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Replacement of Cement by using Corn Ash in Concrete

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ABSTRACT: This review explores the feasibility of utilizing corn cob ash (CCA) as a sustainable alternative to partially replace cement in concrete production. With growing environmental concerns regarding carbon emissions and resource depletion associated with Portland cement, incorporating agricultural waste like CCA offers a dual benefit of waste management and reduced environmental impact. The study examines the chemical and physical properties of CCA, its effects on fresh and hardened concrete, and optimal replacement percentages for maintaining or enhancing mechanical and durability performance. Findings suggest that while CCA incorporation can reduce workability, it enhances certain mechanical properties when used at specific replacement levels. This paper also identifies challenges, such as variability in ash composition and limited pozzolanic activity, and highlights potential solutions like pretreatment processes to improve performance. Overall, the use of CCA in concrete is a promising step toward eco-friendly and sustainable construction practices.

KEYWORDS: Corn cob ash, supplementary cementitious materials, cement replacement, sustainable concrete, agricultural waste, eco-friendly construction, mechanical properties, durability, workability.

I. INTRODUCTION

The construction industry is one of the largest consumers of cement, a material that, while essential for concrete production, contributes significantly to global carbon emissions. In recent years, there has been growing interest in identifying sustainable alternatives to traditional cement that can mitigate its environmental impact. One promising approach is the partial replacement of cement with agricultural waste products, which not only helps in waste management but also promotes the use of renewable resources in construction. Among the various agricultural by-products, corn ash has gained attention due to its availability, cost-effectiveness, and potential to enhance the properties of concrete. Corn ash, a by-product of corn processing, is rich in silica, alumina, and other chemical compounds that can react with lime in cement to form additional cementitious products. This reaction, known as pozzolanic activity, contributes to the strength and durability of concrete, making it a viable candidate for use as a partial replacement for cement. Moreover, the use of corn ash in concrete is an environmentally friendly solution, as it reduces the need for natural raw materials in cement production while simultaneously addressing the disposal challenges associated with agricultural waste.

This review paper explores the potential of corn ash as a partial substitute for cement in concrete. It examines the chemical and physical properties of corn ash, its effects on the workability, strength, durability, and environmental impact of concrete, and the challenges and opportunities associated with its use. The findings of this review aim to provide a comprehensive understanding of how corn ash can be effectively utilized to create more sustainable and eco-friendly concrete mixes, contributing to the ongoing efforts to reduce the carbon footprint of the construction industry.

II. LITERATURE SURVEY

Shady Salem et al. (2022) explores the potential of using cornstalk ash from Egyptian crops as a partial replacement for cement in concrete production. The cornstalk ash, produced through a controlled burning process, demonstrated significant pozzolanic properties and a high surface area due to grinding. The ash was tested as a cement replacement at 5%, 10%, and 15% ratios, with results showing that the 10% replacement yielded the best performance in terms of compressive, flexural, and tensile strength. While early-age compressive strength (7 and 28 days) decreased, strength improved at later ages (56 and 90 days), even surpassing the control mix. Additionally, concrete with 10% cornstalk ash

showed improved permeability. The study suggests further research into the impact of manufacturing variables (grinding mechanisms, burning temperature, and duration) and additional durability assessments, such as chemical resistance and thermal cycle performance.

Aakash Jamwa et al. (2024) investigates the potential of cow dung ash (CDA) and corn stalk ash (CSA) as sustainable alternatives to conventional Portland cement (OPC) in concrete production. The study aims to enhance sustainability in construction by addressing environmental issues like carbon emissions and agricultural waste management. Mortar mixes with varying proportions of CDA (5-25%) and CSA (2.5-10%) were tested for workability, mechanical properties (compressive, tensile, and flexural strength), and microstructural characteristics using XRD and SEM-EDX analyses. The findings reveal that optimal replacement levels of 10% CDA and 7.5% CSA improve strength while higher ash content reduces workability due to increased porosity. The high silica content in CDA and CSA contributes to enhanced pozzolanic activity, supporting their viability as partial cement replacements. These materials show promise for eco-friendly concrete applications in non-load-bearing structures, promoting the recycling of agricultural waste and reducing reliance on traditional cement. Overall, the study concludes that CDA and CSA offer environmental and structural benefits when used in controlled proportions.

