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Green Concrete: A Leap Towards Sustainability

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***Abstract* -** Green concrete is being increasingly accepted by the construction industry given the dearth of downsides of conventional concrete and the several innate advantages of using green concrete. The major reasons attributed for the increasing demand of green concrete is the need of high-quality concrete products, urge to reduce the carbon footprint and the green-house gas emission, need for conservation of natural resources and the restricted landfill spaces in cities. Green concrete promotes sustainable use of waste materials as the alternatives of the conventional materials used in concrete. Establishment of codes and standard documents, demonstration projects, as well as public awareness, interdisciplinary collaborations and further research and development initiatives are needed to further promote embracing of green concrete in the construction industry in large-scale infrastructure projects.

INTRODUCTION

Due to urbanization, there has been a huge boom in the construction sector. The construction activities have increased manifold leading to a greater utilization of the conventional construction materials. The demand for cement, being the chief component or binder material in the concrete production has also got elevated. Concrete is the second most consumed material after water, with nearly three tonnes being used annually for each person on the planet. The production of concrete involves liberation of greenhouse gases including carbon dioxide. This has a huge impact on the environment. This production of CO_2 results in climatic changes, environmental hazards, human health problems, fossil fuel depletion as well as photochemical ozone formation. Traditional cement CO_2 emission is very high and, in some cases, can be equal to more than 1 tonne per 1 tonne of cement production (Krol and Błaszczyński 2013). Due to this fact ordinary cement, which is often called as Portland cement, unfortunately has become a serious environment and atmospheric pollutant. This happens while producing cement clinker which involves calcination of calcium carbonate which can be represented as:

$$5CaCO_3 + 2SiO_2 \rightarrow (3CaO,SiO_2)(2CaO,SiO_2) + 5CO_2$$

Because of this reaction 1 tonne of cement production is generating about 0.55 tonne of carbon dioxide. Additionally, it requires to combust fossil fuels which emit an extra 0.40 tonne of greenhouse gas. Unfortunately, there is no technology to reduce carbon dioxide emission of clean Portland cement. A peep into the production and consumption of cement in India can be taken in the Table 1. Overall, the domestic production of cement stood at 351 million tonnes in FY 2022, up from 285 million tonnes in FY 2021. The manufacturing of cement involves emission of considerable amount of greenhouse gases in the atmosphere. It is estimated that producing one tonne of Portland cement requires about four gigajoules of energy, which in turn emits 1.25 tonnes of carbon dioxide into the atmosphere (Wilson, 1993).

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Table 1: Production and Consumption of Cement in India ('000 million tonnes)

Year	Production	Consumption
2011-12	223,500.00	222,378.70
2012-13	240,614.00	240,387.60
2013-14	249,826.00	247,480.30
2014-15	261,338.00	257,412.60
2015-16	273,857.00	271,243.50
2016-17	270,375.00	266,823.50
2017-18	287,964.00	284,721.20
2018-19	327,722.00	324,927.90
2019-20	327,266.00	327,928.90
2020-21	284,913.00	285,308.90
2021-22	350,595.00	351,071.90
2022-23	374,558.50	375,190.70

(Source: CMIE, Infomerics Economic Research)

The International Energy Agency aspires Net Zero Emissions by 2050. It is a pathway for the global energy sector to achieve net zero CO_2 emissions by 2050, while also achieving universal energy access by 2030 and major improvements in air quality. The 2023 Net Zero Emissions by 2050 Scenario describes a pathway for the global energy sector to reach net zero CO_2 emissions by 2050 by deploying a wide portfolio of clean energy technologies, without offsets from land-use measures. It involves decisions about technology deployment driven by costs, technology maturity, market conditions, available infrastructure and policy preferences.
But, certain practices and new adoptions of alternate materials and techniques which conceptualize the whole idea of green concrete is the need of the hour. This paper presents an overview of the need of shifting from the conventional concrete to the green concrete making use of alternate waste materials adhering to the environmental concerns, cost advantage and solving the disposal issues yet comparable mechanical and physical properties as conventional concrete.

