Journal of Interdisciplinary Science | ISSN: 2960-9550
Research Article Peer-review, Open Access

Application of Wood Chips as Partial Substitution for Fine Aggregates in Concrete

Mr. Amresh Anand [1]
Dr. Pappu Kumar [2]

Abstract: Due to increasing environmental awareness and stricter regulations regarding industrial waste management, there is a growing interest in studying the properties of industrial waste and finding solutions to utilize its valuable components as secondary raw materials in various industries.

While wood sawdust is still categorized as industrial waste in many countries, it differs from typical waste in terms of its physical and chemical properties. Historically, before refrigeration, it was even used in homes for ice storage during the summer months.

This report explores the potential uses of wood sawdust as a partial replacement for fine aggregate in concrete, considering its specific physical and chemical characteristics and its applications in industries such as construction. The study examines various concrete properties, including fresh, hardened, and durability properties, when different percentages of wood sawdust are used as a partial replacement for fine aggregate. The research also includes the impact of pretreating the sawdust with water and sodium silicate and varying the water-to-cement ratio.

The report investigates the use of a constant 5% wood sawdust replacement for fine aggregate, with different percentages of silica fume used as a partial replacement for cement. The findings indicate a significant reduction in the weight of concrete when wood sawdust is used as a replacement for fine aggregate.

Keywords: wood sawdust, industrial waste, fine aggregate, concrete properties, silica fume.

[1] *Research Scholar, Department of Civil Engineering, Sandip University, Sijoul, Madhubani-847235, Bihar, India*
[2] *Assistant Professor, Department of Civil Engineering, Sandip University, Sijoul, Madhubani-847235, Bihar, India*

Web of Semantics: Journal of Interdisciplinary Science Vol .3 No.4 (2025)
https://wom.semanticjournals.org

INTRODUCTION

Concrete is one of the most widely used materials worldwide, with a history that dates back to ancient civilizations. The Egyptians, around 3000 BC, were among the first to use early forms of concrete for constructing their pyramids, combining grass and mud to make bricks and using lime and gypsum for mortar. The Greeks improved upon this material by adding volcanic ash from Pozzuoli, which led to the term "pozzolana." This innovation allowed for the creation of iconic structures like the Colosseum and the Pantheon in Rome, the latter being the largest unreinforced concrete dome still standing after over

2000 years. Following the fall of the Roman Empire, concrete use declined until the 1950s when Portland cement was developed, marking the revival of modern concrete. Today, concrete plays a crucial role in both large-scale and small-scale construction projects, formed by combining sand, cement, aggregates, and water in precise proportions for optimal performance. Recent research has focused on replacing traditional sand with alternative materials like wood chips, which can modify the properties of concrete. The goal of concrete mix design is to achieve the best balance of strength and durability while maintaining quality, with ongoing efforts to enhance its performance using innovative chemical admixtures and supplementary materials.

TIMBER WASTE

Wood sawdust, also referred to as wood powder or wood dust, is a byproduct produced during various wood processing activities like cutting, drilling, grinding, and sanding. It consists of fine particles or small, irregular wood chips generated as logs are transformed into different sizes. Sawdust can also originate from the residue left by wood-boring insects, birds, and animals, including species like woodpeckers and ants.

The size of the wood particles in sawdust largely depends on the type of wood and the configuration of the saw teeth used during processing. Generally, around 15-20% of the wood's total volume is lost as waste during these procedures.

SAWDUST PRODUCTION

In woodworking tasks such as sawing, milling, and sanding, two primary waste materials are produced: wood dust and wood chips. These processes involve either the fracturing of lignified wood cells or the detachment of entire cell clusters. When the wood cells are fractured, fine dust particles are created, whereas the removal of entire cell clusters results in the formation of wood chips. The degree of fragmentation of the wood cells determines the size of the dust particles produced. For instance, sawing and milling typically involve both cell fracturing and chip formation, while sanding is primarily responsible for breaking the cells, producing finer dust particles. The sawdust produced during these activities can vary in texture and size depending on the specific techniques and tools employed. The equipment used in the wood processing, such as saws with different tooth configurations, plays a significant role in the resulting particle size. Additionally, the type of wood being processed can also affect the characteristics of the sawdust, with hardwoods typically generating finer dust compared to softwoods.

Sawdust, though considered waste, holds potential for various uses, including in construction, agriculture, and even energy production. Its composition and fine particle size make it an ideal candidate for potential applications in industries that seek to repurpose waste materials and reduce environmental impact.

OBJECTIVES OF THE WORK

The objective of this work is to explore the feasibility of using wood chips as a partial replacement for fine aggregates in concrete. The study aims to investigate the impact of incorporating wood chips on the various properties of concrete, including its fresh properties, hardened properties, and durability. By replacing traditional fine aggregates with wood chips, the research seeks to assess how this substitution affects the strength, workability, and long-term performance of the concrete. Additionally, the work intends to evaluate the potential environmental benefits of utilizing a waste byproduct like wood chips, reducing the reliance on conventional resources and contributing to sustainable construction practices. Through this investigation, the goal is to determine an optimal proportion of wood chips that can be used in concrete mix designs without compromising its structural integrity and durability, while promoting the recycling and repurposing of industrial waste.

