RUBBLE RECAST

NAVIGATING THE ROAD TO EFFICIENT C&D WASTE RECYCLING

RUBBLE RECAST

NAVIGATING THE ROAD TO EFFICIENT C&D WASTE RECYCLING

Research direction: Anumita Roychowdhury

Authors: Rajneesh Sareen and Sugeet Grover

Research support: Mitashi Singh and Harikrishnan CU

Intern support: Ayushi Sharma, Akansha Mishra and Ishita Batish

Editor: Akshat Jain

Cover and design: Ajit Bajaj

Illustration: Yogendra Anand

Graphics: Vineet Tripathi

Layout: Surender Singh

Production: Rakesh Shrivastava and Gundhar Das

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support.

Maps used in this document are not to scale.

Citation: Anumita Roychowdhury, Rajneesh Sareen and Sugeet Grover 2024. *Rubble recast: Navigating the Road to Efficient C&D Waste Recycling*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phone: 91-11-40616000
E-mail: cse@cseindia.org
Website: www.cseindia.org

Contents

Experts and organizations whose contributions were invaluable for the research

- Department of Local Self Government, Government of Rajasthan
- Nagar Nigam Greater Jaipur
- Nagar Nigam Jaipur, Heritage
- Jodhpur Nagar Nigam North
- Jodhpur Nagar Nigam South
- Udaipur Municipal Corporation
- Nagar Nigam Kota North
- Nagar Nigam Kota South
- Alwar Nagar Nigam
- Vidya R Nair, Picson Construction Equipments Pvt. Ltd.
- Raghu, Soma Srinivas Reddy Engineers & Contractors
- Dinesh Kumar, Arghya Engineering
- Manoj Saxena, Rise Eleven Group of Companies
- Himanshu Goyal, Rise Eleven Group of Companies
- Ashwin Reddy, Re Sustainability
- Mohd. Nasarullah, Re Sustainability
- Mukesh Dhiman, Re Sustainability
- Neeraj Jain, Terex India Private Ltd.
- Sandeep Malhotra, Ever Enviro Resource Management Private Limited.
- B B Makkar, Former Special Director General, CPWD
- Anurag Jain, Ever Enviro Resource Management Private Limited.
- Pradeep Khandelwal, Retd. Chief Engineer - Municipal Corporation of Delhi
- Radhakrishnan Aiyyer, Aiyyer Environment Resource Management Pvt. Ltd.
- Puzzolana
- Krishnendu Datta, Re Sustainability
- Sanjay Singh, CDE Asia limited
- Harvinder Singh Premjeet Bansal, Pimpri Chinchwad Municipal Corporation
- N P Sharma, Chandigarh Municipal Corporation
- Prabhjot Singh, Chandigarh Municipal Corporation
- Mangesh Dighe, Pune Municipal Corporation
- Rajendra Tidke, Pune Municipal Corporation
- Pimpri Chinchwad Municipal Corporation
- Pune Municipal Corporation
- Chandigarh Municipal Corporation

1. Why this report

India's building space is projected to significantly expand over the next two decades, potentially more than doubling its current capacity.[1] The buildings sector in India already emits close to 500 million metric tonnes (MMT) of carbon dioxide (CO_2) annually through embodied carbon.[2] India's floor area could nearly double as urbanization continues to grow, presenting a significant challenge for the country's Net Zero emissions target by 2070.[3] Global projections indicate, that by 2060, across the world, a city equivalent to the size of Paris will be built every week due to high urbanization trends.[4] To meet this demand, the construction sector has adopted a resource-intensive linear consumption model that consumes a massive quantum of resources.

The extent of the construction sector's dependence on virgin materials is evident from estimates indicating that 40–50 per cent of global resource extraction is directed towards housing, construction and infrastructure development.[5] Sand and gravel are the most frequently extracted minerals responsible for 69–85 per cent of annual mining activities.[6] The construction industry's hunger for them only seems to be growing. This can be witnessed by the fact that international trade of sand has surged six-fold over the past two decades.[7] This extraction from rivers, deltas and coastal ecosystems has come with significant environmental risks such as erosion, biodiversity loss, salination of aquifers and reduced protection against storm surges. These threats endanger livelihoods by compromising water supply, food production, fisheries and other essential services.[8]

Apart from material extraction, their associated emissions and environmental impacts, the present construction scenario is also responsible for generating significant amounts of waste. Construction and demolition (C&D) waste has been found to constitute upto 40 per cent of total waste stream in some cities.[9] While we extract materials at a tremendous environmental cost and produce significant waste, the potential value from debris generated during C&D activities remains underutilized.

