

# Sustainable Concrete Alternatives: A Review of Zero Carbon Concrete

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**Abstract:** *Researchers seek sustainable materials for eco-friendly cement and concrete to reduce CO<sub>2</sub> emissions. This paper offers an extensive overview of the research conducted on concrete technology with minimal to zero-carbon emissions. Carbon-neutral concrete offers a sustainable solution to reduce the construction industry's significant CO<sub>2</sub> emissions. By utilizing alternative binders, recycled materials, and carbon capture technologies, it minimizes the carbon footprint of traditional concrete production. This innovation supports global climate goals, promotes a circular economy, and enables eco-friendly construction practices. Carbon-neutral concrete is a vital step toward a greener, more sustainable built environment.*

**Keywords:** Zero carbon emission, Sustainable concrete, carbon footprints

## I. INTRODUCTION

Concrete, a cornerstone of modern construction, is a significant contributor to global CO<sub>2</sub> emissions due to cement production. Carbon-neutral concrete aims to address this issue by achieving minimal or net-zero emissions throughout its lifecycle. This is achieved through innovative approaches such as alternative binders, carbon capture technologies, and the use of recycled materials. By reducing the environmental impact of construction, carbon-neutral concrete plays a vital role in advancing sustainability and combating climate change.

### Why Carbon Neutral Concrete Matters

The construction sector is responsible for a large portion of global CO<sub>2</sub> emissions, and concrete is at the center of this issue. As the demand for concrete grows due to rapid urbanization and infrastructure development, it becomes increasingly important to find sustainable solutions for reducing its environmental impact. Carbon neutral concrete presents an opportunity to significantly lower emissions from one of the most ubiquitous materials in the world.

Achieving carbon neutrality in concrete can be seen as a vital step toward achieving global climate goals. By reducing the carbon emissions associated with the production and use of concrete, the industry can move closer to net-zero carbon construction and contribute to a more sustainable built environment.

### Carbon Footprint of Concrete

Concrete production, particularly cement manufacturing, is responsible for about 8% of global CO<sub>2</sub> emissions. The main contributors to its carbon footprint are:

#### Cement Production:

Chemical Emissions: CO<sub>2</sub> is released during the production of lime from limestone (about 60–70% of emissions).

Energy Use: The high-energy process relies on fossil fuels, contributing 30–40% of emissions.

Material Sourcing and Transport: Emissions come from mining raw materials (sand, gravel) and transporting them.

Mixing and Curing: The energy for mixing and curing concrete adds additional emissions.

End-of-Life: Concrete has a small ability to absorb CO<sub>2</sub> over time through carbonation, but recycling and demolition also contribute emissions.

### **Objective of Carbon-Neutral Concrete**

The primary objective of carbon-neutral concrete is to minimize or eliminate carbon dioxide emissions associated with its production and lifecycle. This includes reducing reliance on traditional cement, incorporating sustainable materials, and utilizing carbon capture technologies. The goal is to create an environmentally friendly construction material that supports sustainable development while mitigating climate change.

### **How Carbon Neutral Concrete is achieved**

Carbon-neutral concrete is achieved through various innovative methods. These include using alternative binders like geopolymer cement, incorporating supplementary cementitious materials (SCMs) such as fly ash and slag, and utilizing recycled aggregates to reduce raw material extraction. Carbon capture and utilization (CCU) techniques, such as injecting CO<sub>2</sub> into concrete during mixing, permanently sequester carbon. Additionally, energy-efficient production processes and renewable energy sources further reduce emissions. Optimized mix designs and carbon-absorbing additives like biochar also play a crucial role in lowering the carbon footprint of concrete, making it more sustainable for construction.

### **Results of carbon-neutral concrete**

The result of carbon-neutral concrete is a more sustainable building material that reduces the environmental impact of construction. It lowers CO<sub>2</sub> emissions by using alternative materials, energy-efficient production methods, and technologies like carbon capture and sequestration. This contributes to a circular economy, enhances the potential for carbon storage, and helps meet global climate goals by reducing the overall carbon footprint of concrete, one of the largest sources of industrial CO<sub>2</sub> emissions.

### **Examples**

In **India**, carbon-neutral concrete is being increasingly used in sustainable construction projects. Notable examples include the expansion of **Bangalore International Airport**, which incorporated low-carbon concrete to reduce its carbon footprint, and **the Indore SmartCity project**, where eco-friendly materials were used in infrastructure development. Additionally, **many IGBC-certified green building projects across the country** utilize carbon-neutral concrete to promote sustainability. These initiatives reflect India's growing commitment to adopting greener construction practices and reducing the environmental impact of development.

## **II. CONCLUSION**

In conclusion, carbon-neutral concrete represents a promising solution to reduce the environmental impact of the construction industry. By integrating alternative materials, energy-efficient practices, and carbon capture technologies, it can significantly lower CO<sub>2</sub> emissions and even achieve net-zero carbon footprints. This innovation contributes to sustainable construction practices, supports climate change mitigation efforts, and helps meet global sustainability goals, making it a key element in the transition to a greener, more sustainable built environment.