RESEARCH ARTICLE OPEN ACCESS

The Influence Of Date Palm Ash And Nano Silica On Recycled Coarse Aggregates Concrete

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ABSTRACT
The rapid pace of urbanization alongside the continuous construction, renovation, and demolition of structures globally has resulted in a substantial accumulation of construction and demolition (C&D) waste. Utilizing recycled C&D waste as construction aggregates, both coarse and fine, holds significant importance not only from economic and environmental perspectives but also in reducing the strain on natural resources. This experimental study investigates the effects of incorporating colloidal nano-silica (CNS) and Date Palm Ash into recycled aggregate concrete (RAC) concerning mechanical, durability, and microstructural properties. The experiments involve incorporating varying percentages of Date Palm leave ash (0%, 3%, 6%, and 9%) and nano-silica (0%, 1.5%, 3%, and 4.5%) into RAC. Cement plays a crucial role in concrete by providing strong binding among aggregates and enhancing its strength. However, the production of cement involves a significant environmental impact, releasing approximately 1.2 tons of CO_2 per ton of cement, contributing around 8% of the total CO_2 released into the atmosphere. Moreover, the cost of cement production is relatively high. To address these concerns, Date Palm Ash, obtained by incinerating by-products from palm oil mills, is proposed as a replacement for cement. This ash, which lacks sufficient nutrients for use as fertilizer, contributes to pollution. Therefore, various studies are exploring methods to utilize palm ash efficiently. Research findings indicate that concrete incorporating palm ash exhibits higher strength, increased durability, cost-effectiveness, and environmental friendliness. Recycled aggregate concrete is formulated by completely replacing natural coarse aggregates with recycled ones, demonstrating the potential of sustainable construction practices.
Keywords:- Recycled Aggregate Concrete, Recycled Aggregate Mortar, Colloidal Nano-Silica, Mechanical and durability characteristics, Interfacial Transition Zone.

I. INTRODUCTION

In The surge in global construction activities has escalated the demolition of existing structures, resulting in increased debris accumulation and a higher demand for cement and natural aggregates in erecting new buildings. This upsurge not only poses challenges related to debris storage but also raises environmental concerns due to unsightly dumping sites, heightened rainwater runoff, and potential environmental contamination. Recycling demolished concrete waste for construction purposes emerges as a pivotal economic and environmental solution, particularly in developing nations like India, mitigating the environmental hazards associated with their disposal.

The scarcity of high-quality sand in arid regions presents challenges in construction. Sand from these areas often contains natural salts, causing efflorescence on structural surfaces and steel reinforcement corrosion, reducing structural longevity. Furthermore, excessive use of river sand diminishes groundwater levels and elevates natural salt concentration, potentially leading to health issues like kidney stones and arthritis. In such scenarios, repurposing demolished concrete waste assumes critical significance, addressing economic and environmental concerns and reducing reliance on natural resources for concrete and mortar aggregates, consequently mitigating environmental disruption.

Construction and demolition (C&D) waste encompass materials from excavations, roadworks, building projects, and complex debris. Excavation waste includes materials like soil, sand, gravel, and clay, while roadworks debris consists of ballast, concrete, paving stones, and asphalt. Demolition of structurally sound buildings contributes to C&D waste comprising concrete, iron, tiles, roofing, bricks, wood, and ceramics. Managing the substantial waste generated during construction and demolition through recycling, reuse, and reduction methods is essential. Repurposing C&D materials for non-structural building components and pavement construction aids in conserving natural resources. However, challenges such as limited resources for recycling, normalization, declining profit margins, lack of interest, inadequate education, and insufficient awareness about environmental conservation impede the efficient utilization of recycled materials. The Asia Pacific region foresees extensive utilization of processed construction and demolition debris in upcoming construction projects.