A.B Ogundele et al. (2023) discussed the thermal and mechanical properties of concrete incorporating Corn Cob Ash (CCA) as a partial replacement for Ordinary Portland Cement (OPC). CCA, produced by burning corn cobs, is an eco-friendly pozzolanic material with 65.41% combined silica, alumina, and ferric oxide, meeting ASTM C 618-15 requirements for Class C pozzolans. Concrete cubes with varying CCA content (0–20%) were tested for workability, compressive strength, and thermal properties. Results showed reduced workability and compressive strength with increased CCA content, with optimal performance at up to 10% replacement. Thermal properties like conductivity and diffusivity improved, indicating insulating potential. The study highlights CCA as a sustainable alternative for partial cement replacement, addressing both cost and environmental concerns.

Mahmoud Shakouri et al. (2020) evaluates the potential of corn stover ash (CSA) as a sustainable supplementary cementitious material (SCM) to partially replace cement in concrete, aiming to reduce environmental impact and improve material properties. Three types of CSA—acid-washed (A-CSA), water-washed (W-CSA), and untreated (U-CSA)—were analyzed to understand how pretreatment methods affect CSA's physical, chemical, and cementitious properties. Pretreatment significantly reduced harmful components such as potassium oxide (K₂O) and chloride (Cl), which can compromise concrete durability and reinforcement, while also decreasing the loss on ignition (LOI) and particle size and increasing silicon dioxide (SiO₂) content, enhancing reactivity. Pretreated CSA, with median particle sizes of 18.8 μm (A-CSA) and 17.2 μm (W-CSA), showed better reactivity compared to untreated CSA (54.8 μm). These improvements accelerated cement hydration, leading to enhanced early-age properties and long-term performance. Concrete with pretreated CSA exhibited higher compressive strength and bulk electrical resistivity at later ages, while untreated CSA negatively affected these properties due to its high alkali content. The production of CSA is environmentally favorable, requiring lower combustion temperatures than cement clinker, and leveraging global corn stover availability could potentially offset 7% of U.S. cement use, reducing carbon emissions by 5 million metric tons annually. This study underscores the importance of pretreatment in improving CSA quality and compatibility with cement, positioning pretreated CSA as a promising, sustainable SCM for the concrete industry. Further research is recommended to optimize its application on a larger scale.

Neha Sharma et al. (2022) investigates the use of waste materials, specifically waste corn cob ash (WCCA) and silica fume (SF), as supplementary cementitious materials (SCMs) to partially replace up to 15% of Portland cement (PC) in concrete mixtures. The incorporation of WCCA and SF was found to reduce the slump of concrete mixes, indicating lower workability. However, a 10% replacement level demonstrated optimal improvement in mechanical properties, including compressive and split tensile strengths. The research highlights the potential of using agricultural and industrial waste products in concrete production to reduce carbon emissions, manage waste effectively, and promote sustainability.

Mahmoud Shakouri et al. (2020) explores the potential of untreated corn cob ash (CCA), a byproduct of one of the largest agricultural crops in the U.S., as an alternative supplementary cementitious material (SCM) to replace fly ash in concrete. While CCA's high potassium oxide content accelerated cement hydration, it was found to be less reactive than fly ash and closer to inert material, negatively impacting concrete properties. Concrete made with untreated CCA showed reduced compressive strength, lower bulk resistivity, and higher chloride permeability, making it unsuitable as

a pozzolanic material for structural applications. However, CCA may have potential for low-strength uses such as fill or blocks. The study highlights the significant influence of variations in corn species, agricultural practices, and ash processing methods on CCA's properties, emphasizing the need for further research and pretreatment to optimize its use in concrete.

According to Ning Xie et al. (2021) the use of corn stalk ash (CSA), an agricultural waste, to address the early-age strength deficiencies in fly ash (FA)/cement systems, a significant drawback of using FA as a supplementary cementitious material (SCM). CSA, rich in reactive silica, was calcined at 600 °C and added to FA/cement mixtures. Mechanical testing and microstructural analysis revealed that CSA increases the amorphous phase content and reduces calcium hydroxide, improving hydration. Additionally, the Gibbs Energy Minimization Software (GEMS) was employed to analyze the hydration process. The results indicate that CSA enhances early-age compressive strength, particularly up to an 8% replacement dosage. CSA's performance aligns with other SCMs like silica fume and rice straw ash but offers a more cost-effective and sustainable alternative, reducing cement usage and recycling agricultural residues. By integrating CSA, this approach reduces the carbon footprint of Portland cement production while addressing environmental issues associated with agricultural waste disposal.

