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A Detailed Review of Construction and Demolition Waste

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I. Introduction

1.1 General

The debris generated during the construction, renovation, and demolition of buildings, roads, and other structures is called construction and demolition waste (C&D waste). Because of rising urbanisation and infrastructural development, it is a serious and growing global problem. Accelerated urbanization, industrialization, and a rise in economic activity place strain on urban building sectors. In 2011, India had 370 million inhabitants in urban areas alone, which is expected to double by 2030. The Indian construction industry grew at a 10% annual rate during the last decade. Furthermore, from 2000 to 2010, it was instrumental in raising India's GDP from USD 20 billion to USD 60 billion. [1,2] This increased expansion in India has motivated people to build additional infrastructure, which has resulted in the demolition of existing buildings to accommodate the current dynamic population growth in metropolitan areas. The global construction and demolition waste market was worth USD 126.79 billion in 2022 and is predicted to increase at a 7.8% CAGR during the forecast period. [3] The Building Material Promotion Council (BMPTC) estimates that India creates 150 million tons of building and demolition (C&D) waste per year. However, the declared recycling capacity is only 6,500 tons per day (TPD) – less than 1%.

1.2 Construction and Demolition Waste

The content of C&D waste varies depending on the age of the building being demolished, refurbished or the type of structure being built. Figures for C & D waste generation vary by region since they are heavily influenced by the type and style of construction or demolition project activities, which may be regional, site, or project-specific.[4]

In a study, Information from 40 nations across six continents was gathered and critically analyzed. It showed that construction and demolition debris produced in 40 nations globally reached more than 3.0 billion tons per year till 2012, and this trend is continuing. [5]

Recently it was discovered that China's C&D waste generation is estimated to be between 1.6 and 2.5 billion tons. [6] Every year, India produces approximately 112- 431 million tons. [7] According to reports, Brazil generates over 100 million tons of C&D trash. [8]

When older buildings are demolished in India, the most common demolition waste is soil, sand, and gravel, which accounts for bricks and masonry, concrete, metal, wood and others. Bricks, tiles, wood, and iron metal (BMTPC) are sold for reuse or recycling. 90% of the overall waste is excavations, concrete, masonry and wood.

Excavation results in the production of topsoil, clay, sand, and gravel. This can be reused as an infill at the same location after the excavation work is finished, or it can be transferred. During demolition, large quantities of bricks and masonry mixed with cement, mortar, or lime are generated as waste. Stone is formed during excavations or the dismantling of historic structures. Metal trash is generated in the form of pipes, conduits, and light sheet material used in ventilation systems, wires, and sanitary fittings, as well as reinforcement in concrete. Re-melting recovers and recycles metals. Timber from beams, window frames, doors, partitions, and other fittings is reused provided it is in excellent shape. However, wood used in construction is frequently treated with chemicals to prevent termite infestation and requires careful handling when disposed of. Other issues with wood waste include the inclusion of jointing, nails, screws, and fixes. [9]

TABLE 1. Typical composition of Indian C & D waste (CPCB, 2017)

Material	Composition
Soil, Sand & Gravel	36%
Brick & Masonry	31%
Concrete	23%
Metals	5%
Bitumen	2%
Wood	2%
Others	1%

II. Environmental Effects

In recent years, the disposal of C and D waste has become a major challenge. Some building owners, garbage hauliers, and demolition contractors unlawfully and illegally dispose of this waste in order to minimize transportation costs and tipping fees at waste disposal facilities. [10] Unauthorized disposal procedures have a number of negative environmental consequences. [11] For example, unlawful C&D waste disposal has been identified as one of the leading causes of floods in Chennai due to sewer clogging. An unlawful construction landfill collapsed in China, killing 75 people and damaging many facilities. While the literature advocates the recycling of C&D trash, the city corporations in charge of C&D waste management dispose of the material in landfills. Several challenges inhibit the development of infrastructure for recycling C&D trash in India and other developing nations, including a lack of awareness, inadequate legislation, lax enforcement, and insignificant incentives. [12,13]

Potential groundwater contamination is caused by trace amounts of hazardous elements such as organic compounds and heavy metals found in construction materials, or by incorrect disposal of residues or bulk chemicals in the waste stream. Degradation of groundwater quality may also occur as a result of higher levels of normally non-toxic compounds such as chloride, sodium, sulphate, and ammonia found in leachate created by C&D waste materials when landfilled. Other sorts of waste, such as ordinary municipal waste, industrial waste, and hazardous waste, may be attracted to an unlawful disposal site. These would have a negative influence on the site and increase the cost of clearing up the contaminated site. The open burning of demolition materials is a serious source of worry. When plastic, insulating foam, and painted wood are burned, they emit hazardous vapours.

