


Chapter 9

Transforming Spatial Design: Industry 6.0 Technologies and Circular Economy for Optimizing Material Lifecycles

Ishika Rachyutkumar Sojitra

 <https://orcid.org/0009-0008-0319-4281>

Manipal University Jaipur, India

Aditi Nag

 <https://orcid.org/0000-0002-0604-6945>

Manipal University Jaipur, India

ABSTRACT

The integration of Industry 6.0 technologies with Circular Economy (CE) principles is transforming spatial design, fostering sustainability and optimizing material lifecycles. The traditional linear “take-make-dispose” model in construction is unsustainable, necessitating a shift toward smart, self-organizing systems enabled by IoT, AI, blockchain, and big data. This study explores how these technologies enhance resource efficiency, facilitate material reuse, and minimize waste. Case studies of The Edge and Pavilion Circl in Amsterdam highlight strategies like real-time resource monitoring, predictive maintenance, and Design for Circularity (DfC). While challenges include high costs and workforce reskilling, phased implementation and policy incentives can drive adoption. This research underscores the need for architects, engineers, and policymakers to embrace Industry 6.0 and CE to create adaptive, resilient, and sustainable built environments.

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1. INTRODUCTION

Built environments stand as the greatest examples of human ingenuity and are considered a foundation for modern civilization. From small homes to gigantic skyscrapers, our buildings are the definition of how we live, work, and interact with the world. But at this point, that very foundation of our society is at a crossroads. The traditional linear model of “take-make-dispose” underpinning construction for centuries is proving unsustainable in the face of rising environmental challenges, dwindling natural resources, and a growing awareness of the interconnectedness of human activity and planetary health (Sariatli, 2017). Construction industry- one of the largest raw materials consumers and an important generator of global waste in the future would be required to undergo a change of paradigm-an evolution in resource relationship that, in fact, rethinks the notion of spatial design altogether (Breene, 2018). The integration of industry 6.0 technologies with circular economy principles is revolutionizing spatial design, promising sustainable and resilient built environments through redesigned material lifecycles.

The very concept of “space” itself is changing. The role is no longer only that of being a mere passive container of activity but an ever-changing and dynamic environment responding and interacting within its digital counterparts in ways which it is being reshaped, informed, and often dictated by sustainability imperatives. This comes together with advances in technology as well as rising consciousness in society. Industry 6.0 represents a fundamental step forward in industrial revolutions, one in which the two worlds of physical and digital are seamlessly intertwined with hyper-connectivity and decision-making based on data (Yadav, Rab, & Wan, 2023). Besides all the above foundations laid down by previous industrial revolutions, industry 6.0 goes beyond simple automation to create intelligent and self-organizing systems capable of adapting in real-time to new conditions. Such enabling technologies of the Internet of Things (IoT), AI, Big Data analytics, blockchain, and advanced robotics are merged to create smart factories and buildings, which facilitate optimized resource consumption, efficiency enhancements, and also more sustainable resource usage in manufacturing and consumption patterns.

At this stage, the wave of technological advancement is complemented by the CE ideology as it becomes an increasingly practical substitute for traditional linear economic activities. The linear economy, focused on extraction, production, consumption, and disposal, was an overwhelming burden on the finite resources of Earth and resulted in waste at unprecedented levels (Kumar et al., 2021). The opposite, the CE pushes for a closed-loop system where resources stay in use for as long as possible, extract all possible value, and generate as much waste as possible (MacArthur, 2013). This implies abandoning the “end-of-life” philosophy and embracing a regenerative approach that involves the reuse, repair, refurbishment, remanufacturing,

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