Recycled coarse aggregate (RCA) commonly contains residual adhering mortar, making it notably more porous compared to virgin aggregate. The characteristics of RCA are contingent on the quantity of mortar adhering to its surface, encompassing properties such as grain size, specific gravity, bulk density, water absorption, crushing value, and impact value. A comprehensive assessment of these properties is imperative to understand the nature of RCA, thus facilitating its utilization as aggregate in concrete production.

The recycling process of construction and demolition (C&D) waste commences with segregating unwanted residual materials like wood, plastics, and metal fragments, constituting around 10% of the total waste. The remaining heavier waste is processed through crushing machines, reducing it to smaller sizes, with size fractions separated based on their intended applications. Typically, fines are best recovered through a wet process.

Recycled aggregates (RA) are created by crushing demolition debris, and recycled aggregate concrete (RAC) is formed by incorporating these recycled aggregates into the binder. The scarcity of landfill space for disposing of substantial volumes of solid waste generated from deteriorating concrete structures is a widespread challenge faced by most nations. RCA, especially derived from this demolished debris, has proven successful as construction materials in recent years. Addressing issues of environmental contamination, depletion of natural resources, and land scarcity for C&D waste disposal can be approached by substituting some or all natural aggregates in concrete with recycled aggregates.

However, a primary concern with recycled aggregates is the presence of residual old mortars, adversely impacting their properties in comparison to natural aggregates. Research indicates that recycled aggregates often exhibit lower density and higher water absorption capacity than their natural counterparts. Recent studies demonstrate that concrete incorporating RCA performs comparably to concrete made with natural aggregates.

II. MATERIAL AND METHODOLOGY

The present study assesses the behavior of two key aspects: (i) Concrete employing recycled coarse aggregate (RCA) in lieu of traditional natural coarse aggregate (NCA) and partial replacement of cement with colloidal nano-silica (CNS) and Date Palm Ash by weight. (ii) Cement, with partial substitution by weight of CNS and Date Palm Ash for cement. The interfacial transition zone (ITZ) between the cementitious material and coarse/fine aggregates significantly influences concrete and mortar behavior. The experimental investigation aimed to discern variations in the cementitious material, mechanical properties, durability, quality, and microstructural attributes of concrete and mortar mixes using these recycled materials. Initially, the physical characteristics of RCA, NCA, Date Palm Ash, and CNS were evaluated.

The experimental work unfolded in phases. The first phase involved collecting concrete waste fragments from a locally demolished staff quarter, processed further by crushing into smaller pieces using a jaw crusher to obtain the required size for recycled coarse aggregate (RCA). Physical characteristics like particle size distribution, bulk density, specific gravity, water absorption, abrasion value, and aggregate impact value of RCA were determined. The second phase focused on identifying the properties of control and Recycled Aggregate Concrete (RAC) mixes, replacing NCA entirely with RCA and varying the partial replacement of cement with CNS (0%, 1.5%, 3%, and 4.5%) and Date Palm Ash (0%, 3%, 6%, and 9%) by weight. Fresh properties of RAC were determined through a slump test, while mechanical and durability tests assessed hardened RAC properties, including compressive strength (CS), splitting tensile strength (STS), flexural tensile strength (FTS), and non-destructive test parameters. Concrete mixes were prepared with varying percentages of CNS and Date Palm Ash (0%, 1.5%, 3%, 4.5%, and 0%, 10%, 15%, 20% respectively) partially replacing cement in colloidal form.

