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A review on concrete recycling

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Abstract

Concrete is one the most used material in construction. Considering its capacity to harden upon water contact, solidification, and acquisition of full strength, concrete becomes capable of withstanding significant stress. Over the past century, concrete structures have gained immense popularity and found extensive application in diverse architectural project. This prominence places concrete at the forefront of contemporary design and high-performance structure construction, due to its inherent structural benefits. Consequently, concrete production has witnessed a surge, facilitated by on-site production methods and straightforward construction processes. However, this heightened production has led to a significant generation of concrete waste, reaching up to 80 percent of the original produced volume in some regions worldwide. Recognizing the environmental implications, the reduction of concrete waste through recycling has emerged as a sustainable approach. Extensive research has been conducted to explore methods such as concrete recycling and the incorporation of other waste construction materials into concrete, thereby investigating their effects on concrete properties. This comprehensive review delves into the various material mixtures employed and their implications on the application of recycled concrete.

Keywords: Concrete; Recycling; Waste glass; Sustainable construction materials; Environment management

1. Introduction

Environmental management and sustainable development compel all industries, including construction, to adopt proper methods for environmental protection. Extensive extraction of natural resources for building construction jeopardizes sustainability and sparks concerns from environmentalists (1), as construction by nature is not an environmental-friendly industry.. The building industry significantly contributes to global warming, prompting various suggested alternatives to mitigate its impact on the environment. However, comprehensive building development and redevelopment plans in different countries exacerbate construction-related issues, particularly with building demolition (2, 3).

Long-term plans need to be considered while trying to optimize the use of natural resources especially regarding construction recycling. The disposal hierarchy comprises six levels based on their varying environmental impact, which includes reduce, reuse, recycle, compost, incinerate, and landfill. From these methods reuse, recycle and reduction are collectively called the "3R" (4, -6). To effectively minimize construction waste generated on-site, it is crucial to foster comprehensive coordination among all parties involved in the design and construction processes. A sustainable construction process should form to (7, 8):

- Enhance customer satisfaction and improve overall quality of life.
- Provide flexibility and effectively address anticipated future user demands.
- Create and support desirable natural and social environments.

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- Optimize the efficient utilization of resources.

Probably the most idealistic mean to deal with the waste material is to prevent it from being created in the first place (9). Recycling, as one of the strategies for waste minimization, can offer three major benefits (10):

- Minimize the demand for new resources
- Lower transportation and production energy expenses
- Promote the reuse of waste materials that would otherwise end up in landfills

Construction and demolition waste including demolished concrete, bricks and masonry, wood, glass, insulation, roofing, wire, pipe, rock, and soil constitutes a significant component in the total waste (11). Concrete is one of the most widely used materials in construction due to its stability and exceptional strength in withstanding high levels of stress (12). One of the most important applications of concrete is Concrete-Filled Double Steel Tubular (CFDST) columns, which has revolutionized the construction industry by introducing a new level of structural integrity and safety. The steel fibers dispersed throughout the concrete matrix, enhances the material's ductility and crack resistance. This unique property allows CFDST to absorb energy and distribute loads more effectively, mitigating potential failure points and enhancing overall structural performance (13). Over the past century, concrete structures have gained significant popularity and have been employed in various types of construction projects. Nonetheless, the extensive use of concrete has resulted in the generation of a considerable amount of waste. In specific regions, this waste can account for up to 80 percent of the originally produced volume. To tackle this issue, methods such as concrete recycling and incorporating other waste construction materials into concrete have emerged as crucial approaches in recent decades (5-7, 12). In this review, we focus on examining different material mixtures and their impact on the application of recycled concrete. Our objective is to elucidate sustainable practices that minimize concrete waste and promote the effective utilization of recycled concrete in construction projects.

2. Literature Review of Concrete Recycling

In an article by Vivian W.Y. Tam in 2008 the concrete practice in Australia was compared to the suggested concrete recycling methods in terms of financial benefits (14). At that time the construction waste in Australia was dumped in landfills and new products were produced from the rocks and supplied to the site for new concrete production. The author evaluated the beneficial difference of the mentioned method with recycling method at each level. In terms of the financial benefits and costs, the concrete recycling method achieved a positive net benefit while the time practice method received a negative net benefit. The recycling method also caused less air pollution (about 16.5% of landfill space charge), noise pollution (about 17.7% of landfill space charge), gas emission (about 17.4% of landfill space charge), and energy consumption (about 23% of landfill space charge). The author reported that aggregate produced by the recycling methods was more economical in long-term than using natural materials. Although, one of the factors affecting the viability of aggregate recyclers was the availability of feed materials, which could limit the recycler ability to operate at or near capacity. It also could affect the quality and uniformity of the recycled products, which pose a risk to use of recycled materials in the industry. Natural material producers continue to supply bulk materials for buildings and road construction because they are able to supply sufficient high-quality materials for a wide variety of high-grade applications. However, it might be challenging for the recycler to maintain a predictable revenue stream because of uncertainty related to future feed availability and quality or market price fluctuations (14).