LITERATURE REVIEW

Several research studies have explored the use of wood chips as a partial replacement for fine aggregates in concrete, examining various aspects of its impact on concrete properties. Mohammed et al. (2014)

found that incorporating wood chips improved the workability of concrete, with higher proportions and water-to-cement (w/c) ratios leading to increased slump values. However, beyond certain proportions, workability began to decline due to excess water absorption by the wood chips.

Priya et al. (2018) observed a similar trend, where the workability improved up to 30% replacement but decreased beyond that due to water absorption.

Ahmed et al. (2018) studied the effect of wood chips on the modulus of elasticity and found a decrease in this property with higher sawdust replacement percentages.

Khoshroo et al. (2019) examined the combined effects of wood chips and a natural pozzolan, Chekneh, and found that both materials positively influenced the mechanical and durability properties of concrete, especially when combined in optimal proportions.

Gohil et al. (2019) and Muruganantham et al. (2020), focused on other waste materials as partial substitutes for fine aggregates, demonstrating potential benefits for concrete strength and quality when incorporating various industrial byproducts.

Chachar et al. (2022) and Chandramouli et al. (2022) similarly explored the effects of rice husk ash and waste glass powder on concrete properties, showing that these substitutes could enhance concrete strength while addressing environmental concerns.

Sharba et al. (2023) specifically examined wood chips treated with water, cement paste, or sodium silicate, finding that although the addition of wood chips decreased strength properties, it helped lighten the concrete and improve workability.

Sultana et al. (2024) focused on the potential for using sawdust in low-priority projects and concluded that although sawdust reduced compressive strength, it could be a cost-effective solution for specific applications.

These studies suggest that while wood chips and similar materials can affect concrete properties, their optimal use depends on careful control of proportions and treatment methods to balance workability and strength.

FINDINGS

The present study aimed to develop a concrete mix incorporating sawdust as a partial replacement for fine aggregates, focusing on density and compressive strength criteria. Additionally, the study sought to evaluate the impact of substituting sand with sawdust on various concrete properties, including split tensile strength and durability.

CONCLUSIONS

Based on the thorough analysis of the concrete mixes incorporating sawdust as a partial fine aggregate replacement, the following conclusions were drawn regarding various concrete properties:

WORKABILITY

The workability of concrete with wood sawdust as a partial replacement for fine aggregate increases with higher replacement levels when pretreated with water at a water-cement ratio of 0.5. However, a reduction in the water-cement ratio from 0.5 to 0.44 leads to a decrease in workability compared to mixtures with higher ratios. Additionally, at a constant fine aggregate replacement level, the workability decreases as cement is replaced with silica fume. It was also observed that pretreating the wood with sodium silicate enhances the workability of the concrete more effectively than water pretreatment. Based on these findings, the optimal replacement is determined to be 5% wood chipping as fine aggregate, with sodium silicate pretreatment and 12% silica fume as a cement replacement.

DENSITY OF FRESH CONCRETE

The density of fresh concrete incorporating wood sawdust as a partial replacement for fine aggregate decreases as the replacement percentage increases, following pretreatment with water at a water-cement ratio of 0.5. When the water-cement ratio is reduced from 0.5 to 0.44, the density of the concrete declines even further. However, at a constant fine aggregate replacement level, an increase in density is observed when cement is partially replaced with silica fume. The density is notably lower when wood is pretreated with sodium silicate. The optimal replacement content determined by this study is 5% wood chipping as fine aggregate with sodium silicate pretreatment and 12% silica fume as a cement replacement.

COMPRESSIVE STRENGTH

The compressive strength of concrete with wood sawdust as a partial fine aggregate replacement shows a declining trend as the replacement percentage increases after pretreatment with water. At a water-cement ratio of 0.5, the strength significantly decreases. However, reducing the water-cement ratio from 0.5 to 0.44 leads to an improvement in compressive strength, although it still falls short of the control concrete's strength. Substituting cement with silica fume further improves strength. When the wood is pretreated with sodium silicate, the compressive strength is higher compared to water pretreatment. The optimal replacement content for compressive strength is 5% wood chipping as fine aggregate with sodium silicate pretreatment and 12% silica fume as a cement replacement.

SPLIT TENSILE STRENGTH

The split tensile strength follows a similar pattern to the compressive strength. As the percentage of wood sawdust replaces fine aggregate, the split tensile strength decreases significantly when pretreatment with water is used, at a water-cement ratio of 0.5. However, reducing the water-cement ratio from 0.5 to 0.44 leads to an increase in split tensile strength, though still lower than the control concrete. At a constant fine aggregate replacement level, replacing cement with silica fume further improves the split tensile strength. Additionally, wood treated with sodium silicate shows higher split tensile strength than wood treated with water. Based on the findings, the optimal replacement content for split tensile strength is 5% wood chipping as fine aggregate with sodium silicate pretreatment and 12% silica fume as a cement replacement.