III. RESULT OF EXPERIMENT WORK

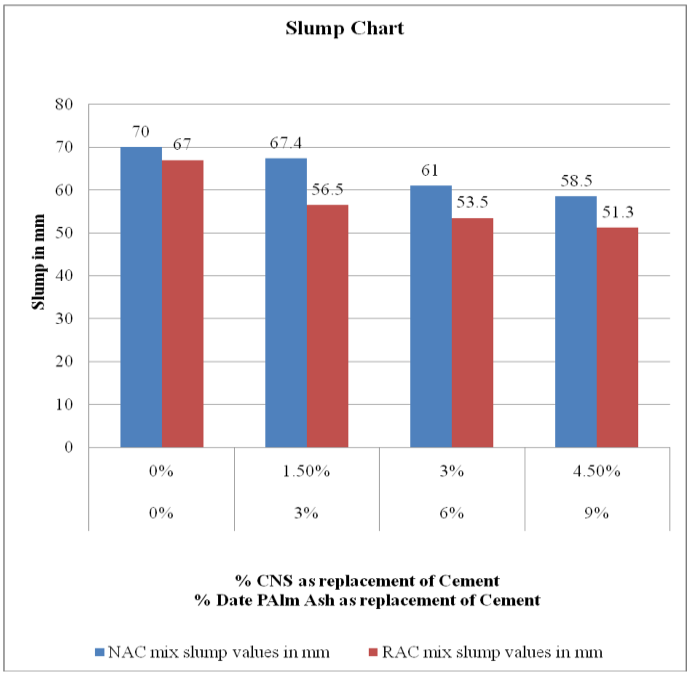


Fig 1: Variation in slump values of concrete mixes with NAC and RAC at different percentage replacement of cement with CNS and Date Palm Ash

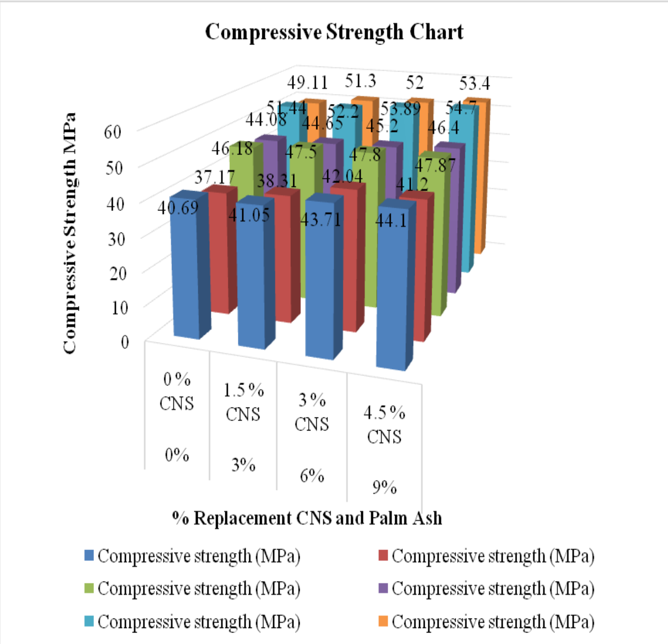


Fig 2: Variation in compressive strength values of concrete mixes with NAC and RAC at different percentage replacement of cement with CNS and Date Palm Ash

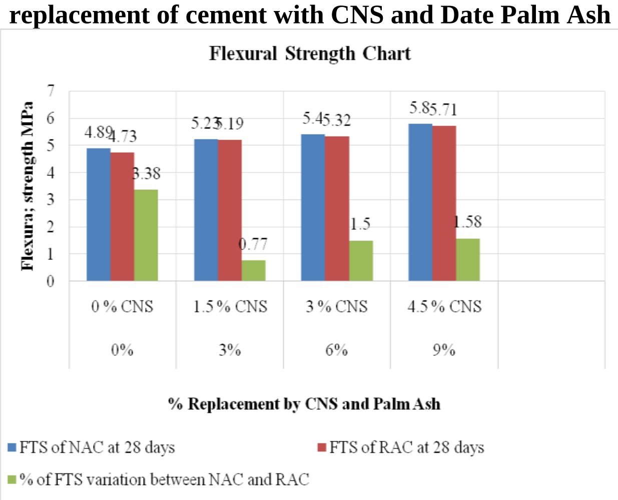


Fig 3: Variation in flexural tensile strength of concrete mixes with NAC and RAC at different percentage replacement of cement with CNS and Date Palm Ash

