Cement Concrete Could be Substituted with Environmentally Friendly Alternative Materials

Ar. Priyanka Chavan

Associate Professor

Sinhgad College of Architecture, Pune

ar.priyankajadhav@gmail.com

601, Mohite Paradise – G, Sinhgad Road, Pune 411051

Working with various firms for a couple of years after graduation, she has the experience of dealing with a variety of projects which includes the majority of institutional, residential and projects dealing with public works. Due to her keen interest in environment protection and role of architecture in the same, she further chooses to pursue further education in Environmental planning and Architecture. Her involvement in Academic as a full-time faculty gives her the opportunity of making further generations sensitive towards their surroundings.

Ar. Sejal Desarda

Assistant Professor

Sinhgad College of Architecture, Pune

sejaldesarda@gmail.com

401, Manas Dreams, Baner 411045

She has a professional experience of three years after graduation. She dealt with varied projects of residential, commercial and urban development. During her practice she developed a keen interest in people centric design and decided to pursue her Masters in Architecture with majors in Urban Design. She is now a full-time faculty and her approach is to make students aware about the necessity of Urban Design and Planning.

Abstract: Modern times present a variety of issues for the construction industry, chiefly as a result of the growth of the urban population and the depletion of natural resources used to produce building materials. Additionally, a greater understanding of climate change is causing businesses to reconsider their plans for creating more environmentally friendly building materials. Various usable products are been made out of the decomposable wastes that are focused for utilizing its nutritional and desirable qualities. Environmental pollution on earth surface, water, and air is caused by waste. Before they cause pollution, it should be renewed to usable arrangement to minimalize the pollution level as well as helps to produce engagement and to make recyclable environment. Many different kinds of agro-waste, including rice husk ash (RHA), sugarcane bagasse ash (SCBA), and bamboo leaf ash (BLA), among others, have been found as effective solutions in the creation of sustainable building materials. The focus of this research is on conventional materials whose ongoing usage has a negative impact on the environment, with an emphasis on identifying alternative techniques to generate sustainable construction materials. Many investigations also demonstrations that the pollution problem taken about by the misuse of conventional construction materials such as cement can be solved by re-using agro-based waste. This can also help not only to challenge the material but also the ecological concern of marshalling of the waste in landfills. The review's conclusions demonstrated the viability of using agricultural waste to create environmentally friendly building materials because such materials met recognized building standards. This suggests that agricultural production materials have the ability to replace traditional building materials and, as a result, achieve great economic, ethical, and social sustainability.

Keywords: sustainable, construction materials, agricultural by-products

Introduction

The human population has been growing steadily, from 6.8 million in 2009 towards the current 7.7 million by 2021 and an expected 9.7 billion by 2050, according to a quick examination of world population statistics. On the one hand, population growth is a direct result of rising health and mortality rates, which have been improving over time.

Every nation's growth depends heavily on the construction industry. All citizens are involved in this industry either directly or indirectly. It is the primary source of income for around 30% of the global population. Construction is one of the least environmentally sustainable industries in the world since it uses around half renewable and half non-renewable resources. It is obvious that the construction industry is a significant industry sector in the world, yet owing to the negative effects of building site activities, workers in this industry despise their jobs. On the other hand, growing populations also suggest greater strain being placed on social resources like housing. The exponential rise in housing demand puts further pressure on the construction sector as well as the manufacturing of common building materials like cement, steel, aluminum, and wood. Higher building expenses are a result of the large electrical and thermal energy required in the manufacturing of traditional building materials like cement. During this phase changes in construction practice can help in easing out of construction pollution.

Construction industry and effect on environment: The construction industry is a bigger contributor to these environmental issues. Due to the excessive use of construction materials, many resources have been exhausted. The production methods also create a larger carbon footprint and pollute the air, earth, and water.