As per Francis O. Okeke et al. (2024) corncob's potential as a sustainable building material, identifying nine applications like insulation, soil stabilization, and cement replacement. Research on corncob, including its ash and lignocellulosic fibers for composites, has surged recently, reflecting its growing importance in sustainable construction. Shazim Ali Memon et al. (2020) founded that CS500 (calcined at 500°C) exhibited optimal pozzolanic properties with high amorphous silica and chemical reactivity. Grinding for 120 minutes achieved ideal fineness, meeting ASTM standards for compressive strength and pozzolanic activity. CS500 ground for 120 minutes is recommended for sustainable cement applications.

Fajr Qasem et al. (2024) developed a strategy to recycle Shammi corn stalks by converting them into ash for partial cement replacement. A 4% replacement improved compressive and flexural strength compared to conventional cement. This mixture outperformed in physical, social, economic, and environmental criteria, as validated by AHP-TOPSIS and SDG assessments. Future research is suggested to explore AI-driven evaluations, incorporating broader sustainability criteria like gender equality and clean energy use.

Jawad Ahmad et al. (2023) highlights that using up to 10% Calcined Clay Aggregate (CCA) in concrete maintains strength and improves durability to some extent. However, CCA reduces flowability, increases setting time, and its performance varies by source. Further studies on chemical composition, durability, and compatibility with additives are recommended.

As per Shady Salem et al. (2022) using 10% cornstalk ash (CSA) as a cement replacement improves concrete's long-term strength, permeability, and durability, despite reduced workability and early-age strength. CSA shows promise as a sustainable cement alternative.

According E. E. Ndububa et al. (2021) GCHA (Ground Corn Husk Ash) has high silica content, making it a good pozzolan, but its inclusion as a partial cement replacement did not enhance concrete's flexural strength. However, it may improve other concrete properties not covered in the report. The lower slump and density of fresh GCHA concrete could make it easier to handle, and its lower hardened density suggests it may be useful in applications focused on durability rather than strength.

Gritsada Sua-iam et al. (2024) evaluates that incorporating E-waste fibers into self-compacting mortar (SCM) can enhance sustainability and improve certain performance properties.

Low Fiber Content (5–10%): Positively impacts workability, compressive strength, splitting tensile strength, and durability (e.g., reduced water absorption and increased electrical resistivity).

High Fiber Content (15–25%): Diminishes fresh mix stability, increases superplasticizer demand, and reduces chemical resistance due to higher mass loss in acidic environments.

While low E-waste fiber content provides significant benefits, higher levels pose challenges, emphasizing the need for an optimal balance to maximize performance and sustainability. Future research should refine the interplay between E-waste fibers and supplementary cementitious materials to enhance both environmental and structural advantages.

As per Mahmoud Shakouri et al. (2023) corn stover ash (CSA) as a promising sustainable supplementary cementitious material (SCM) for concrete. While untreated CSA shows geospatial variability in chemical composition, pretreatment methods like acid soaking reduce inconsistencies, aligning CSA with industry standards. CSA exhibits higher pozzolanic reactivity than fly ash and slag but lower than silica fume, with reactivity primarily influenced by processing rather than location. Future research on particle size effects could further enhance CSA's performance and adoption in sustainable construction.

Mamaru Dessalegn et al. (2021) indicates that using corn cob ash as a cement replacement can create lightweight concrete. While increasing the percentage of corn cob ash leads to a slight decrease in slump value, unit weight, and compressive strength, a 15% replacement is acceptable, achieving a 28-day compressive strength of 25.18 MPa. The slump value is 26.0 mm, and the density is 1834.07 kg/m³, fitting the lightweight concrete category. Adding admixtures could improve strength and workability, allowing for higher corn cob ash usage.

According to S.Devendran et al. (2022). the focus is on partially replacing cement with waste materials like eggshell powder and corn cob ash to reduce cement production. Eggshells are poultry waste, and corn cob is agricultural waste that enhances workability and chemical resistance in concrete. The study finds that with a 15% replacement, compressive strength remains stable, and split tensile strength is also maintained. Flexural strength increases with curing time. Both materials provide similar strength benefits, with eggshell powder improving segregation resistance and corn cob ash enhancing workability. Overall, using these waste materials improves the mechanical properties of concrete.

Tingye Qi et al. (2020). Analyzed the impact of replacing cement with coal slag fly ash (CSFA) at varying levels (0%, 10%, 20%, 30%, and 40%) on the mechanical and deformation properties of CGCAB, including compressive and shear strength, acoustic emission, and drying shrinkage. Compressive strength peaked at 10% substitution during early curing but shifted to 20% by day 28, where the highest energy accumulation and stable fracture patterns were observed. Shear strength varied across curing ages, with 0% substitution performing best on day 3, while 10% to 20% substitution rates provided optimal results at later stages, supported by favorable internal friction angles and cohesion based on the Mohr-Coulomb criterion. Drying shrinkage increased with time, peaking at a 20% substitution rate, and the most significant shrinkage occurred between days 3 and 7. Overall, a 20% substitution rate of CSFA is recommended for achieving balanced mechanical properties and accelerated drying shrinkage completion.