In another study by Vivian W.Y. Tam in 2009, the effectiveness of concrete recycling was compared between the Australian and Japanese construction industries, focusing on environmental considerations and the recycling process (15). The research findings indicated a high level of awareness about concrete recycling in both countries. The major benefits identified in implementing concrete recycling were reducing the need for new landfills and conserving natural materials. However, challenges were also identified, including the high cost of recycled products and limited applications for recycled concrete. To promote the use of recycled materials, it was suggested to define more detailed classifications, particularly for recycled aggregate. The assessment revealed different challenges in the transition to concrete recycling for each country. Australia faced difficulties with limited applications of recycled concrete, forming recycling teams, and preparing comprehensive plans. In Japan, challenges included high charges for sending concrete waste to recycling companies and difficulties in on-site placement of recycling machines. Poor quality of recyclable products was also found as one of the major difficulties in implementing concrete recycling in Australia, while Japan as a leading country in using recycled aggregate developed various concrete recycling technologies to improve the quality of recycled aggregate. Japan enacted clear standards and technical specifications for different grades of recycled concrete. Notably, the Australian concrete recycling practice lagged behind Japan's (15). Drawing from Japan's experience, recommendations for improving concrete recycling in Australia included:

- Developing a unified policy in concrete recycling
- Providing government financial support
- Establishing clear technical specifications and standards for using recycled aggregate in structural applications

In studies conducted by Shima et al in 1999 and 2000 (8, 16), authors developed a technology to produce high-quality aggregate from demolished concrete using a 'heating and rubbing method' (HRM). In HRM aggregate can be recycled as raw material for ready-mixed concrete, while fine powder (HRM powder) from cement paste will be recycled as raw material for cement, cement admixture, or soil stabilizer. This technology can be fully implemented in concrete recycling. Even though the production of recycled aggregate using the HRM requires considerable fuel for heating and electricity for rubbing, the life-cycle analysis showed that the implementation of the HRM would be able to decrease the CO2 emissions through the utilization of the HRM powder as cement-related inputs **(Figure. 1)**.

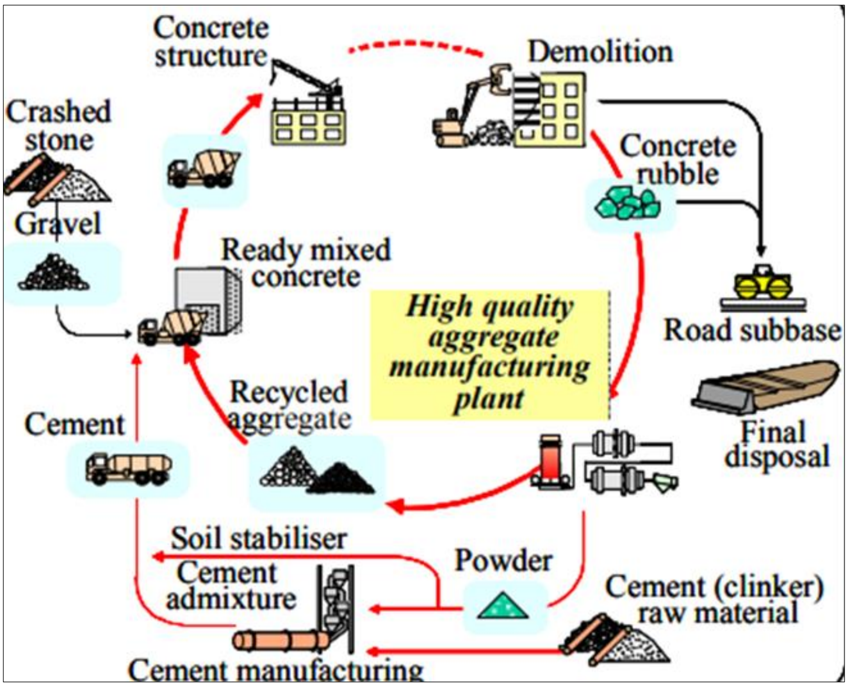

Figure 1 Schematic flow of concrete recycling system (8)

Shima et al. evaluated multiple scenarios for future scenario with regard to concrete recycling system and analyzed the results based on the applicability of the technology in Japan (8). The scenarios that were assessed in the research included influence of carbon tax, subsidy, and the spread of cutting overlay method. The model is connected to an input-output table that has been extended by a detailed description of concrete-related industries as well as some concrete recycling processes. The authors then developed multiple models based on concrete lifetime under different scenario assumptions that was mentioned to predict the amount of recycling concrete for the future (8, 16).