Construction materials produce millions of tons of waste each year all over the world. These building materials have high levels of embodied energy, which results in significant CO_2 emissions. According to the Scientific and Industrial Research Organization, cement has an embodied energy of roughly 7.8 MJ/Kg and steel has about 32 MJ/Kg. Cement is the material that produces the most CO_2, while processing and transporting building supplies both produce significant amounts of CO_2. By the year 2050, the global cement production could reach 3.5 billion metric tons, assuming that the use of building materials remains constant throughout the world. However, the production and utilization of building materials are both rising annually. If this is the case, then the annual output of cement could exceed 5 billion metric tons, emitting roughly 4 billion tons of CO_2 (carbon dioxide). The influence of construction materials is more dominant than the impact of other sources because of their widespread use. Because human needs and lifestyles are always changing, buildings' average lifespans are getting shorter, which leads to more waste being disposed of in landfills or recycled each year as buildings are demolished or renovated.

These findings suggest the need for additional scientific study to create building materials that are both more ecologically friendly and sustainable but also more reasonably priced without sacrificing building quality.

The most common construction material throughout the world is cement, which is used to make concrete. Global cement production was at 4.5 billion tons in 2016, and by the end of 2050, it's predicted to be around 6 billion tons. Carbon dioxide (CO_2) is released into the environment during the calcination of raw resources, including such limestone for clinker manufacturing and fossil fuels being used heating, during the manufacture of cement. Cement manufacturing produces 0.7–1 tons of CO_2 per ton of cement produced, or around 6%–8% of all anthropogenic CO_2 emissions. Additionally, the production of cement results in the discharge of numerous toxic gases, including carbon monoxide, nitrogen oxides, and Sulphur dioxide, as well as the contamination of heavy metals in the environment.

The most significant and pressing difficulty facing the cement industry at the moment is reducing CO_2 emissions and pollutants throughout the manufacturing process. Using supplemental cementitious materials as a partial substitute for concrete cement is a very appealing strategy; it can save emissions of CO_2 by up to 30%–40% and power utilization by up to 80%. Additionally, SCM usage lowers costs and enhances some concrete qualities. The most widely utilized SCM has historically been industrial wastes like fly ash from burning coal and blast furnace granulated slag from steel manufacture. The global shift away from coal utilization toward renewable energy and toward secondary manufacture from waste metal is threatening the availability of fly ash and pulverized blast furnace slag. It is therefore vital to develop alternate suitable SCM to replace cement.

Agricultural waste and its effect on environment:

Typically, agricultural wastes come from a variety of sources, namely farming, raising livestock, and aquaculture. The "3R" waste management approach currently uses these wastes for a variety of purposes. The six agricultural waste functions of management were used to present a typical waste disposal option for a chicken farm and to examine the agricultural waste management program (AWMS). Through a variety of direct and indirect mechanisms, agricultural waste has the potential to be hazardous to plants, animals, and people.

The nutritional and desirable features of the biowaste are being concentrated on in order to create diverse useable goods. Waste in general is polluting the air, water, and surface of the world. It should be transformed into useful form prior to contamination to reduce pollution levels, create jobs, and create an environmentally friendly environment.

Through actions either on or off the field, the agriculture sector also makes a significant contribution. There are both useable and non-usable components to these waste items. There are many distinct types of waste and they originate from many different places. The potential for its economy is increased by the waste materials' high nutritional values. This chapter studies and discusses the different forms, sources, and ways in which solid wastes can be transformed into numerous useable forms.

Agricultural waste estimates are uncommon, but they are typically believed to provide a sizeable fraction of the world's total trash to the industrialized world. Wastes again from irrational use of intensive farming techniques and the abuse of cultivation-related chemicals are typically present in agricultural development.

Waste products are either useable or useless items that are left over after the manufacture or composition of the principal goods made by human activity. India produces 62 million tonnes of mixed trash annually—waste that is both recyclable and nonrecyclable—with an average yearly growth rate of 4%, based on the Press Information Bureau.

Rice husk ash (RHA):

