A REVIEW- USE OF RECYCLED MATERIALS AS AN ALTERNATIVE TO REPLACE NATURAL AGGREGATES IN CONCRETE

Rajdeep Singh*and Shashi Bhushan Suman
Department of Civil Engineering
Nirwan University, Jaipur
Email: turkiya.chetan7@gmail.com

Abstract: - The literature review meticulously explores the wealth of existing knowledge pertaining to the utilization of recycled materials in construction, concentrating particularly on RFA sourced from Construction & Demolition Waste (CDW). The primary objective of this section is to furnish a thorough and all-encompassing overview of the contemporary landscape of researchin sustainable construction practices, encapsulating key discoveries and the progressive evolution of ideas in this field. The basic principles of modern development include protecting the environment, preserving natural resources and promoting sustainable development. The addition of recycled materials (RA) to concrete stands is an important step towards achieving these goals. Traditionally the use of RA has been limited to low-level applications due to concerns about its strength and durability The findings emphasize the importance of overcoming the challenges associated with heterogeneous waste sources, offering a nuanced understanding of the role of mixed recycled aggregates (MRA) in enhancing the performance of cementitious materials.

KeyWords:- construction, recycled materials, Waste

1. INTRODUCTION

Due to the critical depletion of natural resources, there are worldwide efforts to find new aggregates to produce concrete. The use of recycled materials could be an alternative to replace natural aggregates in concrete to meet at least part of the aggregate demand, reduce environmental problems and production costs. However, more information on the properties, cost-benefit and performance of concrete is needed for the successful use of recycled aggregates (RA) (Yang 2021). The rapid surge in urbanization and industrialization over recentdecades has led to the depletion of crucial construction materials, notably sand, and the accumulation of industrial waste. The detrimental environmental consequences of excessive sand dredging from riverbeds, coupled with the limited availability of land for industrial waste disposal, have prompted an exploration of sustainable alternatives (Rao et al., 2019). Recycling industrial wastefor integration into the construction industry stands out as a promising strategy for sustainable development. This approach not only addresses the need for reducing sand demand but also provides an eco-friendly solution to waste disposal challenges (Srivastava and Singh, 2020).

Underutilization of Mixed RecycledAggregates (MRA) in Cementitious materials

Ferreira et al. (2021) reported the prevalent underutilization of mixed recycled aggregates (MRA) in cementitious materials, primarily stemming from the challenges posed by the heterogeneous nature of rubble sources and the absence of specific regulations governing their incorporation. Through a meticulously designed three-stage experimental program, the study is dedicated to assessing the variability inherent in MRA and comprehensively understanding its impact on the physical and mechanical properties of cement and lime-based mortars. The research employs advanced statistical modeling techniques, harnessing the power of Machine Learning algorithms. These computational tools play a pivotal role in identifying the optimal volumetric ratio of cement: hydrated-lime: MRA for modified mortars. The outcomes of the study bring to light that mortars composed of MRA at a ratio of 1:1:6 exhibit markedly superior mechanical strengths and exhibit advantageous capillary water absorption characteristics. These positive attributes are attributed to the filler effect imparted by the MRA. Poon and Kou (2010) reported the properties of cementitious plaster mortars containing recycled fine aggregate (RA). RA is purchased from recycling facilities that process mixed demolition waste through mechanical crushing, screening and separation. Two layers of plaster mortar mixture were created by keeping the water/cement and aggregate/cement ratios constant at 0.55 and 3, respectively. In this series, water sand and natural gravel powder started to be used respectively, and these ratios were gradually changed by recycling 25%, 50%, 75% and 100%. The results of the study showed that the mechanical properties (such as compressive strength, bending strength and elastic modulus) of mortars containing RA were lower than those of mortars mixed together. Braga et al. (2012) This paper conducts a performance evaluation of cement- based mortars that integrate extremely fine aggregates sourced from recycled concrete. The experimental program includes a range of standardized tests aimed at enhancing mortar performance concerning strength, water absorption, shrinkage, and water permeability. The research yields highly positive results, indicating improvements in several properties of the modified mortars. This suggests the viability of incorporating up to 15% recycled concrete fines into mortar compositions.