2.1. Concrete waste recycling Benefits

In attention to sustainable and environmental development it is important to adopt the most protected methods of construction globally. The hierarchy of disposal options categorizes environmental impacts into six levels, from low to high: to reduce, reuse, recycling, compost, incinerate and landfill (17). Waste concrete generated about 50% of the waste landfills, and one way resulted in generated concrete waste on site reduction is the method involves "3R", which is defined as recycle, reuse, and reduction. Minimizing waste strategies, recycling has three benefits (i) cut down on new resources demand, (ii) reduce costs of the transport and production energy, (iii) waste utilization (14, 18). If these methods are not properly implemented, there would be a lot of waste generated **(Figure. 2)**. Applying the combination of all these three methods is essential to prevent mass waste generation on site. Five major causes noticed to be responsible for concrete waste listed as: (i) over ordering, (ii) lost during transportation, (iii) installation waste, (iv) poor workmanship, (v) design change. One of the most efficient way to manage the waste generating is to recycle the concrete at construction in order to protect the environment by reducing filling the landfills with waste concert. Considering concrete as a form of solid waste, recycling emerges as a viable option for optimizing construction waste production. Assessing the costs and benefits of concrete recycling reveals a balanced approach that transforms waste into new production, thus aligning with environmentally friendly practices (19).

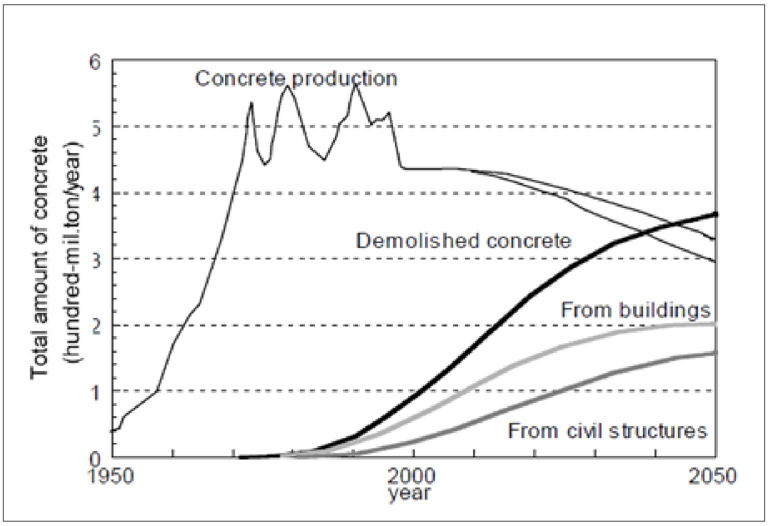

Figure 2 Estimated amount of demolished concrete (20)

Counting concrete waste as the solid generated waste at construction, cause recourse shortage and environmental issues. To address the interplay between environmental hazards, economic growth, and resource utilization, the "6R" principles were employed, focusing on reducing inefficiencies and eliminating concrete waste. These principles encompass practices such as reuse, recycle, recover, reduce, redesign, and remanufacture (21).

The mass production of concrete more than nominal needed amount resulted in major environmental pollution in construction industry. To reduce the associated costs as well as the environmental footprint of construction materials, numerous attempts have been made to incorporate locally available solid waste materials (22, 23). Among the most locally available solid waste materials that has a high availability, glass is an amorphous, sustainable concrete for circular economy non-crystalline material that has a high content of Silicon (Si) (24, 25). Glass is estimated to have a waste production of around 100 million tons, annually, where only around 26% of it has been reported to be recycled. Glass offers versatile applications in the realm of construction. Not only can it partially replace Ordinary Portland Cement (OPC) or serve as a filler in fine sizes, but it can also function as fine sand, serving as a primary ingredient in concrete (26, 27). Presently, glass is predominantly manufactured using three main types: Borosilicate, alum inosilicate, and soda-lime based glass. Embracing sustainable design practices, recycling waste materials can significantly reduce costs while minimizing environmental harm. The utilization of glass in producing porcelain cement offers advantages from both a sustainability perspective and an energy consumption standpoint. When employed in powdered form, glass can effectively reduce the porosity and permeability of the concrete. Conversely, larger glass particles can decrease the Interfacial Transition Zone (ITZ), generate air voids and water-filled pores, and ultimately leading to a reduction in density (14, 28-30).

Often, recycled concrete is utilized for non-structural elements like road bases and foot pathways due to concerns about its inferior quality. To enhance the quality of recycled concrete, various methods have been employed (31). These methods encompass different aspects that influence concrete characteristics such as density, elasticity, resistance, permeability, and mechanical properties. Concrete durability refers to its ability to withstand damage caused by environmental factors. Higher water absorption can lead to a decline in surface quality, ultimately compromising the material's strength and suitability for use in the design process (7). The methods used to improve the quality of recycled concrete and address these challenges were divided into three areas:

- Matrix improving of recycled concrete
- Adhered mortar removing
- Adhered mortar strengthening