REFERENCES

1. Mohammed, B. S., Abdullahi, M. and Hoong, C. K. (2014) 'Statistical models for concrete containing wood chipping as partial replacement to fine aggregate', Construction and Building Materials. Elsevier Ltd, 55, pp. 13–19. doi: 10.1016/j.conbuildmat.2014.01.021.

2. Ahmed, W. et al. (2018) 'Effective use of sawdust for the production of eco-friendly and thermal-energy efficient normal weight and lightweight concretes with tailored fracture properties', Journal of Cleaner Production. Elsevier Ltd, 184, pp. 1016–1027. doi: 10.1016/j.jclepro.2018.03.009.

3. Khoshroo, Moein & Shirzadi Javid, Ali Akbar & Shalchian, Mohammad & Nik, Fatemeh. (2019). Evaluation of Mechanical and Durability Properties of Concrete Containing Natural Chekneh Pozzolan and Wood Chips. Iranian Journal of Science and Technology, Transactions of Civil Engineering. 44. 10.1007/s40996-019-00305-8.

4. Gohil, Jay & Gohel, Jay. (2019). "Experimental Investigation of Egg Shell Powder as Partial Replacement with Cement and copper slag with fine aggregate in Concrete".

5. Dahal, Peshal & Shrestha, Prabesh. (2019). EFFECT OF FINE AGGREGATES ON WORKABILITY OF CONCRETE.

6. Muruganantham, Ashok & Jayabalan, Peroshini & James, Daniel Ronald Joseph & Saraswathy, V.. (2020). Experimental study on partial replacement of fine aggregates using recycled plastic waste beads in concrete. Journal of Structural Engineering (Madras). 47. 132-143.

7. Chachar, Zameer & Ali, Imtiaz & Raza, Muhammad & Narwani, Tulsi & Raza, Ismail & Hussain, Mudasir. (2022). Flexural Behavior of Reinforced Concrete Beams by using Rice Husk Ash as Partial Replacement of Fine Aggregates in Cement Concrete. Jurnal Kejuruteraan. 34. 599-604.

10.17576/jkukm-2022-34(4)-08.

8. Chandramouli, Dr & Chaitanya, J. & Bifathima, Dr & Krishna, K.. (2022). An Experiment Investigation on Concrete by Partial Replacement of Fine Aggregate with Glass Powder for M25. International Journal For Multidisciplinary Research. 04. 563-566. 10.36948/ijfmr.2022.v04i04.063.
9. Tayeh, Bassam & Ahmed, Samir & Abdel Hafez, Radwa. (2022). Sugarcane Pulp Sand and Paper Grain Sand as Partial Fine Aggregate Replacement in Environment-friendly Concrete Bricks. Case Studies in Construction Materials. 18. e01612. 10.1016/j.cscm.2022.e01612.
10. Singh, Gaurav & Chaurasia, Shriram. (2022). “Feasibility of waste copper slag with coal bottom ash in concrete as partial substitution of fine aggregate”. Innovative Infrastructure Solutions. 7. 10.1007/s41062-022-00773-4.
11. Feitosa, Maria & FERREIRA, SILVIO & Delgado, João & Silva, Fernando & Oliveira, Joaquim & Oliveira, Pedro & Azevedo, Antônio. (2023). Use of Sewage Sludge for the Substitution of Fine Aggregates for Concrete. Journal of Composites Science. 7. 10.3390/jcs7010021.
12. Sharba, Ali & Fahad, Jasim & Altaai, Salwa. (2023). the feasibility of improving concrete strength properties by adding waste wood chips. Journal of Applied Engineering Science. 21. 1-8. 10.5937/jaes0-40263.
13. Sultana, Rayhana & Wahid, Ferdous & Dola, Jannatul. (2024). Suitability of using sawdust in concrete as partially replaced fine aggregate. 7. 72-75.
14. IS 456: 2000, “Indian Standard Code of Practice for Plain and Reinforced Concrete”, Bureau of Indian Standard, New Delhi
15. IS 10262: 1982, “Recommended Guidelines for Concrete Mix design”, Bureau of Indian Standard, New Delhi
16. IS 383: 1970, “Specification for Coarse aggregate and Fine aggregate from Natural Sources for Concrete”, Bureau of Indian Standard, New Delhi
17. IS 9103: 1999, “Indian Standard Concrete Admixture Specification”, Bureau of Indian Standard, New Delhi
18. IS 5816: 1999, “Spliting Tensile Strength of Concrete Method of Test”, Bureau of Indian Standard, New Delhi
19. IS 9399: 1959, “Specification for Apparatus for Flexural Testing of Concrete”, Bureau of Indian Standard, New Delhi
20. IS 516: 1959, “Flexural Strength of Concrete”, Bureau of Indian Standard, New Delhi