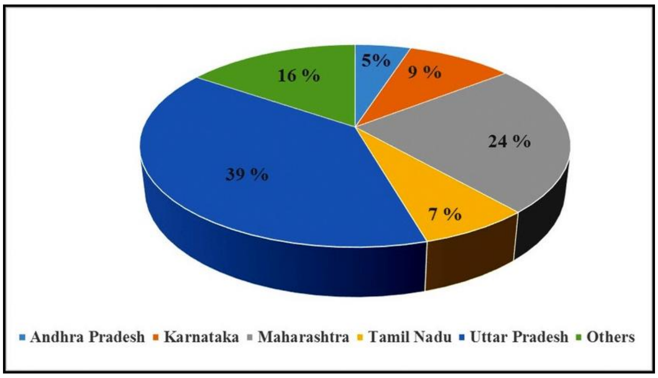
Rice husk ash (RHA) is produced by the rice industry as an agricultural remainder. Rice husk (RH) is the outer layer of the rice grain which is burned to form Rice husk ash (RHA). About 20% of RH (by weight) leftovers as RHA after the burning process. There aren't any known RHA applications that are good right now. RHA disposal at landfills contaminates the air and water in the neighborhood. Low-cost building can be achieved by the right usage of RHA as a supplemental cement replacement by the concrete industries. RHA contains granular or non-crystalline silica in the regulated burning chamber. RHA's microporous cellular structure aids in the pozzolanic reaction's conductance when Regular Portland Cement is present. Furthermore, differing RHA particle sizes have an impact on the hydrolysis process in concrete. SiO2 from the controlled combustion of RHA contributes to the formation of a secondary Calcium Silicate-Hydrate (C-S-H) gel, representing the growth of concrete strength.

As with rice husk ash, managing solid waste from waste products or residues is a severe environmental concern. Reactive amorphous silica, which contains around 90% silica, is created by burning rice husk. RHA is a component used to create self-compacting concrete (SCC). RHA greatly affects the characteristics of self-compacting concrete because of its pozzolanic nature. Strength and durability of SCC are improved by adding 10–15 percent RHA as a partial replacement of cement. Investigating the role of RHA in SCC would not only increase its use in SCC but also lower the cost of land-filling and offer a more sustainable and energy-efficient solution to the problem of carbon dioxide emissions from cement consumption.

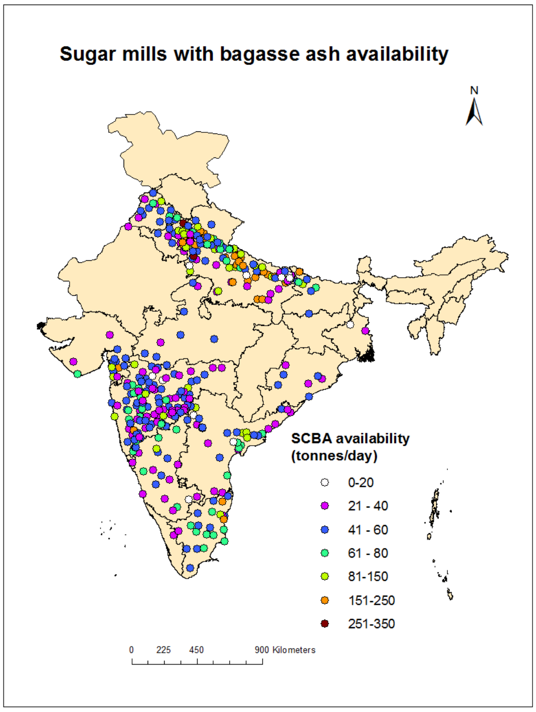
In India, 20 million tons of paddy are produced each year. Due to this, approximately 24 million tons of rice husk and 4.4 million tons of rice husk ash are produced annually. Steel, cement, and refractory bricks are the top three industries where rice husk ash is used. It can also be used for a number of other purposes. In India, rice husk is employed in a variety of small-scale applications, including the production of partition boards and animal feed. However, these applications are not systematic, and rice husk provides little nutritional value. Due of its fibrous nature, it may prove lethal for feeding cattle. India is the world's second-largest producer of rice, therefore a methodical approach towards this material may give birth to something like a new sector of rice husk ash in India.