These methods can have both positive and negative effect included mechanical grinding treatment, which can result in micro- cracks on the recycled concrete surface. But mortar strengthening can result in surface coating with calcium carbonate and pozzolan slurry. Matrix improving can modify Batching with limiting water absorption during mixing process (32, 33). A variety of material can be used in recycled concrete lead in different forms of sustainability. Material like coal ash, increase attention to adding multi- functional known as waste material has the potential to replace Portland cement (7, 31). In most area of the world, the waste produced concrete is exceed the amount that needed for road subbase. To add quality, rubbing and heating methods were used in recycling concrete. Carbon tax is effectively promoting sustainable recycling system (8). various research studies have shown that incorporating glass mixtures into concrete offers beneficial impacts, particularly as a substitute for fine aggregates in self-compacting concrete (SCC) mixes with recycled waste glass, typically at levels ranging from 10% to 50% by volume. However, it's worth noting that most of these studies have observed a reduction in concrete density when waste glass is added. Nonetheless, the inclusion of glass waste in the concrete mix has demonstrated a promising reduction in the overall dead load (10, 34).

2.2. Lifecycle design

An essential consideration in life cycle design is the value of materials, which highlights the importance of incorporating recycling concepts. This approach, often referred to as inverse manufacturing or the recycling factor of the design system, plays a pivotal role in accelerating the transition towards a closed-loop system **(Figure. 3)** (8).

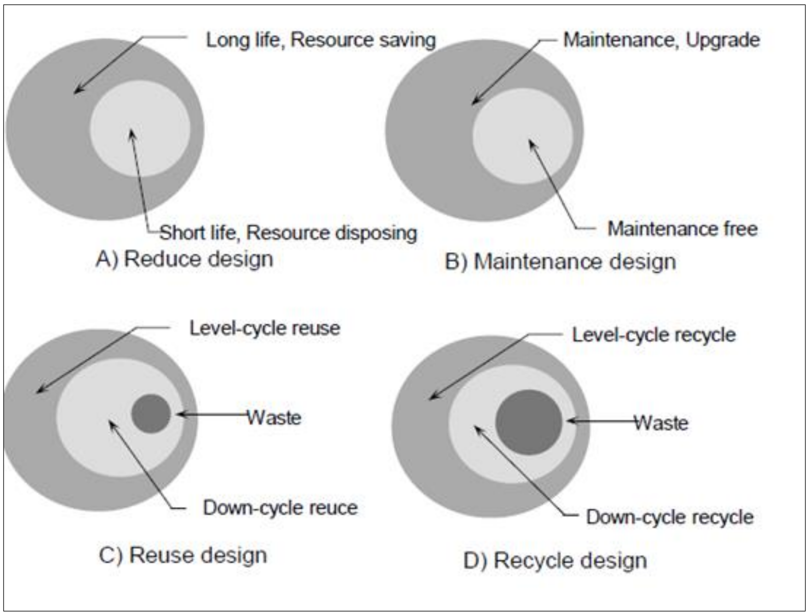

Figure 3 Relationship between design objectives representing the essential functions of structures (35)

Concrete recycling technology has been developed significantly. Making recycled material despite the problem of high costs appears to be favorable regarding its vital proposition. Recycling material in a closed loop is more environmentally friendly but it’s a great challenge too regarding the vast of energy consumption (8, 35).

2.3. The Effect of Recycled Concrete Aggregate (RCA) Incorporating Wastepaper Sludge Ash (WPSA) as Partial Replacement of Cement

Concrete serves as a predominant construction material in the erection of numerous buildings. To enhance the essential strength characteristics of concrete, a considerable body of research and innovation is imperative to achieve the desired objectives. In the concrete mix, WPSA been used as cementations material with partially replace of OPC. The concrete mixture comprises of concrete cubes containing a blend of Water-Pre-Soaked Aggregates (WPSA), OPC, regular coarse aggregates, fine aggregates, and coarse Recycled Concrete Aggregates (RCA) with a maximum size of 20 mm, along with the appropriate water content. Notably, the WPSA was incorporated into the mixture as a fibrous admixture. To enhance the mixing efficiency, the lumps of WPSA were pre-blended with water using an electrical mixer before incorporating them into the concrete mixture (36, 37).

To investigate the efficacy of utilizing industrial WPSA and RCA as a sustainable approach in concrete production, a series of experimental tests were conducted. According to the test results, the following conclusions were drawn:

- A 5% replacement of cement by WPSA with 50% RCA and a water-cement ratio of 0.45 exhibited optimum compressive strength development compared to the normal mix concrete with grade C25

- Cement in concrete can be replaced by up to 5% of WPSA by weight, resulting in a 15% increase in compressive strength at 28 days
- Concrete mix workability improves as the WPSA content decreases
- With decrease in WPSA content, mean weight increases for mixture with 15% WPSA content and all percentage of RCA thus making concrete light weight.
- The use of WPSA as a partial replacement for cement effectively addresses the limitations of recycled aggregate, particularly higher water absorption, in the production of recycled aggregate concrete.
- The strength and physical quality of concrete mixtures with WPSA blended cement and RCA can be accurately assessed by measuring their compressive strength.
- Incorporating WPSA in concrete contributes to the conservation of natural resources used in cement manufacturing, promoting a more sustainable and environmentally friendly concrete construction industry
- By using RCA in concrete, greener concrete can be achieved
- Different concrete strengths can be achieved by varying the proportions of coarse aggregates, RCA, and WPSA

RCA usage in concrete can prove to be inexpensive as it is undesirable material that can be obtained freely without cost (36-38).