Use of coarse Recycled Concrete Aggregates (RCAs) in concrete production

Riyar et al. (2021) reported the ramifications of incorporating coarse Recycled Concrete Aggregates (RCAs) as a viable substitute for natural coarse aggregates in concrete manufacturing. The physical attributes of the coarse recycled aggregates undergo refinement through three distinct beneficiation techniques: chemical beneficiation, mechanical beneficiation, and chemical-mechanical beneficiation. The study meticulously evaluates the alterations in the properties of Recycled Aggregate Concretes (RAC) resulting from the utilization of both non-beneficiated and beneficiated aggregates. The results manifest a discernible decrease in the hardened state properties of concrete when RCAs are employed asreplacements for natural aggregates. This discovery suggests a promising avenue for elevating the sustainable use of recycled aggregates in concrete production by leveraging beneficiation techniques. Through the strategic implementation of chemical, mechanical, or combined beneficiation methods, the study posits that the overall performance of Recycled Aggregate Concretes can be enhanced. Babu et al. (2014) the basic principles of modern development include protecting the environment, preserving natural resources and promoting sustainable development. The addition of recycled materials (RA) to concrete stands is an important step towards achieving these goals. Traditionally the use of RA has been limited to low-level applications due to concerns about its strength and durability. However, advances in technology and developmentsin composites have paved the way for its use in concrete. This article examines the effect of RA treatment on the compressive strength and durability (water absorption, adsorption, chloride ion penetration, drying shrinkage and wear resistance) of high-strength concrete. Experimental results show that the recycling process improves the strength and performance of recycled concrete (RAC) compared to virgin RA. Grade and treatment have a clear impact on RAC product. When processed, recycled materials can replace up to 50% of fine aggregateswith a strength of 70 MPa or higher in concrete.

Properties of Recycled Demolition Aggregate (RDA)concrete

Mohammed and Sabir (2021) this study endeavors to delve into the characteristics of Recycled Demolition Aggregate (RDA) concrete through a comprehensive series of experimental inquiries. The meticulous preparation of five distinct RDA concrete ratios is conducted, encompassing a range from 0% to 100% substitution of gravel weight with RDA. Furthermore, the experimental design incorporates the replacement of 10% of cement with silica fume (Si), and the introduction of steel fibers (SF) in varying percentages (0.5%, 1.0%, and 1.5%). The RDA undergoes treatment with cement mortar, supplemented with the addition of a superplasticizer (SP) admixture constituting 1% of the total cementitious materials (TCM). The concrete properties subjected to scrutiny encompass density, compressive strength, splitting tensile strength, and modulus of rupture. The findings elucidate a discernible reductionin compressive strength, splitting tensile strength, and rupture modulus values as the RDA ratioincreases relative to normal concrete. The density of RDA concrete is observed to be approximately 9% lower than that of normal concrete. Despite these variations, the research conclusively asserts that RDA demonstrates suitability for incorporation into concrete, meeting specified standards and underscoring its potential as a sustainable alternative within the realmof construction materials.

Feasibility of crushed recycledcoarse aggregate (CRCA) as a fineaggregate replacement

According to Soni and Shukla (2021) the challenges arising from sand scarcity in construction and the environmental strain caused by excessive natural sand (NS) mining from rivers have underscored the need for sustainable alternatives. While recycled sand (RS) has been considered a potential substitute obtained from the production of recycled coarse aggregates, its variable composition and high water absorption limit its extensive utilization. Furthermore the application of recycled coarse aggregates in structural concrete encounters restrictions imposed by BIS-383, owing to its inferior properties in comparison to traditional RS. This is primarily attributed to a reduced amount of hydrated cement content, resulting in increased water absorption. The focus of this study is on the production of crushed recycled coarse aggregate (CRCA) and an exploration of its technical feasibility as a substitute for fine aggregate in NS. X-ray diffraction analysis showcases the potential suitability of CRCA as a viable alternative to NS in concrete. The research presents compelling evidence that concrete, boasting enhanced compressive strength, can be achieved through the complete incorporationof specific CRCA as a fine aggregate. The utilization of scanning electron microscopy (SEM)and electron diffraction spectroscopy (EDS) offers valuable insights into the mechanisms governing strength development in concrete containing CRCA. In addition to these findings, the study endeavors to establish empirical regression-based models. These models aim to systematically evaluate the mechanical strengths of concrete across varying percentages of CRCA, with a specific focus on particle grades. This systematic approach provides a comprehensive framework for assessing the feasibility and performance of CRCA as a sustainable alternative to NS.