III. UTILIZATION

The circular economy is an economic system based on business models that replace the "end-of-life" concept—a stage of any product that does not receive continuing support, either because existing processes are terminated or it has reached the end of its useful life—with reducing, reusing, recycling, and recovering materials in the production/distribution and consumption processes. [14]

The method of converting C&D waste into Recycled Aggregates in specialist recycling plants has been around for a while and gained prominence after WWII. Since then, significant progress has been made in the installation and development of treatment plants with the goal of generating recycled aggregate of the best possible quality. [15] The utilization of recycled aggregates in geopolymer concrete produces more workability than natural aggregates. This is because the pores of recycled aggregate have a high water absorption capacity, which improves the fluidity of the geopolymer concrete mixture. [16] High sodium hydroxide solution concentrations provide limited workability geopolymer concrete at the same liquid-to-binder ratio. This is due to the higher amount of silica and alumina leaching out at high geopolymerization solution concentrations, which enhances matrix stiffness. [17] Ground granulated blast furnace slag and fly ash combination-based geopolymer recycled materials concrete may be more workable than Portland cement concrete at the same water-to-cement ratio. [18] The compressive strength of Portland cement and geopolymer concretes decreases as the recycled aggregate component increases. But, the compressive strength of geopolymer concrete is greater than that of Portland cement concrete, especially when young. This is because temperature curing speeds up the polymerization reaction between the fly ash and the alkaline solution, resulting in faster initial aggregate bonding. Furthermore, the use of a geopolymer binder in recycled aggregate concrete alters the physical and chemical properties of the concrete. The reduction in void volume, density and uniformity of microstructures, development of new products, and lack of calcium hydroxide all result in geopolymer recycled aggregate concrete with higher compressive strength than Portland cement recycled aggregate concrete. Also, the density of the matrix is reduced by increased recycled aggregate content, holes at the microstructure interfacial transition zone, and a looser structure. [19]

Waste glass from building demolition and crushed containers has been widely researched as a recycled aggregate in concrete as well as a supplemental cementing ingredient. [20] According to one study, cementitious materials treated with microscale glass powders displayed superior mechanical and durability capabilities at later ages when compared to control concrete materials. These enhancements are most likely the result of the microstructure improvement generated by the pozzolanic feature of glass particles. [21] An inquiry looked into the viability of using recycled glass cullet as an aggregate in self-compacting concrete. With increasing recycled glass content, there was an increase in blocking ratio, workability, and air content, as well as a drop in compressive strength. Simultaneously, drying shrinkage and chloride ion penetration appeared to be decreasing. Overall studies of fresh and hardened qualities revealed that self-compacting concrete with recycled glass aggregates is feasible. [22]

To make blocks, broken bricks can be combined with cement and glue. These blocks are most commonly used for enclosure, greening, and ground tile. Using broken bricks as a raw material substitute for brick manufacture should be the third major recycling technique of crushed bricks, after road foundation. [23] A study developed C&D waste brick in two different compositions (F-type and C-type). As a replacement for natural coarse and fine aggregates, cement and fly ash were employed as a binder, together with C&D waste. For the necessary composition, physical and mechanical testing (compressive strength and water absorption) were performed in accordance with Indian Standards. The results were compared to the industry standard values for clay bricks. C-type brick has a composition of 1:2.75:2.25 (binder: fine aggregate: coarse aggregate). within Indian Standards for compressive strength of 9.91 N/m2, water absorption of 8.8%, and self-weight of 3.6 kg. The created sustainable product can be actually implemented in any area indicated by the manufacturer and fulfil the goal of solid waste management. [24]

Several studies have been conducted that indicate the possible use of various types of wood waste, or wood byproducts, as raw materials in the manufacture of particleboards. [25] Because of the scale at which timber or wood may be recovered, timber has a high recycling potential. If structural timber cannot be reused as is, it can be converted to glulam or further treated for non-structural elements such as panels, weatherboard, and chip or fibre-based products. [26] Wood from C&D Waste may differ from other wood wastes since it can be polluted with other elements such as cement, gypsum, or finishing products. C&D Waste wood can also be influenced by environmental factors like moisture, temperature, and UV light from the sun while being stored. This radiation can induce superficial changes in wood, such as micro-cracks, which might compromise the final product's quality. [27]

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IV. CONCLUSION

Rapid urbanization has led to a number of sustainability-related challenges. India will continue to consume massive amounts of fine and coarse aggregates and generate comparable amounts of C&D Waste. As cities grow in size, they will need to get materials from farther away, adding to higher transportation emissions as well as the effects of quarrying and other operations. Many Indian regions will import sand from other countries. C&D Waste recycling has the ability to alleviate these difficulties. A significant portion of garbage that is dumped openly or landfilled causes land use disputes and wastes precious construction minerals. C&D Waste may undoubtedly contribute significantly to the national economy while decreasing the use of natural resources and meeting the material requirements of various construction projects.

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