2.4. Utilization of Recycled Concrete as Aggregates for Sustainable Development

Sustainable development involves many interlinked aspects including nature, environment, society, economy, technology and politics, and it is an embodiment of an integrated performance index. In developing countries, due to great efforts in infrastructure constructions, the urbanization process is surely accelerated at a high-speed rate. However, along with the rapid development of construction, construction waste has been produced continuously, which exerts a side effect on environmental quality (39, 40). The term “construction and demolition waste (CDW)” has been widely used for referring to the solid waste produced during new construction, renovation, and demolition of buildings. To a large extent, CDW has caused a series of terrible environmental problems, and produced a bad effect on economic construction and social development. Worldwide, CDW often constitutes 10%–30% of the solid waste found at numerous landfill sites. Remarkably, in China, it constitutes a substantial 30%–40% of the total municipal solid waste, raising significant concerns about waste management practices. Notably, waste concrete stands out as the predominant component of CDW, accounting for more than 40% of the overall volume, necessitating effective strategies for sustainable waste reduction and resource utilization (39, 40).

In order to effectively utilize the waste concrete, it is necessary to employ it as recycled aggregate of new concrete, which can be named as recycled aggregate concrete (RAC). Consequently, mechanical properties of RAC need to be deeply investigated to expand the application scope of RAC, especially in building structures. In China, RAC has attracted much attention from construction departments as a structural concrete. So far, some research has been carried out on its material properties. Substantial research has been conducted on its material properties, exploring various aspects of its performance. For instance, Zhu et al. investigated the thermal properties of concrete blocks prepared with low-grade recycled aggregates (41), while Rao et al. studied the behavior of RAC under drop weight impact load (42). Additionally, Belen et al. analyzed the structural RAC with 100% recycled coarse aggregate (RCA) content (43), and Xiao et al. conducted a series of tests on shear transfer across cracks in RAC (44). Moreover, several researchers have launched studies on the durability properties of RAC (45, 46). It is noteworthy that the mentioned strength indexes of RAC were all evaluated after a standard curing period of 28 days (41-46).

It seems that the research on time-based mechanical properties of RAC under uniaxial compression and flexural condition is still limited for using the original RCA, and the experimental data based on the long age concrete are in a state of blank. Meanwhile, previous studies just selected rough and large interval of RCA replacement ratio, which might lose some special performances of RAC under certain kinds of RCA replacement ratio. Further, the constitutive relationship between stress and strain also needs to be clarified for RAC with micromesh increasing ratio when it is applied to structural members. Based on the results of this experimental investigation, the following conclusions are drawn:

- The peak strain value of RAC generally increases with the increase of the RCA content. For the RCA replacement ratios of 80%, 90% and 100%, the peak strain values increase by about 15% compared to that of the NAC
- The compressive strength of RAC including the prism compressive strength at the standard age and at two years, the flexural strength and the cube compressive strength generally increase with the increase of RCA content

2.5. Strength Characteristics of Recycled Aggregate

Concrete is a composite construction material composed primarily of aggregate, cement and water. In general, aggregate make up 60%-75% of total concrete volume, so their selection is important. Also, they control concrete properties, aggregate provide bulk, strength, and wear resistance in this application. Hence, the selection and proportioning of the aggregate should be given careful attention. The aggregate is generally coarse gravel or crushed rocks such as limestone, or granite, along with a fine aggregate such as sand or stone dust. Bulk of pavement structure is formed by aggregate (47, 48).

Recycled asphalt pavement (RAP) is the removed and reprocessed pavement material containing asphalt and aggregate. The use of RAP has become a common practice in the construction of new, reconstruction of new, reconstruction of old, and hot mix asphalt pavements. However, little research has been done to examine the potential of incorporating RAP into cement concrete (49, 50). A study by Mashed Delwar et al. (1997) investigated the use of combinations of course and fine RAP aggregate in normal concrete mixes and compared the results of compressive strength to conventional mixes with 0.4 and 0.5 water cement ratios (51). Compressive strength values were found to decrease with the increase in RAP content. Another study by Baoshan Huang, et al (2005) found that RAP could be incorporated into Portland cement concrete without any modification to tube conventional equipment or procedures (52). Without any treatment, there was a systematic reduction in compressive and split tensile strength with the incorporation RAP in concrete. Salim Al-Oraimi, et a1. (2009) also used RAP as a coarse aggregate, substitute in two different normal Concrete mixes having 28 days cube compressive strengths of 33 and 50 MPa. RAP was used with 25, 50, 75,100% replacement of coarse aggregate. According to test result, the slump decreased with the increase RAP content and the compressive and flexural strength decreased with the increase in RAP content. However, the surface absorption was not significantly affected by the addition of RAP. The results indicated the viability of RAP as an aggregate in nonstructural concrete applications (53).

