacing a portion of the mixture with plastic increased void content

		brick aggregate, and plastic waste aggregate on the physical, mechanical, and microstructure possessions of concrete.	and water absorption while decreasing thermal conductivity. Additionally, dry shrinkage was lower in mixes containing plastic compared to R.M. at all ages.
4	**(Dawood and Adnan, 2022)**	This study investigates the feasibility of using PVC waste as a partisan substitute for sand in concrete mixtures. In this experiment, PVC replaces fine aggregate by weight.	A small reduction in the capacity of beams could enable the recycling of a significant amount of plastic waste
5	**(Falih et al., 2022)**	The impact of employing (PET) waste as a partisan alternative for fine aggregate on the structural manners of shafts was examined.	raising of PET ratio in the concrete beams guides to a growth in failure load, maximum deflection, ductility index, strain, and energy absorption likened to the reference beam
6	**(Adnan and Dawood, 2021)**	This study aimed to investigate the product of employing plastic scrap particles as a partisan alternative for fine aggregate on the mechanical properties of a concrete mixture.	Test results showed that the partial alternate by weight in the mixture improved the compressive strength.
7	**(Adnan and Dawood, 2020)**	Evaluate the mechanical properties of concrete reinforced with waste PET fibers.	During the testing of reinforced concrete beams, it was observed that there was a slight decrease in the ultimate failure load of the specimens and secant stiffness. However, there was a significant improvement in ductility behavior for all beams, especially in the hybrid beam.

3.2 Types of Plastic Wastes Recycled for Sustainable Concrete

Macromolecules called polymers consist of a recounted structural unit known as a monomer. Adhesives between these monomers form the polymer **(Maes et al., 2023)**. The term poly comes from the Greek phrase for many, while mers refers to parts. Polymers can be natural or artificial, with the latter form often referred to as plastic, which comes from the Greek word for fit with mold. Different types of plastic, known as polymers, can be categorized based on their manners towards temperature. There are two main categories: thermoplastic polymers **Fig. 7a** and thermoset polymers **Fig. 7b**. Thermoplastic polymers have a linear or branched figure, making them soft and able to be heated and cooled repeatedly. Examples include polyethylene terephthalate, polyvinyl chloride, polypropylene, polyethylene, and polystyrene. On the other hand, thermoset polymers have a tough grid design and do not moist when heated. They are known for their strength. Standards of thermoset polymers include polyester, epoxies, and phenolic. The molecular poundage and configuration, whether longitudinal, forked, or networked, plays a primary role in determining the properties and variety of plastic **(Awad et al., 2019).**



(a) (b)

Figure 7. Plastic layout (a) Thermoplastic longitudinal and forked layout (b) Thermosets web layout **(Huang et al., 2018).**

There are multiple varieties of plastic**(Mong et al., 2023).** The result of every class on the motorized and thematic parcels of concrete, or the essence of the most suitable usage of separate kinds, whether sand, gravel, or supporting fibers, is decided through examination and successive useful investigations. It is feasible to aid from the category of plastic species to create a view of their essential scientific effects and their result on the circumstances to select the most suitable option **(Arafat and Alam, 2018).**

The American Society for Testing and Materials ASTM has established the **(ASTM D4000, 2004),** including essential manuscripts from both ASTM and the International Organization for Standardization ISO focusing on plastic testing **(Aljalawi, 2023).** The manuscript outlines all the different types of plastic and the corresponding ASTM standards for each type **(Grigoriadis et al., 2023)**. With this system, users can accurately identify the type of plastic based on the available information and tabulate its various properties. **(Awad et al., 2019).** In the earlier periodic years, multiple examinations have concentrated on plastic implementation. Plurality industrial plastic developments and their environmental influence currently own regulation specifications created by the Society of the Plastic Industry and were presented consequence numbers of 1.0 to 7.0. **Table 6** outlines the classifications of plastic and its belongings according to the last writings.

Table 6. Classes of Plastic and Them Parcels **(Yadav, 2008; Reda, 2023)**

Category	ID No.	ID Name	Specific gravity (kg/m^3)	Strength of tension (MPa)	Modulus of Flexural (MPa)	Common Usage
Polyethylene Terephthalate	1.0	Pet	1300-1400	50-75	2400-3100	Water vial
Polyethylene With High Density	2.0	Hdpe	942-965	20-30	1000-1500	fruit store and games
Polyvinyl Chloride	3.0	Pvc	1300-1600	40-50	2100-3400	tube
Polyethylene With Low Density	4.0	Ldpe	920-930	8-30	250-350	depict
Polypropylene	5.0	Pp	900-910	30-40	1200-1700	seed utensils
Polystyrene	6.0	Ps	1000-1100	35-50	2600-3400	Compact disc
Other	7.0	-	-	-	-	Baby Feeding

Fig. 8 shows a diagram of the typical plastic recycling process to reduce plastic pollution **(Khadke et al., 2021).** Further fabrics can be counted into concrete to transform its engineering parcels **(Aziz et al., 2023).** Some of these additives have a positive influence on concrete belongings, while others may have a negative impact**(Reda et al., 2023)**. Additive materials like plastics exist combined with concrete elements to enhance their engineering effects **(Dawood et al., 2020).**

Figure 8. The typical stages involved in plastic recycling **(Khadke et al., 2021).**