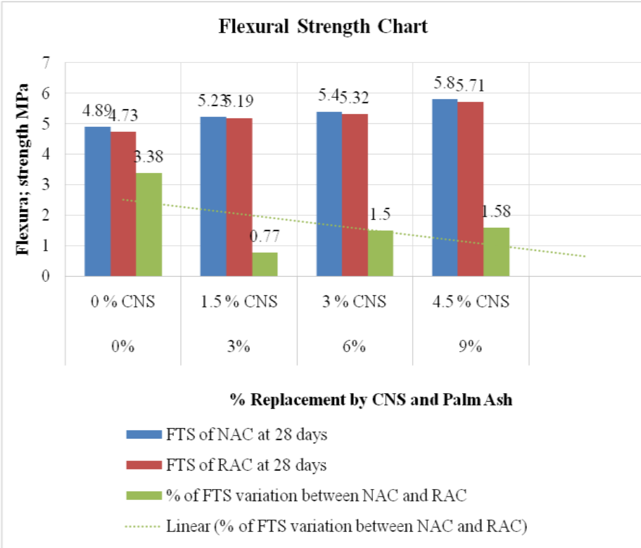


Fig 4: Variation of FTS of NAC and also in RAC with variation in the percentage replacement of cement with CNS by weight

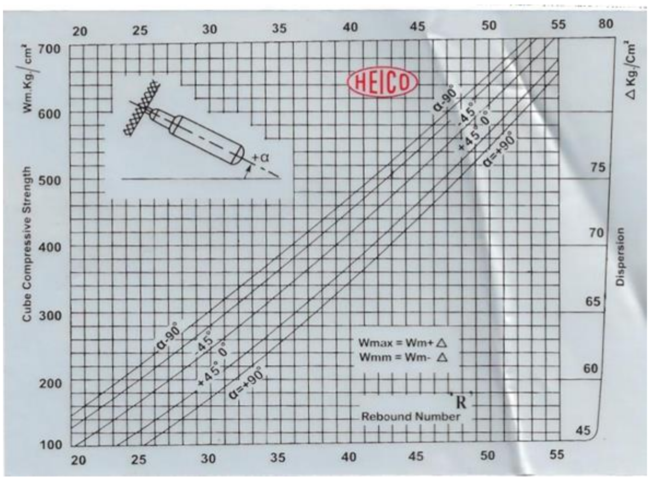


Fig 5: Calibration chart of Rebound hammer

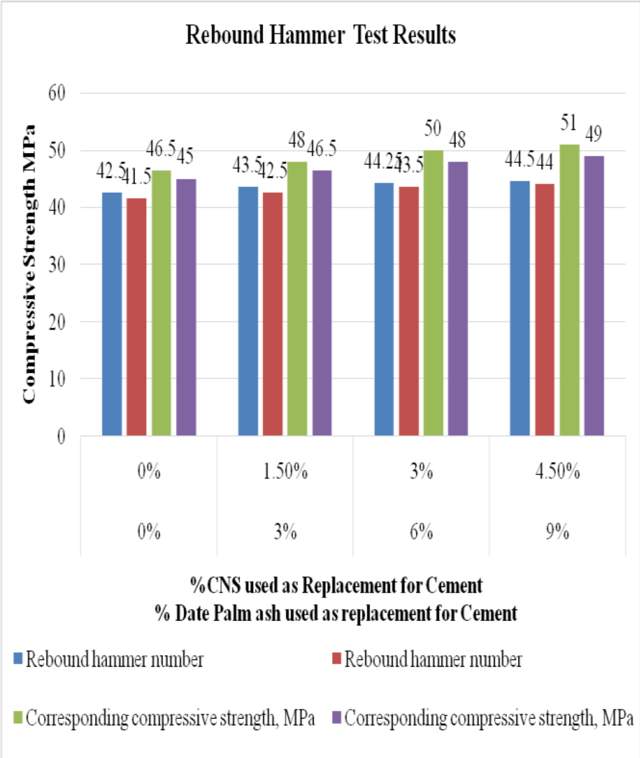


Fig 6: Variation in Rebound hammer test results of cement mixes with NAC and RAC at different percentage replacement of cement with CNS and Date Palm Ash