A laboratory experiment by Mohsin Khan (2018) investigated the physical and mechanical properties of cement concrete comprising of RAP, in different proportions. Recycled asphalt pavement used in this study was obtained from the debris of dismantled asphalt road (50). The aim was to determine the strength characteristic of RAP for application in high strength concrete, which will give a better understanding on the properties of concrete with RAP as an alternative material to fresh coarse aggregate in concrete. This might help in achieving economy in road construction as well as saving environmental degradation in term of reduced mining and less pollution. Use of RAP would also conserve resources, landfill space and generate profit for the recyclers. The project's core objective was to create eco-friendly concrete suitable for transportation applications, focusing on aggregate properties, compressive, and flexural strength (50).

Regarding aggregate characteristics, RAP proved economically advantageous and exhibited a lower specific gravity (2.49) and higher water absorption (1.3) than fresh aggregate. RAP aggregate's gradation met requirements for replacement of fresh coarse aggregate. Both RAP and fresh aggregate had comparable crushing values, adhering to mix design standards except for bitumen content. In terms of strength, compressive strength comparisons were made between RAP mixes (B, C, D, E) and fresh mix M30 (A) after 7 days. RAP mixes' compressive strength was lower by 10.4% to 39.5%, with a consistent reduction in M30's strength (approximately 60%) when RAP was used. RAP also slowed the rate of strength gain. Flexural tensile strength comparisons after 28 days showed diminishing values for RAP mixes (4.1% to 29.1%), with M30's strength dropping about 70% using RAP aggregate. Overall, the study concluded that RAP inclusion primarily affected compressive strength (50).

3. Conclusion

The construction industry's ecological impact underscores the urgency for innovative waste reduction solutions. Concrete and demolition waste emerge as a significant proportion of the overall waste, considering concrete's widespread use in construction. To effectively tackle this issue, the incorporation of the 3R principles — reduce, reuse, recycle — presents a potent means to curtail waste generation. Among these principles, recycling, particularly concerning concrete, yields multiple advantages, including diminished resource demand and lowered energy expenses. This recycling practice not only attends to environmental apprehensions but also holds economic benefits. Several research studies have showcased the viability of integrating Recycled Concrete Aggregates (RCA) into fresh concrete mixes. Yet, this endeavor is not without challenges in terms of maintaining consistent quality. However, techniques like the HRM have emerged to enhance the caliber of recycled aggregates. Concurrently, the reutilization of waste materials, like glass, in concrete production underscores sustainability. The adoption of life cycle design principles further accentuates the significance of recycling to establish a closed-loop system. Ultimately, these collective endeavors synergistically contribute to fostering a more sustainable construction industry, all while effectively addressing the complexities posed by environmental and resource-related concerns.

Compliance with ethical standards

Disclosure of conflict of interest

Sara Shomal Zadeh, Navid Joushideh, Behrokh Bahrami, and Sahel Niyafard affirm that there are no conflict of interest including: financial interests, personal relationships, or any other affiliations that could influence the objectivity and integrity of the research and its findings presented in this manuscript.

References

[1] Horvath A. Construction materials and the environment. Annu. Rev. Environ. Resour.. 2004 Nov 21, 29:181-204.

[2] Mansourimajoumerd P, Mahdavinejad M, Niknia S, Shirvani M. Comprehensive Strategies for Optimization e_Energy System in Different Climate Zone. in the 4th International Conference on Architecture, Arts and Applications www. Iconfaaa. Com 2020 Oct 12.

[3] Mansourimajoumerd P, Bazazzadeh H, Mahdavinejad M, Nia SN. Energy Efficiency and Building's Envelope: An Integrated Approach to High-Performance Architecture. InUrban and Transit Planning: City Planning: Urbanization and Circular Development 2023 Apr 1 (pp. 25-33). Cham: Springer International Publishing.

[4] Turkyilmaz A, Guney M, Karaca F, Bagdatkyzy Z, Sandybayeva A, Sirenova G. A comprehensive construction and demolition waste management model using PESTEL and 3R for construction companies operating in Central Asia. Sustainability. 2019 Mar 15, 11(6):1593.

[5] Ménard Y, Bru K, Touzé S, Lemoign A, Poirier JE, Ruffie G, et al. Innovative process routes for a high-quality concrete recycling. Waste management. 2013, 33(6):1561-5.

[6] Tam VWY. Economic comparison of concrete recycling: A case study approach. Resources, Conservation and Recycling. 2008, 52(5):821-8.