3.3 Applying Curing Compounds

An earlier study identified and evaluated the curing compounds between 1996 and 1998. Based on the discoveries, changeovers were created to curing specifications so that a curing blend with heightened moisture retention factors is always applied. The second part of the investigation concentrates on how curing blends should be involved in pavement consistency to convey a constant scope of sufficient viscosity. A curing blend with adequate wetness and retention factors are of no use unless it is involved perfectly. In multiple issues, reviews of this strategy are restricted to calculating the cleared casks along the flank of the pavement to confirm that a satisfactory magnitude of curing blend has been set via the sprayer as shown in **Fig. 9**. Numerous characteristics, such as waft and muddy nozzles, will influence how greatly the treatment finishes on the pavement texture and the capacity to accept constant scope **(Vandebossche, 1999).** The curing blend shall fit all conditions according to **Table 7 (Keleş and Akpinar, 2022).** Given no bleed water in roller-compacted concretes and evaporation occurs immediately, which may result in surface deterioration through shrinkage cracking and shallow micro-cracks, proper curing is essential immediately after placement to prevent excessive evaporation from the pavement surface after final compaction. Various curing techniques, such as membranes, canvases, cotton mattresses, wet sand, sprinkler trucks, etc.**(American Concrete Institute, 1987).** The specimens are subjected to a different curing process. To cure the concrete specimens normally, they are saved in their molds for nearly 24 hours. Then, they are released from the molds and put in a curing tank filled with water until the time of testing (7 and 28 days) **(Al-Hubboubi and Abbas, 2017).**

Table 7. Requirements for curing compounds **(Vandebossche, 1999).**

Characteristics	minimal	maximal
some Solids, weight percent	0.42	_____
Reflectance percent 72 hrs.	0.65	_____
Water losing, kg/m^2 in 24 hrs. **(ASTM C156, 2002)**	_____	0.15
Water losing, kg/m^2 in 72 hrs. **(ASTM C156, 2002)**	______	0.40
Examine of Settling, ml/100 ml in 72 hrs.	______	2
Void optimum content, g/Letter	______	350
Infrared Spectrum, carriage	100% poly alpha methyl styrene	

To cure concrete, a mix contains either wax or resin **(Gawad and Fawzi, 2021)**. This compound is mixed with water or solvent and then involved in the pavement surface. As the water or solvent disappears, it leaves behind a wax or resin membrane on the pavement's surface. This membrane helps to keep moisture in the concrete. Another choice for curing concrete is to use a compound that contains emulsified linseed oil **(Fawzi and Agha, 2023).** This type of compound works by sealing the concrete's pores, which delays the evaporation rate. Also, the compound's adhesive allows stop damage generated by freezing-thawing cycles and deicing chemicals during the required duration of premature strength evolution. **Table 8** According to **(ASTM C309, 2019)** and **(AASHTO M 148, 2005)** Different sorts of fluid membrane-forming combinations are organized by their pigment and the sort of solid branch used to form the membrane **(Vandebossche, 1999)**.

Table 8. Curing blend categories **(Vandebossche, 1999).**

Pigment		SOLID Member	
kind	Characterization	ID	Characterization
1	pure or Translucent w/out Dye	A	No Restriction
1-D	pure or Translucent w/ Fugitive Dye	B	Resin
2	White Pigmented		

Figure 9. RCC Application of curing mixture **(McLeod and Laughlin, 2001).**

4. CONCLUSIONS

That study can provide a good technology to dispose of high contents of waste plastic and at the same time can reduce the effect of high sulfate content in Iraqi sand. In addition, the review explores the use of waste-demolished fabrics as a substitute for aggregate in roller-compacted concrete.

1- Employing plastic waste in the concrete leader to decrease landfill costs, Environmental corrosion, and the consumption of natural resources and energy to produce environmentally eco-friendly concrete green concrete
2- The capability to create sustainable RCC by using waste material (plastic) led to an improvement in mechanical strength (compressive, flexural, splitting tensile strength decreased by plastic waste as replacement volume of aggregate).
3- The economic and environmental benefits of substituting cement in roller compacted concrete mixture with waste materials could be significant depending on the final application.
4- The usage of plastic as a reserve has reached satisfactory and favorable results, mainly if taking into account the environmental advantages and effects where only 9% of plastics are recycled around the world. Therefore, needs to produce greener concrete eco-friendly concrete to reach near net-zero carbon emission.
5- The addition of hydrated lime in thick and opening RCC mixes can significantly decrease their porosity and absorption. A 5% lime concentration yields the lowest porosity and absorption rates. In comparison to the reference mix, the porosity of thick mixes decreases by approximately 13.85%, while opening mixes decrease by 23.7%. Absorption rates see a decrease of around 6.7% for thick RCC mixes and 24% for opening RCC mixes.
6- the results of compressive strength tests of RCC samples after 28 days of curing, can be observed that RCC mixtures get a compressive strength higher than the minimum limit required in ACI 327equal to (28 MPa) so that results approved the ability to produce RCC safely and without risk of compressive strength deterioration.
7- that RCCP could use different types of aggregate without losing strength. Also, using waste materials in RCCP could have several benefits, such as reducing greenhouse gas emissions and global warming, lowering the need for natural aggregates, preserving valuable land resources, lowering transportation costs, and delivering economic construction.

NONOMENCLATURE

Symbol	Description	Symbol	Description
A	area, m^2.	kg	Weight, Kilogram.
g	Weight, gram.	ml	Volume, mele-letter
hrs	time, hours	min	Time/minute

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Zena K. Abbas: Review & editing, Writing and Methodology.

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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