Interdisciplinary Approaches to Science and Management for Innovative Development

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Chapter 10

Circular Shift: Sustainable Engineering Infrastructure for a Changing World

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Abstract

In civil engineering, circular construction is a new way of executing that aims to reduce waste from construction and demolition, increase the reuse of materials, and encourage environmentally friendly building practices. For decades, the industry has used the linear model of construction, which is based on the order in which raw materials are initially first considered, products are made of them, used for construction at a suitable place, and then thrown away as dump. This linear model has spoiled the environment and the raw material resources and released more greenhouse gases, leading to global

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warming. As urban areas around the world grow at an unprecedented rate, the need for housing and infrastructure has skyrocketed. This system made a pressure on natural resources and environment in managing the waste management systems. The construction industry is the third most contributor of waste leading to carbon emissions leading to climate change.

Keywords: *Industry, Innovation, construction, recycling and Infrastructure.*

Introduction

The concept of circular construction has emerged as a practical solution for the problem of linear model which shows an upward trend. Circular construction is based on the larger idea of the circular economy. The main aim is to change how buildings are designed, built, maintained, and taken apart considering the current technologies. The main goal is to bind the circle for material loops by reusing, repairing, recycling, and regenerating resources throughout the construction process. The linear economy ends with disposal, but the circular economy focuses on keeping materials and products in use for as long as possible. This reduces the need for new resources and has less effect on the environment. This chapter discusses the problems and possible future directions for making circular construction a part of regular civil engineering work.

Circular construction is an interdisciplinary approach that needs to consider engineers, Government authorities, architects, policymakers, scientists to work together for closing the loop of problem stated above

in the environment. The ideas of implementation of sustainable design, life cycle of raw materials, managing the resources wisely and implementation of new technologies are included in this interdisciplinary approach. On use of modular construction, scheduling, using recyclable materials, material flow analysis and smart waste management systems are the techniques used to reduce the construction industry impact on environment in negative manner.

From the standpoint of an engineer, in circular construction the construction and demolition waste materials need to be reuse and recycle to the maximum extend by implementation of laws and policies by the Government. The main aim is to educate the policymakers, researchers and practitioners about the tools, techniques and encourage them to shift towards the environment which is more resource effective and regenerative.

Alignment of SDGs in Circular construction

Circular construction enables in an essential role in achieving the sustainable development goal (SDGs) plays a pivotal role in achieving several United Nations Sustainable Development Goals. The alignments of SDGs are

SDG 9: Industry, Innovation, and Infrastructure to support the clean technologies by encouraging the sustainable industrialization and innovation in construction and materials usage.

SDG 11: Sustainable Cities and Communities which promotes the safest, inclusive and sustainable urban environment. It also aims in

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reduction of pollution, optimizing the resource available and urban infrastructure development.

SDG 12: Responsible Consumption and Production which mainly aims in waste reduction, sustainable management of materials. It encourages the reduce, reuse, recycle and minimal waste generation

SDG 13: Climate Action aims in supporting the battle of climate change by lowering emission of GHGs in construction sector by reusing the materials and using energy efficient.

Sources of C & D waste

At different stages of construction, Construction and Demolition waste generated are

S.No	Sources	Waste Generated
1	Site Preparation	Excavated soil, uprooted vegetation, rocks, site grading spoil
2	Construction Activities	Excess concrete, brick and block debris, timber cut-offs, steel off cuts, tiles, pipes
3	Demolition Works	Crushed masonry, broken tiles, roofing sheets, plaster, wiring, sanitary fixtures
4	Renovation/Refurbishment	Discarded doors/windows, false ceilings, floor tiles, insulation material
5	Infrastructure Projects	Asphalt and concrete from road repairs, culverts, bridge components
6	Packaging Waste	Cardboard, plastic wrap, pallets, cement bags
7	Temporary Structures	Shuttering materials, scaffolding components (damaged), tarpaulin sheets

