

# Chapter 9

## Advancing Smart and Sustainable Construction: Integrating Circular Economy, Energy Efficiency, and Economic Viability in the Built Environment

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### ABSTRACT

*Nearly 39% of all global CO<sub>2</sub> emissions and about 30% of natural resources are used in the construction industry, which makes it very important for sustainability. Although more businesses choose renovations, pay attention to energy saving, and focus on CSR, sustainable changes move at a slow pace due to lacking economic and environmental integration. Progress in sustainable products, circular economy models, energy-saving building techniques, and digital system applications are reviewed*

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*in this chapter. The use of low-carbon cement, recycled composites, passive design, prefabrication, and AI is changing the construction field. At the same time, the high expenses, strict rules, and reserved attitude among investors delay the industry's progress. It points out that policy incentives, financial instruments, and effective regulations are the most important for a change to green and efficient construction.*

## **INTRODUCTION**

Improvements in construction are being pushed to the forefront of the world's sustainability issues; with the end product producing almost 39% of total carbon dioxide emissions (CO<sub>2</sub>) and almost 30% of natural resources. The mandate for renovation, rehabilitation, and energy integration in the built environment has led to a shift to intelligent and sustainable construction practices. Adoption of the mentioned CSR initiatives, however, continues to be slow, and it is primarily because of the absence of integrated approaches that consider the environmental as well as the economic feasibility factors. This review examines state-of-the-art progress in sustainable materials, circular economy approaches, energy-saving methods of construction, and digital construction technologies. The study identifies such low carbon cement substitutes, recycled composites, passive design concepts, modular prefabrications, and AI-powered optimization which seem to be changing the face of construction. In addition, such things as the role of carbon capture, life cycle assessment and smart urban energy systems are analyzed to determine the impact of modern construction to the environment. In spite of such innovations, the high prices, regulatory hurdles and reticence of the market continue to stymie a wide spread use. This paper aims at offering an integral assessment of incentives through the government, financial models and regulatory strategies that could boost the transition to net zero construction. The construction industry can realize a resilient, low carbon, and resource-efficient future by combining advances in technology with circular economy principles and the economics of feasibility.

### **The Need for Smart and Sustainable Construction**

The construction industry is among the most extreme contributors to global carbon emissions, exhaustion of natural resources and energy usage. With the acceleration of urbanization, there is increased demand for infrastructure and housing, which has meant that the use of energy intensive materials like concrete, steel and bricks as become too prevalent. The built environment is responsible for about 39% of CO<sub>2</sub> emissions globally with about 28% derived from operational energy use and 11% due to embodied carbon in buildings (Terzis, 2025). In addition, construction

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