What is Green Concrete?
Jin and Chen (2013) defined green concrete as concrete produced by utilizing alternative or recycled waste materials to reduce energy consumption, environmental impact and natural resource consumption. Green concrete comes in various forms such as high-volume fly ash concrete, ultrahigh performance concrete, geopolymer concrete, lightweight concrete to mention a few. Green concrete offers numerous environmental, technical benefits and economic benefits such as high strength, increased durability, improved workability and pumpability, reduced permeability, controlled bleeding, superior resistance to acid attack, and reduction of plastic shrinkage cracking. These characteristics promotes faster concrete production, reduction of curing waiting time, reduction of construction costs, early project completion, reduction of maintenance costs and increased service life of construction projects. Therefore, green concrete may be concrete with partial to total replacement of ordinary Portland cement as a binder or concrete integrating waste and recycled materials as the constituent materials.

Alternative Materials to be Used in Green Concrete
The waste materials play the roles of either supplementary cementitious materials or alternative aggregates in green concrete. The replacement of cement with fly ash, blast furnace slag and other alternate materials in manufacturing green concrete to reduce the impact on the environment and also a means to reduce the overall cost of the manufacturing process.

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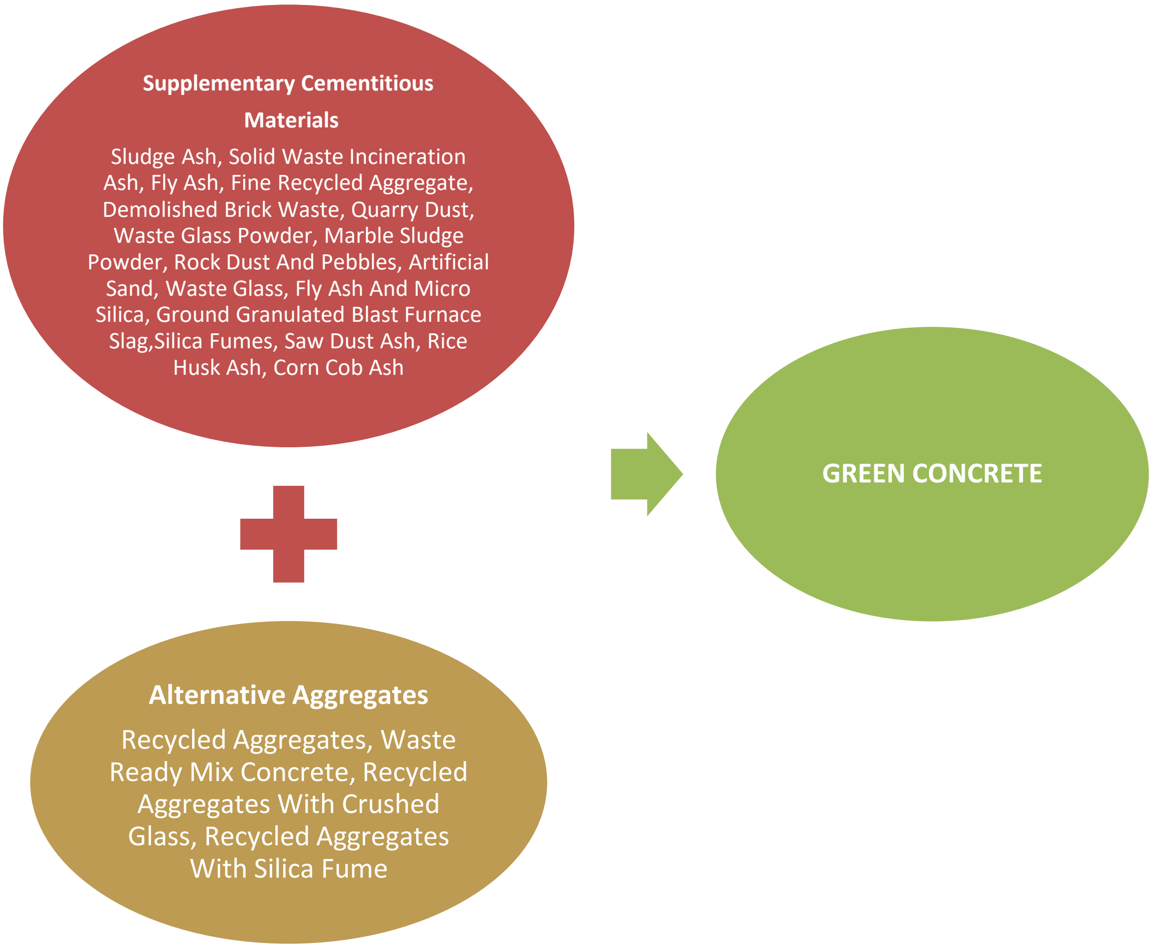