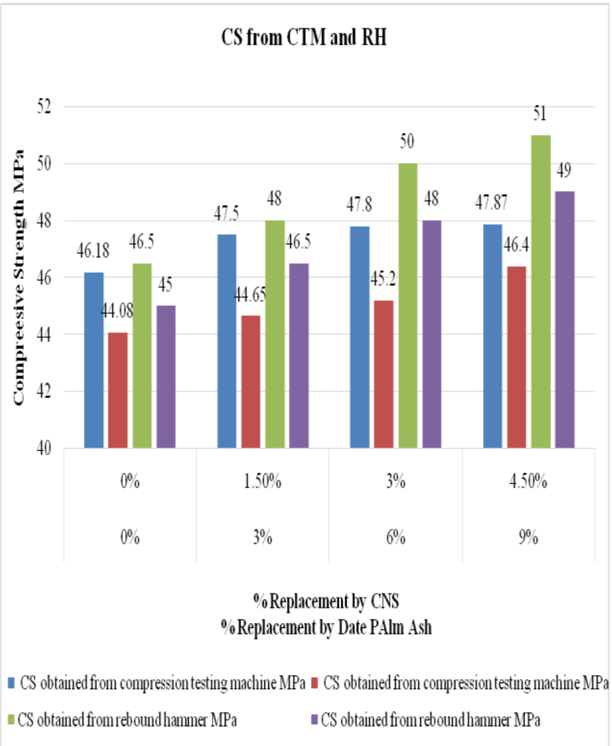
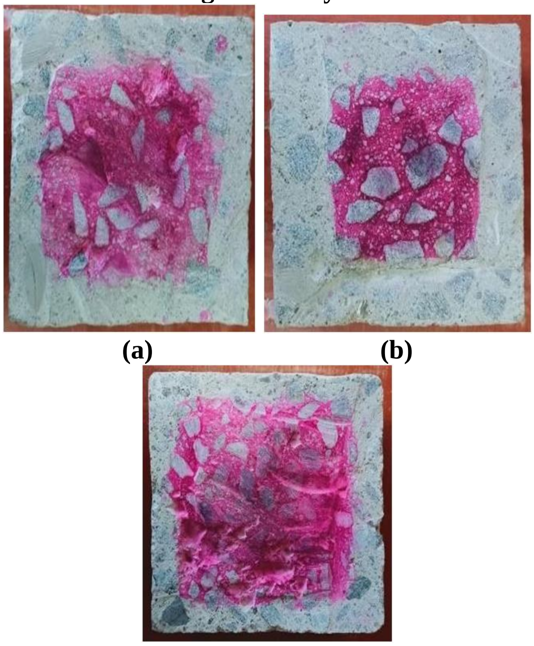


Fig 7: Variation in compressive strengths obtained from direct compression test and rebound hammer test at the age of 28 days



(a) (b)

(c)

Fig 8: Cross sectional view of tested specimen samples (a) NAC (b) RAC (c) RAC- CNS-DPA

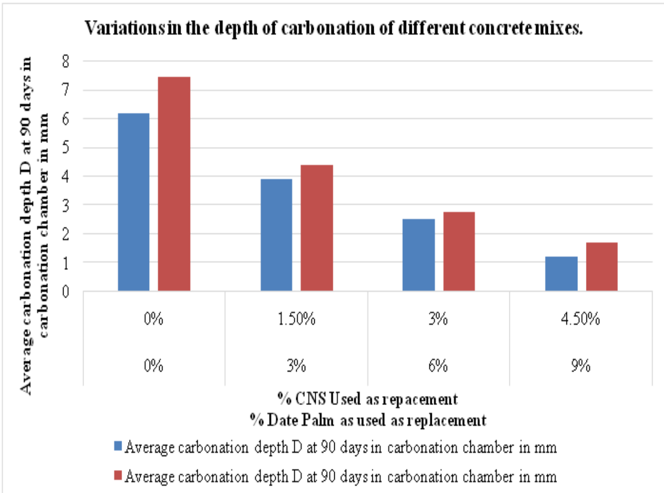


Fig 9: Variation of average carbonation depth in NAC and RAC mixes with variation in the replacement of cement with CNS and Date Palm Ash