Recycled powder derived from aeratedconcrete blocks and sintered clay bricks

Li, et al. (2020) this paper focuses on the study of recycled powder derived from aeratedconcrete blocks and sintered clay bricks, with a specific emphasis on particle size variations. The powder is categorized into different groups based on particle sizes ranging from 0–0.045 mm, 0.045–0.075 mm, and 0.075–0.15 mm. The study calculates the energy consumption required to produce powder of different particle sizes through grinding. Subsequently, mortar samples are cast using various groups of powder, with cement replacements of 10%, 20%, and30%. The investigation encompasses fresh mortar properties, including slump and slump loss,as well as the mechanical properties and shrinkage of hardened mortar after 28 days of curing, with a focus on shrinkage over 60 days. Results indicate that aerated concrete blocks are moreeasily crushed than sintered clay bricks, although grinding aerated concrete blocks into powder finer than 0.30 mm incurs higher energy consumption compared to sintered clay brick powder.Mortar strength improves with a 10% replacement of cement with recycled powder. The activities of the powder obtained from aerated concrete blocks and sintered clay bricks vary, influencing the fluidity of the mortar and resulting in differential shrinkage. The unique microstructure of aerated concrete block powder, characterized by 2–3 μm pores, is identified as a significant factor contributing to reduced mortar fluidity and increased shrinkage. Liu et al. (2020) investigates the recycling potential of aerated concrete blocks (ACB) and sintered clay bricks (SCB) by employing their sand particles as recycled sand in concrete production. Due to the inherent challenges of using ACB and SCB as recycled coarse aggregate, the study focuses on mitigating the degradation in workability and mechanical properties by exploring their application as recycled sand. Recycled sand, categorized by particle sizes, is incorporated into mortar specimens as natural sand replacements at varying levels. The results indicate an improvement in mortar strength when using recycled sand from ACB and SCB, with shrinkage performance varying between the two materials. Scanning electron microscopy reveals the presence of micro-pores in ACB and SCB sand particles, suggesting an internal curing effect that enhances the microstructure of the interfacial transitionzone between recycled sand particles and cement paste. Overall, the study highlights the potential of recycled sand from ACB and SCB to positively influence the properties of mortarin concrete applications.

Fine recycled concrete aggregates (RCA)

Ledesma et al. (2014) this research delves into the examination of both short- and long-term properties of masonry mortar that incorporates various replacement ratios of natural sand with fine recycled concrete aggregates (RCA). The recycled materials, obtained from a recycling plant and subjected to a 4 mm sieve, were directly incorporated into the mixtures while maintaining their original particle size distribution. A pozzolanic CEM-IV/A (V) 32.5 N cementwith 29% fly ash was utilized at a 1:7 volumetric cement-to-aggregate ratio. Five different mortars were prepared, each featuring distinct replacement ratios (0%, 5%, 10%, 20%, and 40%). A rigorous analysis was performed on the data, employing one-way analysis of variance to discern statistically significant effects on various fresh and hardened properties. Advanced techniques such as X-ray diffraction (DRX) and electron microscopy were employed to scrutinize morphologies and trace the evolution of main mineral phases over a curing period extending to 180 days. The results of this study demonstrate that a replacement ratio of up to 40% represents a feasible alternative for producing environmentally friendly masonry mortar. This underscores the potential for incorporating sustainable practices into the realm of construction materials.

Alternative fine aggregates (AFAs)

According to Singh and Chourasia (2020) the construction industry makes a significant contribution to the depletion of natural resources and environmental imbalance, especially dueto unplanned mining activities. The use of heavy stones in construction leads to excessive use of sand, endangering the ecosystem and causing a shortage of quality raw materials. Industrial waste and construction waste further contribute to environmental problems. For this purpose, the use of alternative fine aggregates (AFAs) from various sources seems to be a promising method. Crushed Sand (CRS), Industrial Byproduct (IBP) and Recycled Fine Aggregate (RFA) are different types of AFA that provide economic, sustainable and social benefits when placedin concrete. Although existing literature supports the ability of EFA to produce positive results, extensive research is necessary to validate and strengthen confidence in its use. This article discusses the physical, chemical and mechanical properties of rocks using different types of AFA. It also shows research on durability, microstructure and life cycle analysis, highlighting that this sand alternative leads to stability, stability, work and can be used for construction. Thisreview focuses on the reasons why EFA will become an important tool in the future. Akhtar and Sarmah (2018) reported the significant environmental impact of concrete production and construction and demolition waste (C&D) generation, which contribute substantially to continuous carbon dioxide emissions. The primary objective is to present a global overview of C&D waste generation, examining recent studies focused on enhancing recycled aggregate concrete properties through various supplementary materials. Data from 40 countries across six continents are critically analyzed, emphasizing current C&D waste generation and governmental policies. The worldwide C&D waste generation surpassed 3.0 billion tonnes annually by 2012 and continues to rise. Developing countries, particularly India and China, face the challenge of implementing effective systems for monitoring and utilizing their substantial C&D waste, necessitating government-led initiatives for public awareness. Recycled aggregates from C&D waste are deemed of inferior quality, prompting researchers to recommend the use of pozzolanic materials for improvement. Suggestions include employing recycled aggregates in the range of 30 to 50% to attain strength comparable to natural aggregate concrete when coupled with supplementary cementitious materials.