Use of Alkali-activated binders

Alkali-activated binders are one of the green alternatives to conventional ordinary portland cement. This is because of the partial or whole replacement of ordinary portland cement with aluminosilicate precursors. These are generally waste products from different industrial and agricultural processes such as fly ash, ground granulated blast furnace slag, rice husk ash etc. Total exclusion of ordinary portland cement from manufacturing of concrete implies a noteworthy paradigm shift towards sustainability of concrete. Carbon dioxide emission reduction up to 80% have been reported in the literature when alkali-activated binders are used in place of OPC (Duxson and Provis 2008). The use of these aluminosilicate precursors in concrete also paves way in solving the disposal issue posed by these waste materials.

Use of Recycled Aggregates

Aggregates and sand are a natural resource and limited in quantity. Given the dearth of urbanization, there is unscrupulous usage of these resources. Considering the fact that natural aggregate supplies are diminishing, there is a need to look for other sustainable options for their replacement. One such possibility is the use of recycled aggregates to manufacture ‘green concrete’. The demolished materials are considered as construction and demolishing (C&D) waste, and concrete constitutes a large part of this waste. Using recycled concrete in place of natural aggregates will help reduce the total cost of concrete production because aggregates need not be hauled from remote locations if not available locally. The combination of recycled aggregates with significant quantities of fly ash or blast furnace slag as a replacement for Portland cement is also a very viable option from both economic and environmental aspects. Green concrete would reduce the demand for conventional natural resources and lead to reduced energy consumption, generation of greenhouse gas in the manufacturing process of cement. These reductions can be considered as one of the construction industry's major contributions to the global greenhouse gas emission reduction objective. As the quantity of construction debris increases, it constitutes the construction and demolition waste and eventually lands up in the waste repositories or landfills, contributing to the existing management burden. Therefore, seeking alternative means of usage

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of concrete from construction and demolition operations to protect the environment and to gain economic benefits is pertinent.

Also, the extraction of aggregates from pits and quarries results in the destruction of the natural habitat of many species and causes disturbance of the pre-existing stream flow and water resources (Winfield and Taylor, 2005). The mining of aggregates alters the natural slope of the nearby areas causing a significant change in the drainage pattern of the catchment areas. The infiltration of rainwater into the soil undergoes a natural filtration process by passing through many layers of finer fractions of soil and aggregates. Mining of aggregates also disturbs this process hampering the groundwater reserves as well by reducing the water storage capacity of the ground.

Advantages of Green Concrete

- The process of manufacturing green concrete is not distinct than the conventional concrete.
- There is reduction in environmental pollution due to lesser greenhouse emissions.
- Compressive and split tensile strength is better with some materials compared to conventional concrete.
- The consumption of ordinary portland cement is largely reduced.
- Green concrete is economical compared to conventional concrete.

The major barriers for green concrete utilization in construction are the stereotyped approach, systemic lock-in, lower qualities of locally available materials, increase in construction costs, and technical barriers to name a few (Wesseling and Vooran 2016, Jin and Chan 2013).

CONCLUSIONS:

There is significant potential in waste or recycled materials to produce green concrete. The replacement of conventional constituents of concrete by waste materials and by products gives an opportunity to manufacture economical and environment friendly concrete. It has been reported that partial replacement of ingredients shows better compressive and tensile strength, improved sulphate resistance, decreased permeability and improved workability. Total exclusion of ordinary portland cement from manufacturing of concrete implies a noteworthy paradigm shift towards sustainability of concrete.

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