Composition of C & D waste

S.No.	Material Type	Range	Remarks
1	Concrete & Aggregates	40–50%	Major component from foundations, columns, slabs
2	Bricks & Masonry	10–15%	Includes clay bricks, mortar, plaster debris
3	Wood & Timber	5–10%	Shuttering, doors/windows, interior works
4	Metals (Steel, Aluminum)	2–5%	Reinforcement bars, pipes, frames, roofing
5	Plastics & Packaging Waste	2–3%	PVC pipes, insulation, wrapping, paint cans
6	Glass, Ceramics & Tiles	~5%	Window panes, tiles, sanitary ceramics
7	Other Materials	~2–3%	Bitumen, fabrics, cables, gypsum boards

Policies and Regulatory Frameworks

The legal demands and rules which are enforceable are in need of sustainable environment for safeguarding compliance and strengthen the responsibility in building industry. These rules enforce a formal framework in separation of materials, collection, recycle, reuse and disposal of C & D waste by also promoting the use of sustainable materials in both public and private projects. The environmental friendly rules have been enforced by the Government of India to deal with construction and demolition waste. In this, a Construction and Demolition garbage Management rule, 2016 is the revolutionary law which made the garbage segregation at source as mandatory. It also encourages the proper disposal of C & D waste and to use the recycled materials. This law made the execution of special places for recycling

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through Municipal Governments. Environment Protection law (1986) enforces the power of central government to protect the emission and controlling the trash disposal directly to the building. The municipal Solid trash Management Rules, 2016 supported the urban authorities to manage the types of trashes and garbage including C & D waste. Its main goal is reduce, recycle, reuse.

The Solid debris Management Rules of 2016 make this even stronger by requiring source separation and giving producers more accountability, which also applies to people who make construction debris. Rules about air and water purity are also very important. The Air (Prevention and Control of Pollution) Act of 1981 says that building operations must use responsible demolition methods and keep dust down to keep emissions under control. The Water (Prevention and Control of Pollution) Act of 1974 also sternly forbids the release of untreated building contaminants into bodies of water. The Energy Conservation Building Code (ECBC), 2007, requires buildings to be designed in a way that uses less energy and materials. This indirectly promotes circular concepts by reducing waste of materials and energy. The National Building Code (NBC) of India, 2016 sets out detailed rules for materials, structural design, and building methods. It encourages the use of eco-friendly and reusable parts. The Factories Act of 1948, even though it is older, is still very important for keeping construction and demolition workers safe and healthy, especially when they are working with recycled materials or in areas with hazardous waste. Together, these regulations make a strong legal base for implementing circular construction practices in India.

Incentives for circular construction

Governments and financial institutions globally have established various financial and regulatory incentives to promote the widespread use of circular architecture. These incentives aim to encourage the adoption of sustainable materials and technology while reducing the barriers to entry associated with circular activities. Certain regions offer tax incentives and refunds, including reduced GST rates for green-certified building products, thereby enhancing their affordability. Subsidies and incentives are provided to builders and developers who acquire on-site recycling equipment to enhance the management of construction and demolition (C&D) waste. Access to green building loans, which offer reduced interest rates, is increasing, contingent upon certifications such as GRIHA, LEED, or IGBC. Furthermore, enterprises utilizing recycled or certified environmentally sustainable products are often favored in government procurement processes, so gaining a competitive advantage in public bids.

Expedited approvals and other administrative incentives are also useful instruments. Building permits may be accelerated for projects that demonstrate evident circular building methodologies, such the reduction of virgin material usage, the repurposing of demolition waste, or the implementation of modular components. Furthermore, strategies such as material reuse and adaptive reuse of structures are being explored to promote reductions in embodied carbon via carbon credits and emissions trading programs. The Chennai Metropolitan Development Authority (CMDA) has expedited permits for significant public housing and infrastructure projects utilizing modular

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construction and repurposing construction and demolition waste, promoting resource efficiency and sustainability in urban development.

