Eco-Friendly Concrete: Investigating Different Product Synergies

Abhishek Choubey[1], Bikesh Tripathi [2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Sam Global University, Raisen-464551, Madhya Pradesh, India

Abstract- *The construction economy significantly impacts a country's progress. Abundant waste materials, both industrial and natural, can be utilized in concrete to enhance its strength and promote economical construction. Fly ash, a commercial waste with cementitious properties, and coconut fiber, a naturally occurring waste, are two such materials. Coconut fiber, in particular, is a cost-effective option with high strength, tensile, flexural, and impact resistance. This research reviews existing studies on the use of fibers, including coconut fiber, in concrete, highlighting their potential to improve concrete properties and support sustainable construction practices.*

Keywords- Metakaolin, Split tensile strength, Steel fibres, Compressive strength.

I. INTRODUCTION

Portland cement is a fundamental component of concrete construction, but its production contributes to environmental concerns, accounting for around 2.5% of global industrial waste emissions. To mitigate this impact, incorporating waste materials in construction is gaining traction. Reusing waste materials serves a dual purpose: reducing waste disposal and conserving natural resources. This approach promotes sustainable development in the construction industry.

Using waste materials in civil construction is crucial for reducing the environmental impact of the industry. By partially replacing Portland cement with waste products, we can decrease energy consumption, greenhouse gas emissions, and construction costs. Mineral admixtures, such as pozzolanas, can enhance concrete's compressive strength, pore structure, and permeability. This approach not only reduces the amount of Portland cement used but also lowers carbon dioxide emissions, energy consumption, and the rate of global warming.

II. HIGH STRENGTH CONCRETE

High-strength concrete (HSC) is characterized by its exceptional crushing strength properties, which often require specialized materials and techniques beyond conventional practices. The definition of HSC is relative and context-dependent, varying with local conditions, technological advancements, and industry standards.

III. LITERATURE REVIEW

The relevant literature pertaining to the use of metakaolin, steel fibre and super-plasticizer in concrete carried out in India and abroad has been reviewed and presented as under:-

Fan et al. (2024) investigated the effects of nano-metakaolin (NMK) on the chloride ion diffusion resistance (CDR) of fly ash (FA) cement-based materials. Among various nanomaterials tested, NMK showed the highest cost-effectiveness in improving CDR, with an optimal content of 5 wt%. NMK significantly enhanced the CDR, flexural strength, and compressive strength of FA cement mortar, particularly at early hydration ages (7 days). The addition of 5 wt% NMK reduced the chloride ion diffusion coefficient by 73% and increased flexural strength by about 10% at 7 days. NMK also refined the internal structure of FA cement mortar, promoting C-S-H gel formation and reducing harmful pores.

According to Zhou et al. (2023), the elastic modulus of MK10 samples increased by 3%, 12.8%, and 9.4% compared to the control sample at 7, 28, and 90 days, respectively. This progressive improvement indicates that the ongoing pozzolanic reaction and microstructural refinement continue to enhance the stiffness of the concrete over time.

According to Chu et al. (2022), Elastic modulus is a crucial parameter in structural design, evaluating the stiffness of concrete members. Despite its excellent mechanical properties and durability, ultra-high-performance concrete (UHPC) has limited use due to its relatively low elastic modulus. This study designed high elastic modulus UHPC (HEMUHPC) using the Modified Andreasen and Andersen particle packing model. The effects of alumina micro-powder

on workability, microstructure, and mechanical properties of HEMUHPC were investigated. Results showed that adding alumina micro-powder reduced porosity and improved flexural strength, compressive strength, and elastic modulus. The optimal alumina content was 10%. Nanoindentation tests revealed that the high elastic modulus of alumina micro-powder (90-135 GPa) contributed to the improvement in HEMUHPC's elastic modulus.

An experimental study has been carried out by Vardhan et al. (2012) on the influence of steel fibre on concrete at a dosage of 0.8% volume of concrete. Experimental analysis had been done by using M20 mix and tests were conducted as per suggested methods by relevant codes. The study factors of this investigation comprised compressive strength, split tensile strength and flexural strength of fibre reinforced concrete. The outcomes showed that the compressive, split tensile and flexural strength of fibre reinforced concrete is increased by 32.14%, 52.38%, 12.68% respectively when compared to the normal concrete.

The shear strength of Steel Fibre Reinforced Concrete moderate deep beams without stirrups having span to depth ratio 2.0, 2.4, 3.0, 4.0. 12 beams were investigated by Patel et al. (2012). 12 numbers of beams were tested to failure under two point symmetrical loading. Complete shear deformation behaviour along with load-deflection response, modes of failure and crack patterns are studied. Shear strength is assessed using empirical equations suggested in this work for assessment of ultimate shear strength of moderate deep beams without stirrups. Experimental results are compared with theoretical results computed from proposed equation. The comparison shows that the equation suggested gives the accurate estimates of shear strength.

An experimental study has been carried out by Karthikeyan and Balamurugan (2011) on the Partial replacement of cement with marble powder. It has been observed that the replacement of 10% of metakaolin with cement, the compressive strength and split tensile strength of cylinder increases and extra any replacement of metakaolin with concrete the compressive strength and split tensile strength of cylinder reduces. Thus, it has been concluded that the best possible percentage for replacement of marble powder with cement is 10% for both cubes and cylinders.

The properties of concrete paving blocks made with waste marble investigated by Shirulea al. (2012). Mechanical strength reduces with increasing marble content. Whereas freeze-thaw, durability and abrasive wear resistance increases. Waste marble is well utilizable instead of the usual aggregate in concrete paving block production. Incorporation of marble waste provides concrete paving blocks of adequate quality.

IV. DISCUSSIONS AND CONCLUSIONS

Various waste products can be used in concrete production, with the choice of material depending on local availability. This paper provides an overview of supplementary products, aiding in the selection of suitable waste materials. The incorporation of these products affects concrete properties, including workability, shear resistance, tensile behavior, and other characteristics, which are influenced by the amount of supplementary products used.

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