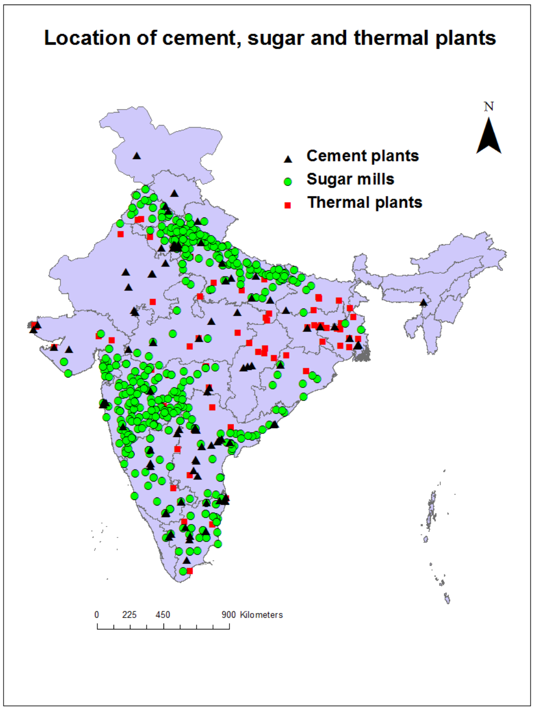
Sugarcane bagasse ash (SCBA)

Sugar cane bagasse ash is an ample byproduct of the ethanol and sugar industry. SCBA is usually used as a fertilizer or is inclined of in landfills, which has directed to increased environmental concerns. Waste material called Sugarcane Bagasse Ash (ScBA) is frequently used in the concrete industry. Due to its excellent pozzolanic qualities, it can be used as a partial replacement for cement in cement content and can be an acceptable alternative for preparing concrete mixes. Cement has just been partially replaced by ScBA in concrete mixtures in proportions of 0%, 10%, 15%, 20%, and 25% by weight in order to maximize the percent cement replacement by ScBA. Through study of several qualities like workability, compressive, and split tensile force (STS), the various effects of replacement by ScBA were examined. The method of sulphate resistant was also used to assess the durability of concrete. A rising number of research have recently concentrated on the expanding usage of cement substitute sugarcane bagasse ash (SCBA) made from agricultural waste. The Food and Agriculture Organization of the United Nations reports that sugarcane is the most productive crop in the world, with global sugarcane production reaching 1.91 billion tons in 2018. Fresh sugarcane is first shred, and then powerful rollers collect the juice. Bagasse is the fibrous residue that remains after the juice has been extracted (it makes up around 30%–34% of the bulk of new sugarcane). Second, the bagasse is utilized as cogeneration fuel in sugar mills. Finally, after being burned in a cogeneration boiler, bagasse is converted into SCBA (around 2%–3% by a mass of bagasse).



Because of its widespread availability and strong pozzolanic qualities, SCBA has received much study attention about its potential as SCM. The characteristics of newly-poured and hardened concrete containing SCBA were studied. They focused on the interaction between the SCBA concrete's compressive strength, tensile strength, and flexural strength. ASR (alkali silica reaction), electrical resistivity, carbonation resistance, resistance to acid and sulphate attack, and other crucial concrete qualities were not taken into account. Additionally, few research have summarized the microscopic examination of the pore structure, interfacial transition zone, and concrete morphology of SCBA. The sustainable environmental quantification in the use of SCBA in the manufacturing of Portland cement, which has





bec
om
e
increasingly significant in recent years globally, was not even mentioned in the evaluation.

India produces 90 million tons of bagasse annually, of which 8 to 10% by weight is used to make bagasse ash, or 44 220 tons a day. Ash generation is primarily rising as a result of the quickening pace of cogeneration process adoption in sugar mills. However, the growing volume of SCBA has not been utilized efficiently and is frequently disposed of locally. On the one hand, the priceless land is occupied by SCBA that was disposed of arbitrarily. On the other hand, it is also believed that groundwater might become contaminated by SCBA leakage. Therefore, employing SCBA in cement might lessen environmental contamination brought on by SCBA that was carelessly disposed of as well as the release of CO2 and other dangerous gases. Sugarcane Bagasse Ash's Effect on Concrete Properties

- Heat from hydration: With a rise in SCBA replacement level, total heat and peak average heat decline. A surface's resistance, choosing a time. The amount of water needed to make cement paste the typical consistency, Workability will improve when SCBA replacement levels rise.
- Soundness: Minimal growth, but not to the maximum allowed
- Compressive strength: As SCBA replacement level increases, it first rises and then falls.
- Split tensile strength: As replacement rate rises, it first rises and then declines.
- Flexural strength: Rises as curing age and SCBA content both rises.
- Elasticity modulus: Almost unchanged
- Thickness decreases, indentation modulus rises, and hardness increases in the interfacial transition zone (ITZ).
- Porosity: Rises with an increase in replacement rate.