[7] Al-Waked Q, Bai J, Kinuthia J, Davies P. Durability and microstructural analyses of concrete produced with treated demolition waste aggregates. Construction and Building Materials. 2022, 347:128597.

[8] Shima H, Tateyashiki H, Matsuhashi R, Yoshida Y. An advanced concrete recycling technology and its applicability assessment through input-output analysis. Journal of advanced concrete technology. 2005, 3(1):53-67.

[9] Fatta D, Papadopoulos A, Avramikos E, Sgourou E, Moustakas K, Kourmoussis F, Mentzis A, Loizidou M. Generation and management of construction and demolition waste in Greece—an existing challenge. Resources, Conservation and Recycling. 2003 Dec 1, 40(1):81-91.

[10] Qaidi S, Najm HM, Abed SM, Özkılıç YO, Al Dughaishi H, Alosta M, et al. Concrete Containing Waste Glass as an Environmentally Friendly Aggregate: A Review on Fresh and Mechanical Characteristics. Materials. 2022, 15(18):6222.

[11] Tomosawa F, Noguchi T, Tamura M. The way concrete recycling should be. Journal of advanced concrete technology. 2005, 3(1):3-16.

[12] Rajaei Lak H, Rajabi E, Ghodrati Amiri G, Shakouri A. Numerical Analysis of Regular Reinforced Concrete Frames under Near-Fault Ground Motions. Iranian Journal of Science and Technology, Transactions of Civil Engineering. 2023 Feb, 47(1):399-414.

[13] Mohammed Ali, A., Besharat Ferdosi, S., Kareem Obeas, L., Khalid Ghalib, A., & Porbashiri, M. (2024). Numerical study of the effect of transverse reinforcement on compressive strength and load-bearing capacity of elliptical CFDST columns. *Journal of Rehabilitation in Civil Engineering*, *12*(1).

[14] Tam VW. Economic comparison of concrete recycling: A case study approach. Resources, conservation and recycling. 2008 Mar 1, 52(5):821-8.

[15] Tam VW. Comparing the implementation of concrete recycling in the Australian and Japanese construction industries. Journal of Cleaner production. 2009 May 1, 17(7):688-702.

[16] Shima, H., Tateyashiki, H., Nakato, T., Okamoto, M. and Asano, T. (1999). "New Technology for Recovering High Quality Aggregate from Demolished Concrete." Proceedings of Fifth International Symposium on East Asia Recycling Technology, 106-109, 1999.

[17] Peng CL, Scorpio DE, Kibert CJ. Strategies for successful construction and demolition waste recycling operations. Journal of Construction Management and Economics 1997, 15(1):49–58.

[18] Edwards B. Sustainable architecture: European directives and building design. Oxford: Architectural Press, 1999.

[19] Luangcharoenrat C, Intrachooto S, Peansupap V, Sutthinarakorn W. Factors influencing construction waste generation in building construction: Thailand's perspective. Sustainability. 2019 Jul 2, 11(13):3638.

[20] IIDA K, SAEKI T, Nagataki S. An Integrated Concrete Recycling System Including Cement. Concrete library international. 2001 Dec.

[21] Jawahir IS, Bradley R. Technological elements of circular economy and the principles of 6R-based closed-loop material flow in sustainable manufacturing. Procedia Cirp. 2016 Jan 1, 40:103-8.

[22] Arrigoni A, Panesar DK, Duhamel M, Opher T, Saxe S, Posen ID, MacLean HL. Life cycle greenhouse gas emissions of concrete containing supplementary cementitious materials: Cut-off vs. substitution. Journal of Cleaner Production. 2020 Aug 1, 263:121465.

[23] Lehne J, Preston F. Making concrete change. Innovation in Low-carbon Cement and Concrete. 2018.

[24] Omran A, Tagnit-Hamou A. Performance of glass-powder concrete in field applications. Construction and Building Materials. 2016 Apr 15, 109:84-95.

[25] Topcu IB, Canbaz M. Properties of concrete containing waste glass. Cement and concrete research. 2004 Feb 1, 34(2):267-74.

[26] EPA U. Facts and figures about materials, waste and recycling. EPA, Environmental Protection Agency. 2019 Nov, 12.

[27] Jiang G, Keller J, Bond PL. Determining the long-term effects of H2S concentration, relative humidity and air temperature on concrete sewer corrosion. Water research. 2014 Nov 15, 65:157-69.

[28] Afshinnia K, Rangaraju PR. Influence of fineness of ground recycled glass on mitigation of alkali–silica reaction in mortars. Construction and Building Materials. 2015 Apr 15, 81:257-67.

[29] Saccani A, Bignozzi MC. ASR expansion behavior of recycled glass fine aggregates in concrete. Cement and Concrete Research. 2010 Apr 1, 40(4):531-6.

[30] Jani Y, Hogland W. Waste glass in the production of cement and concrete–A review. Journal of environmental chemical engineering. 2014 Sep 1, 2(3):1767-75.