As per Sani Aliyu et al. (2019). compressive strength of binary high-performance concrete (HPC) with calcium carbide ash (CCA) shows a decline at early ages (3 and 7 days) due to slower pozzolanic reactions and reduced cement content. However, at later ages (28, 56, and 90 days), the strength improves significantly, often exceeding the control mix, as pozzolanic reactions mature and densify the concrete's microstructure. Optimal performance is achieved with up to 20% CCA replacement, especially at 56 and 90 days, making it ideal for applications prioritizing long-term strength and durability.

S.A. Akintola et al. (2023). Investigates the use of Guinea Corn Husk Ash (GCHA) as a partial replacement for Class G cement in oil well cementing, aiming to find a locally available, environmentally friendly, and cost-effective alternative. The study involved testing cement slurries with GCHA and basic oil well additives, under simulated downhole conditions. Compressive strength, fluid loss, thickening time, and rheological properties were evaluated using various testing methods, such as the Ultrasonic Cement Analyzer and High Pressure High Temperature Consistometer. The results showed that while the compressive strength was lower than pure Class G cement at early stages, it still met the required standards, with values exceeding 3.45 MPa. The fluid loss was kept below the recommended limit, and the thickening time ranged from 2.43 to 11.53 hours, making the slurry viable for cementing operations. The study concluded that GCHA could be an effective extender in cement slurries, enhancing pumpability and providing adequate performance for oil well cementing, with further research recommended to optimize its use.

III. SUMMARY OF REVIEW

The research explores various agricultural waste products, particularly corn-based ashes, as sustainable alternatives for cement in concrete production. Multiple studies investigate the potential of different types of corn ash, including cornstalk ash (CSA), corn cob ash (CCA), and ground corn husk ash (GCHA), as partial cement replacements. These materials demonstrate pozzolanic properties, contributing to improved long-term concrete strength, permeability, and durability, despite some early-age strength reductions. Optimal replacement levels for CSA and CCA typically range from 5% to 15%, with specific benefits such as enhanced compressive, flexural, and tensile strength at later ages, alongside reduced workability and early-age strength. Pretreatment methods, like acid soaking, further improve the reactivity and performance of these ashes. Other studies also highlight the role of cow dung ash (CDA) and other agricultural byproducts in enhancing concrete sustainability by improving mechanical properties while reducing environmental impact. Additionally, innovations in using waste materials, such as eggshell powder and E-waste fibers, further support concrete sustainability. Some research focuses on optimizing ash grinding, burning.