Conclusion

The result of the study shows that there is great potential for the utilization of waste sugarcane bagasse ash and rice husk in concrete as replacement of fine aggregate as well as cement and fine aggregate. Decrease in slump value by 25% and compaction factor by 9% is examined when the replacement of sand by SBA in the concrete mix. Compressive strength of concrete cube at 7 days, 14 days and 28 days are decreased by 20%, 19% and 18% respectively when 40% SBA was used to replace cement. Compressive strength of concrete decreases initially with the inclusion of SBA. Flexural strength of concrete at 14 days and 28 days are decreased by 6% and 5% respectively when 40% SBA was used to replace fine aggregate.

The sugarcane bagasse ash influences the quality of cement. It has a good chemical composition and physical properties such as fineness, expansion, setting time and compressive strength. The best composition of sugarcane bagasse ash as substitution material in cement was 9% in weight of total weight of base material. If an optimal amount of superplasticizer is used, up to 20% of RHA and up to 10% of SCBA can replace OPC in cement without negatively impacting 6-month compressive strength or corrosion potential. The cement replaced by rice husk ash (RHA), Sugarcane Bagasse Ash (SCBA) and Fly Ash (FA) can be used for High performance Concrete, Insulators, Green concrete, Bathroom floors, Industrial factory floorings, Concreting the foundation, Swimming pools, Waterproofing and rehabilitation.

References:

- Potential Use of Rice Husk Ash (RHA) in Flowable Fill Concrete Kazi Islam1 and Zahid Hossain. College of Engineering, 504 University Loop, Arkansas Bioscience Institute (ABI), ABI-233W, State University, Jones

---

- V. Jittin *et al.* Evaluation of rheological and durability characteristics of sugarcane bagasse ash and rice husk ash based binary and ternary cementitious system.

Construct. Build. Mater. (2022)

- P. Jagadesh *et al.* Evaluation of mechanical properties of sugar cane bagasse ash concrete. Construct. Build. Mater. (2018)
- Y.R. Loh *et al.* Sugarcane bagasse-the future composite material: a literature review

Resour. Conserv. Recycle. (2013) F.L. Barbosa *et al.*

- Partial cement replacement by different sugar cane bagasse ashes: hydration-related properties, compressive strength and autogenous shrinkage. Construct. Build. Mater.

(2021) J.C.B. Moraes *et al.*

- Improving the reactivity of a former ground sugarcane bagasse ash produced by autogenous combustion through employment of two different additional grinding procedures. Construct. Build. Mater. (2021) G.C. Cordeiro *et al.*
- Effect of mechanical processing on sugar cane bagasse ash pozzolani city. Cement Concr. Res. (2017) L. Rodier *et al.*
- Potential use of sugarcane bagasse and bamboo leaf ashes for elaboration of green cementitious materials. J. Clean. Prod. (2019) V.G. Jiménez-Quero *et al.*
- Influence of sugar-cane bagasse ash and fly ash on the rheological behavior of cement pastes and mortars. Construct. Build. Mater. (2013) A. Bahurudeen *et al.*
- Performance evaluation of sugarcane bagasse ash blended cement in concrete. Cem. Concr. Compos. (2015) V. Ríos-Parada *et al.*
- Characterization and use of an untreated Mexican sugarcane bagasse ash as supplementary material for the preparation of ternary concretes. Construct. Build. Mater. (2017) D.H. Le *et al.*
- Fresh and hardened properties of self-compacting concrete with sugarcane bagasse ash-slag blended cement. Construct. Build. Mater. (2018) S. Praveenkumar *et al.*
- Strength, permeability and microstructure characterization of pulverized bagasse ash in cement mortars. Construct. Build. Mater. (2020) G.C. Cordeiro *et al.*
- Chrisna du Plessis (2002). Agenda 21 for Sustainable Construction in Developing Countries. A discussion document. The International Council for Research and Information in Building and Construction (ICRIBC), CIB, and UNEP International Environmental Technology Center. CSIR Building and Construction Technology, Pretoria, S.A. (Environmental Impact of Construction Materials and Practices) May 2014 DOI:10.13140/RG.2.1.2581.0001