(a) (b) (c)

Fig 10: Cross-section of specimens after testing for water penetration (a) NAC, (b) RAC and (c) RAC-CNS-DPA

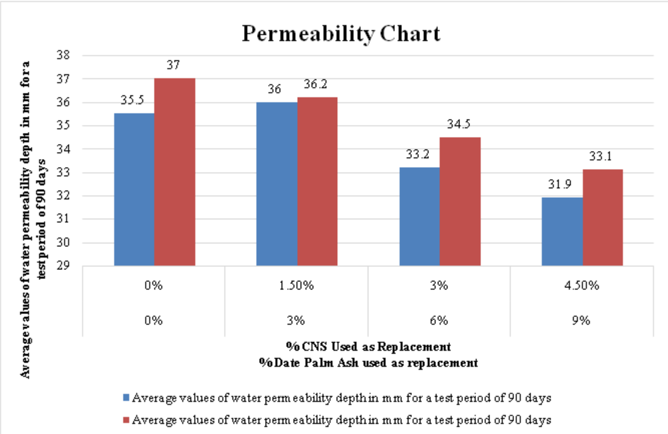


Fig 11: Variation in average depth of water permeability with variation in replacement of cement with CNS and Date Palm Ash in NAC and RAC mixes

The examination of concrete properties by utilizing Normal Aggregate Concrete (NAC) with varying percentages of Colloidal Nano-Silica (CNS) replacement for cement (0%, 1.5%, 3%, and 4.5%) and Date Palm Ash substitution at weights of 0%, 3%, 6%, and 9%. Similarly, Recycled Aggregate Concrete (RAC) was studied with the same combinations of cement and CNS. The focus of this chapter was to analyse the mechanical properties, durability characteristics, and acid attack resistance of these concrete mixes. Relationships between different concrete parameters were established to assess the impact of CNS. Notably, an enhancement in mechanical properties and durability features was observed as cement was replaced by CNS in recycled aggregate concrete mixes. This chapter underscores the potential for enhancing concrete durability by integrating CNS. Furthermore, it suggests the feasibility of producing concrete incorporating Recycled Aggregate (RA) and CNS for diverse structural applications across various fields.

IV. CONCLUSIONS

Addressing housing needs for everyone poses a significant challenge due to population fluctuations witnessed in numerous countries. Consequently, outdated low-rise structures are being demolished to make way for their skyscraper counterparts, aiming to offer improved living spaces. However, this process generates a substantial volume of damaged waste, leading to disposal challenges and substantial financial and resource wastage. Hence, there exists a clear opportunity and necessity to repurpose such waste to construct cost-effective housing solutions. In this specific scenario, a comprehensive examination of Recycled Concrete Aggregate (RCA) properties alongside an analysis of Recycled Aggregate Concrete (RAC) incorporating colloidal nano-silica (CNS) has been detailed. The microstructural analysis highlights the enhancement in RAC's properties.

This study investigated and compared the diverse mechanical and durability properties of Normal Aggregate Concrete (NAC), Recycled Aggregate Concrete (RAC), and mortar mixes by substituting different amounts of Colloidal Nano-Silica (CNS) and Date Palm Ash for cement. The primary findings of this research offer valuable insights into the utilization of colloidal nano-silica and Date Palm Ash in crafting recycled aggregate concrete mixtures, an area that currently lacks comprehensive coverage in existing literature.

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