[31] Özalp F, Yılmaz HD, Kara M, Kaya Ö, Şahin A. Effects of recycled aggregates from construction and demolition wastes on mechanical and permeability properties of paving stone, kerb and concrete pipes. Construction and Building Materials. 2016 May 1, 110:17-23.

[32] Wang L, Wang J, Qian X, Chen P, Xu Y, Guo J. An environmentally friendly method to improve the quality of recycled concrete aggregates. Construction and Building Materials. 2017 Jul 30, 144:432-41.

[33] Katz A. Treatments for the improvement of recycled aggregate. Journal of materials in civil engineering. 2004 Dec, 16(6):597-603.

[34] Shao Y, Lefort T, Moras S, Rodriguez D. Studies on concrete containing ground waste glass. Cement and concrete research. 2000 Jan 1, 30(1):91-100.

[35] Tomosawa F, Noguchi T, Tamura M. The way concrete recycling should be. Journal of advanced concrete technology. 2005, 3(1):3-16.

[36] Fauzi MA, Sulaiman H, Ridzuan AR, Azmi AN. The effect of recycled aggregate concrete incorporating waste paper sludge ash as partial replacement of cement. InAIP conference proceedings 2016 Oct 19 (Vol. 1774, No. 1). AIP Publishing.

[37] Bui NK, Satomi T, Takahashi H. Influence of industrial by-products and waste paper sludge ash on properties of recycled aggregate concrete. Journal of Cleaner Production. 2019 Mar 20, 214:403-18.

[38] Sharipudin SS, Ridzuan AR, Mohd Saman H. Performance of foamed concrete with waste paper sludge ash (wpsa) and fine recycled concrete aggregate (frca) contents. Int Sustain Civ Eng J. 2012 Dec, 1(2):19-27.

[39] Chen Z, Xu J, Chen Y, Jing C. A case study on utilization of 50-year-old concrete in recycled aggregate. Journal of Residuals Science & Technology. 2016 Jan 1, 13:2.

[40] Jagan S, Neelakantan TR, Saravanakumar P. Performance enhancement of recycled aggregate concrete–an experimental study. Applied Science and Engineering Progress. 2022, 15(1).

[41] Zhu L, Dai J, Bai G, Zhang F. Study on thermal properties of recycled aggregate concrete and recycled concrete blocks. Construction and Building Materials. 2015 Sep 30, 94:620-8.

[42] Rao MC, Bhattacharyya SK, Barai SV. Behaviour of recycled aggregate concrete under drop weight impact load. Construction and Building Materials. 2011 Jan 1, 25(1):69-80.

[43] Gonzalez-Fonteboa B, Martinez-Abella F, Eiras-Lopez J, Seara-Paz S. Effect of recycled coarse aggregate on damage of recycled concrete. Materials and structures. 2011 Dec, 44:1759-71.

[44] Xiao J, Xie H, Yang Z. Shear transfer across a crack in recycled aggregate concrete. Cement and Concrete Research. 2012 May 1, 42(5):700-9.

[45] Peng L, Zhao Y, Zhang H. Flexural behavior and durability properties of recycled aggregate concrete (RAC) beams subjected to long-term loading and chloride attacks. Construction and Building Materials. 2021 Mar 29, 277:122277.

[46] Levy SM, Helene P. Durability of recycled aggregates concrete: a safe way to sustainable development. Cement and concrete research. 2004 Nov 1, 34(11):1975-80.

[47] Rakunde A, Tidke A, Dhole D, Rewatkar H, Jadhao P, Bagde S, Parteki Y. Use of Recycled Aggregates in Green Concrete.

[48] Saravanakumar P, Abhiram K, Manoj B. Properties of treated recycled aggregates and its influence on concrete strength characteristics. Construction and Building Materials. 2016 May 15, 111:611-7.

[49] Jahanbakhsh H, Karimi MM, Naseri H, Nejad FM. Sustainable asphalt concrete containing high reclaimed asphalt pavements and recycling agents: Performance assessment, cost analysis, and environmental impact. Journal of Cleaner Production. 2020 Jan 20, 244:118837.

[50] Mohsin Khan. Experimental Case Study of Recycled Aggregate Concrete Using Bituminous Pavement Wastes. International Research Journal of Engineering and Technology (IRJET). 2018 Sep, 5(9):854-8

[51] Delwar M, Fahmy M, Taha R. Use of reclaimed asphalt pavement as an aggregate in portland cement concrete. Materials Journal. 1997 May 1, 94(3):251-6.

[52] Huang B, Shu X, Li G. Laboratory investigation of portland cement concrete containing recycled asphalt pavements. Cement and Concrete Research. 2005 Oct 1, 35(10):2008-13.

[53] Al-Oraimi S, Hassan HF, Hago A. Recycling of reclaimed asphalt pavement in Portland cement concrete. The Journal of Engineering Research [TJER]. 2009 Jun 1, 6(1):37-45.