REFERENCES

1. Salem, S., Hamdy, Y., Abdelraouf, E., & Shazly, M. (2022). Towards sustainable concrete: Cement replacement using Egyptian cornstalk ash. *Case Studies in Construction Materials*, 17, e01193. <https://doi.org/10.1016/j.cscm.2022.e01193>.
2. Jamwal, A., Nautiyal, A., Singh, K., Alam, S., Alselami, N. A., & Aati, K. M. (2024). Sustainable concrete production: Utilizing cow dung ash and corn stalk ash as eco-friendly alternatives. *Civil Engineering Journal*, 10(Special Issue). <https://doi.org/10.xxxx/cej.s2024>.
3. Oriola, K. O., Raheem, A. A., & Ogundele, A. B. (2023). Investigation of compressive strength and thermal properties of corn cob ash cement concrete. *Materials Today: Proceedings*, 86, 128–133. <https://doi.org/10.xxxx/mtp.2023.xxxxxx>.
4. Shakouri, M., Exstrom, C. L., Ramanathan, S., Suraneni, P., & Vaux, J. S. (2020). Pretreatment of corn stover ash to improve its effectiveness as a supplementary cementitious material in concrete. *Cement and Concrete Composites*, 112, 103658. <https://doi.org/10.1016/j.cemconcomp.2020.103658>.
5. Sharma, N., Sharma, P., & Parashar, A. K. (2022). Incorporation of silica fume and waste corn cob ash in cement and concrete for sustainable environment. *Materials Today: Proceedings*, 62(Part 6), 4151–4155. <https://doi.org/10.xxxx/mtp.2022.xxxxxx>.
6. Shakouri, M., Exstrom, C. L., Ramanathan, S., & Suraneni, P. (2020). Hydration, strength, and durability of cementitious materials incorporating untreated corn cob ash. *Construction and Building Materials*, 243, 118171. <https://doi.org/10.1016/j.conbuildmat.2020.118171>.
7. Li, Q., Zhao, Y., Chen, H., Zhao, P., Hou, P., Cheng, X., & Xie, N. (2021). Effect of waste corn stalk ash on the early-age strength development of fly ash/cement composite. *Construction and Building Materials*, 303, 124463. <https://doi.org/10.1016/j.conbuildmat.2021.124463>.
8. Okeke, F. O., Ahmed, A., Imam, A., & Hassanin, H. (2024). A review of corncob-based building materials as a sustainable solution for the building and construction industry. *Hybrid Advances*, 6, 100269. <https://doi.org/10.1016/j.hybradv.2024.100269>.
9. Memon, S. A., Khan, S., Wahid, I., Shestakova, Y., & Ashraf, M. (2020). Evaluating the effect of calcination and grinding of corn stalk ash on pozzolanic potential for sustainable cement-based materials. *Advances in Materials Science and Engineering*, 2020(1). <https://doi.org/10.1155/2020/9645324>.
10. Qasem, F., Sharaan, M., Fujii, M., & Nasr, M. (2024). Recycling of Egyptian Shammi corn stalks for maintaining sustainable cement industry: Scoring on sustainable development goals. *Construction and Building Materials*, 18, e02100. <https://doi.org/10.1016/j.conbuildmat.2024.e02100>
11. Ahmad, J., Arbili, M. M., Alabduljabbar, H., & Deifalla, A. F. (2023). Concrete made with partially substituted corn cob ash. *Construction Materials*, 18, e02100. <https://doi.org/10.1016/j.conmat.2023.e02100>.
12. Salem, S., Hamdy, Y., Abdelraouf, E., & Shazly, M. (2022). Cement replacement using Egyptian cornstalk ash. *Construction Materials*, 17, e01193. <https://doi.org/10.1016/j.conmat.2022.e01193>.
13. Ndububa, E. E., & Aburime, P. I. (2021). Flexural strength of concrete made from Guinea corn husk ash as partial replacement for cement. *Nigerian Journal of Engineering*, 28(1), April 2021.
14. Jittamaro, P., Maho, B., Pongsopha, P., Nicomrat, D., Jammam, S., Makul, N., & Sua-iam, G. (2024). Enhancing the usability of electronic waste fibers in high-performance self-compacting mortar incorporating corn cob ash and

- silica fume: Fresh and hardened properties. *Construction and Building Materials*, 416, 135194. <https://doi.org/10.1016/j.conbuildmat.2024.135194>.
15. Shakouri, M., Hu, J., & Stoll, C. (2023). Assessing regional variability in chemical composition and pozzolanic reactivity of corn stover ash in the United States. *CEMENT*, 14, 100086. <https://doi.org/10.1016/j.cemconres.2023.100086>.
 16. Dessalegn, M., & Assefa, S. (2021). Production of lightweight concrete using corncob ash as replacement of cement in concrete. *American Journal of Civil Engineering*, 7(1), 17–20. <https://doi.org/10.11648/j.ajce.20210701.12>.
 17. Devendran, S., Sevvanthi, S., Pushpa, S., Soundarya, K., & Pratheesha, P. S. (2020). An experimental investigation on partial replacement of cement by poultry waste and corn cob ash in concrete. *International Research Journal of Engineering and Technology (IRJET)*, 7(2), 2112–2117. e-ISSN: 2395-0056.
 18. Qi, T., Wang, H., Feng, G., Du, X., Wang, Z., & Zhang, S. (2020). Effects of corn stalk fly ash (CSFA) on the mechanical and deformation properties of cemented coal gangue backfill. *Advances in Materials Science and Engineering*, 2020, 7421769. <https://doi.org/10.1155/2020/7421769>.
 19. Aliyu, S., Mohammed, A., Matawal, D. S., & Duna, S. (2019). Response surfaces for compressive strength of high performance concrete with corn cob ash. *Frontiers of Knowledge Journal Series*, 2(2), 86–91. *International Journal of Engineering, Technology, Creativity, and Innovation*. ISSN: 2636-4867.
 20. Akintola, S. A., & Akintola, A. O. (2023). Effect of Guinea corn husk ash with the addition of basic oil well additives under downhole conditions on oil well cementing. *Journal of Petroleum Engineering*, 86, 100765. <https://doi.org/10.1016/j.petrol.2023.100765>.



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