Implementation of Circular construction in India

Countries all over the world work on achieving SDGs and India have already started the pilot projects relating to circular construction. Some of implementation strategies involved in India are

- Swachh Bharat Mission (2014) which encourages the development of infrastructure in urban by efficient way of segregation, collecting and recycling and reusing the construction and demolition waste. Corporation, Municipalities are government authorities to set up the collection point and providing the processing facilities.
- Asia largest and first C &D waste processing unit was set up in year 2023 in Burari, New Delhi. It was an initiative from private-public partnership from NDMC (North Delhi Municipal Corporation) and IEISL (Indo-Enviro Integrated Solutions Private Limited) and have a processing capacity of 2000 TPD (tonnes per day). The process includes converting the construction waste debris into sand, paver blocks and aggregates. This is considered to be touchstone in recycle of C& D waste.
- GRIHA and IGBC Certification to the buildings promote the circularity in construction by awarding points on using reused/recycled materials, on site waste segregation and using sustainable materials like modular construction systems. These

green building rating systems integrate circularity by awarding points for buildings.

Implementation of Circular construction in Tamil Nadu

- Chennai Smart City Initiatives

  Under this mission, Chennai Corporation concentrate on implementing digital tracking systems which ensures safe disposal and reuse of C & D waste preventing the illegal dumping. It also encourages in implementing the reuse materials in constructing footpath and road laying works reducing the pressure on landfill. For non-structural application works, recycle concrete usage is encouraged.

- Tamil Nadu Urban Habitat Development Board (TNUHDB)

  Implementation of fly ash bricks instead of traditional bricks promotes the sustainable and efficient building practice. On using the prefabricated panels, on –site waste is reduced. The modular design is highly encouraged for its ease of disassembly and reuse of building components and promoting the circular economy.

- Coimbatore Urban Renewal Projects brings the holistic approach to sustainability, health and liveable environment on promoting urban green planning. The concrete reuse has been utilized in road sub grades and recycled concrete in non-structural components, thereby minimizing the carbon footprints.

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Barriers in Implementation of Circular construction

Even though there are more and more incentives and frameworks for circular construction, it is still very hard to put into practice, especially in developing areas like India. One of the biggest problems is that civil engineers, contractors, architects, and local builders don't know enough about it or have had enough training. Many people who work in construction either don't know about circular economy ideas or think they won't work because they think they are too expensive, too complicated, or not effective. The problem gets worse because circular construction isn't taught much in engineering schools or continuing professional development programs. This means that people don't have the knowledge and skills they need to make it work.

There are no clear rules or guidelines for using recycled construction materials, especially for structural purposes, which makes people less sure that they will work. People are still worried about the structural integrity, durability, and long-term performance of recycled aggregates and reused materials, which makes them less likely to be used in load-bearing parts. Also, it is very hard to make it work financially and get people to accept it. The initial costs of technologies like Building Information Modeling (BIM), reverse logistics, and modular systems may be too high for small and medium-sized businesses, even if the lifecycle costs of circular construction are lower. Also, the market for recycled materials is weak and unpredictable, which is sometimes blamed on uncertainty about how well they work and how they look. There are problems with the rules and enforcement mechanisms in institutional frameworks that make it hard to carry out effectively. Even though India

passed the C&D Waste Management Rules in 2016, many local governments in big cities have not properly enforced them. This has led to a lack of working C&D waste processing facilities. Sometimes, the urban planning, public works, and pollution control boards don't work well together, which can slow down the approval of projects that include circular ideas. In the end, problems with infrastructure continue to be a major problem. India currently has about 35 working construction and demolition recycling plants, most of which are in cities like Delhi, Bengaluru, and Ahmedabad. In smaller cities and rural areas, sending trash to faraway recycling centers is not cost-effective or logistically possible, which stops even well-meaning developers from using circular practices.

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