Conclusion: Recycling demolition construction waste for integration into the construction industry stands out as a promising strategy for sustainable development. This approach not only addresses the need for reducing sand demand but also provides an eco-friendly solution to waste disposal challenges However, the review acknowledges challenges, such as the need for more research on unconventional supplementary materials, long-term structural analysis, and the absence of proper standards hindering widespread adoption in real-world applications. The call for further research and the establishment of standards underscores the necessity of endorsing C&D wastein the construction industry for low-risk structural applications.

REFERENCES

1. Akhtar, A. and Sarmah, A.K. 2018. “Construction and Demolition Waste Generation and Properties of Recycled Aggregate Concrete: A Global Perspective.” *Journal of Cleaner Production* **186**:262–81.
2. Babu, V. S., Mullick, A. K., Jain, K. K. and Singh, P. K. 2014. “Strength and Durability Characteristics of High-Strength Concrete with Recycled Aggregate-Influence of Processing.” *Journal of Sustainable Cement-Based Materials* **4**(1):54–71.
3. Braga, Mariana, Jorge D.B. and Veiga, R. 2012. “Incorporation of Fine Concrete Aggregates in Mortars.” *Construction and Building Materials* **36**:960–68.
4. Ferreira, L.S., Ruan, Marcos A. S. Anjos, Cinthia Maia, Licarion Pinto, Afonso R. G. de Azevedo and Jorge de Brito. 2021. “Long-Term Analysis of the Physical Properties of the Mixed Recycled Aggregate and Their Effect on the Properties of Mortars.” *Construction and Building Materials* 274(xxxx):121796.
5. Ledesma, E.F., Jiménez, J.R., Fernández, J.M.., Galvín, A.P., Agrela, F. and Barbudo, A. 2014. “Properties of Masonry Mortars Manufactured with Fine Recycled Concrete Aggregates.” *Computers and Chemical Engineering* 71:289–98.
6. Liu, Qiong, B.L., Jianzhuang X. and Singh, A. 2020. “Utilization Potential of Aerated Concrete Block Powder and Clay Brick Powder from C&D Waste.” *Construction and Building Materials* **238**:117721.
7. Mohammed, H.J. and Sabir, Z.S. 2021. “Properties of Concrete Containing Recycled Demolition Aggregate.” *IOP Conference Series: Earth andEnvironmental Science* 877(1).
8. Poon, C.S. and Shi, C.K. 2010. “Properties of Cementitious Rendering Mortar Prepared with Recycled Fine Aggregates.” *Journal Wuhan University of Technology, Materials Science Edition* **25**(6):1053–56.
9. Rao, M.C., Kumar, S.B. and Barai, S.V. 2019.“Systematic Approach of Characterisation and Behaviour of Recycled Aggregate Concrete Chapter 2.” *Systematic Approach of Characterisation and Behaviour of Recycled Aggregate Concrete* (December):39–63.
10. Riyar, Ram, L., Mudasir, N., Kapoor, K., Singh, R.B. and Singh, P. 2021. “Hardened State Behavior of Beneficiated Recycled Aggregate Concrete.” *Journal of Sustainable Cement-Based Materials* 10(6):319–35.
11. Soni, N. and Shukla, D. K. 2021. “Analytical Study on Mechanical Properties of Concrete Containing Crushed Recycled Coarse Aggregate as an Alternative of Natural Sand.” *Construction and Building Materials* **266**:120595.
12. Srivastava, A. and Singh S.K. 2020. “Utilization of Alternative Sand for Preparation of Sustainable Mortar: A Review.” *Journal of Cleaner Production* **253**:119706.
13. Yang, K.H. 2021. “Shear friction response of lightweight concrete using bottom ash aggregates and air foams” *Journal of Structural Integrity and Maintenance* **6** (1): 37–46.