C&D waste: A potential resource to bring circularity and reduce emissions

Experience from both India and abroad demonstrates that after processing, approximately 80–90 per cent of C&D waste can be repurposed for various

applications such as landscaping, earthworks and civil engineering projects.[10] Despite this, only a fraction of C&D waste gets recycled or reused in India.[11]

Recycling not only addresses the massive amount of C&D waste currently burdening the country but also provides a sustainable alternative to virgin material extraction, thus lowering the associated embodied energy. The processing of recycled aggregates is estimated to produce 40 per cent fewer CO_2e emissions compared to virgin aggregates, thus contributing to the reduction of the carbon footprint.[12] By repurposing materials such as concrete, steel, sand, aggregates and soil, the energy-intensive processes involved in extracting, refining and manufacturing virgin materials are circumvented. In India, where rapid urbanization and infrastructure development are fueling substantial construction activities, the use of recycled materials presents a critical opportunity to decarbonize the built environment.

Current challenges in India: Ecosystem gaps and dominance of informal sector

Currently, most of urban India lacks a proper C&D waste management ecosystem which is critical for this circular approach. Centre for Science and Environment (CSE)'s 2023 report, '*Construction and Demolition waste: Closing the waste loop for sustainability*', captures the gaps in the ecosystem. CSE categorized the different parameters involved in a C&D waste management ecosystem into mandates, steps to curb illegal dumping, collection system, user charges, processing and disposal, and recycle and reuse.

An assessment of 14 cities on these parameters revealed that institutional readiness in many cities is insufficient for systematic and scientific C&D waste management.[13] The implementation of Construction and Demolition Waste Management Rules 2016 has been rather sluggish, with numerous gaps. This includes gaps in data, infrastructure, regulations, enforcement and capacity.

Hence, the onus of retrieving value from this waste has been on the informal sector, which has been thriving because of this. The sector offers a convenient option to the generators to get rid of waste. In areas without a proper C&D ecosystem, this remains the only option. The informal sector recovers valuable material from the C&D waste but the rest of it often gets dumped illegally in city peripheries, forest areas, low-lying areas and waterbodies. Even though this is a more convenient and often cheaper option for the waste generator, the environmental costs for the city are high. In the absence of an effective C&D waste management system, this informal setup will continue to thrive and dump waste throughout the city.

CSE's evaluation of 14 cities also uncovered numerous instances of effective measures taken to formalize C&D waste management. These cities demonstrated improvements across various parameters, including regulatory mandates, initiatives to combat illegal dumping, and efficiency of collection systems. However, only a handful of them had effectively tackled the last leg of the ecosystem—processing, recycle and reuse. Over 34 C&D recycling plants are currently functioning in the country, most of which are highly dependent on the support of municipalities for sustenance.

Delhi is among the few cities which has managed to create a healthy ecosystem with five operational C&D recycling plants and more being built. Delhi has been at the forefront of C&D waste management for over a decade. The first recycling plant was setup in 2009 at Burari with a processing capacity of 500 tonnes per day (TPD). Despite initial struggles due to insufficient quantity and quality of waste feed, the Commonwealth Games in 2010 spurred efforts to clear debris, providing momentum for waste to reach the plant.

However, product uptake still remained a challenge until 2015–16, when the Government of National Capital Territory of Delhi (GNCTD) mandated the use of recycled C&D waste products for all municipal bodies and departments involved in civic works. The development of the market for recycled material, along with tighter surveillance and mandates, created a positive ecosystem. This attracted more players to enter the market and setup C&D recycling facilities in the city. Today, Delhi's C&D installation capacity has increased over ten-fold compared to 2009.

The city has also invested in an extensive collection system with around 255 points for non-bulk waste generators, making waste disposal convenient. Another indicator of Delhi's success can be gauged by its average tipping fees, which are considerably lower than those of other plants studied in this report.

Three stages where the government's support becomes critical for a successful model

There are three stages where the government's support can go a long way in the creation of a successful C&D recycling business.

- The first is during setting up of the recycling plant where the local government finds suitable land for setting up of the facility. The municipality also supports by providing access roads, electricity, water connections, etc. However, the government should attempt to find a site for the recycling plant close to the

city's construction hubs. This can reduce transportation costs associated with waste disposal and products being brought to the market.

- Once the plant has been setup, it requires waste to reach the plant and the recycled products to be absorbed in the market. For this to happen, the government can provide support by having a strong surveillance system and penalizing illegal dumping, mandating uptake of these products, linking construction contractor payments with adherence to uptake mandates, etc.

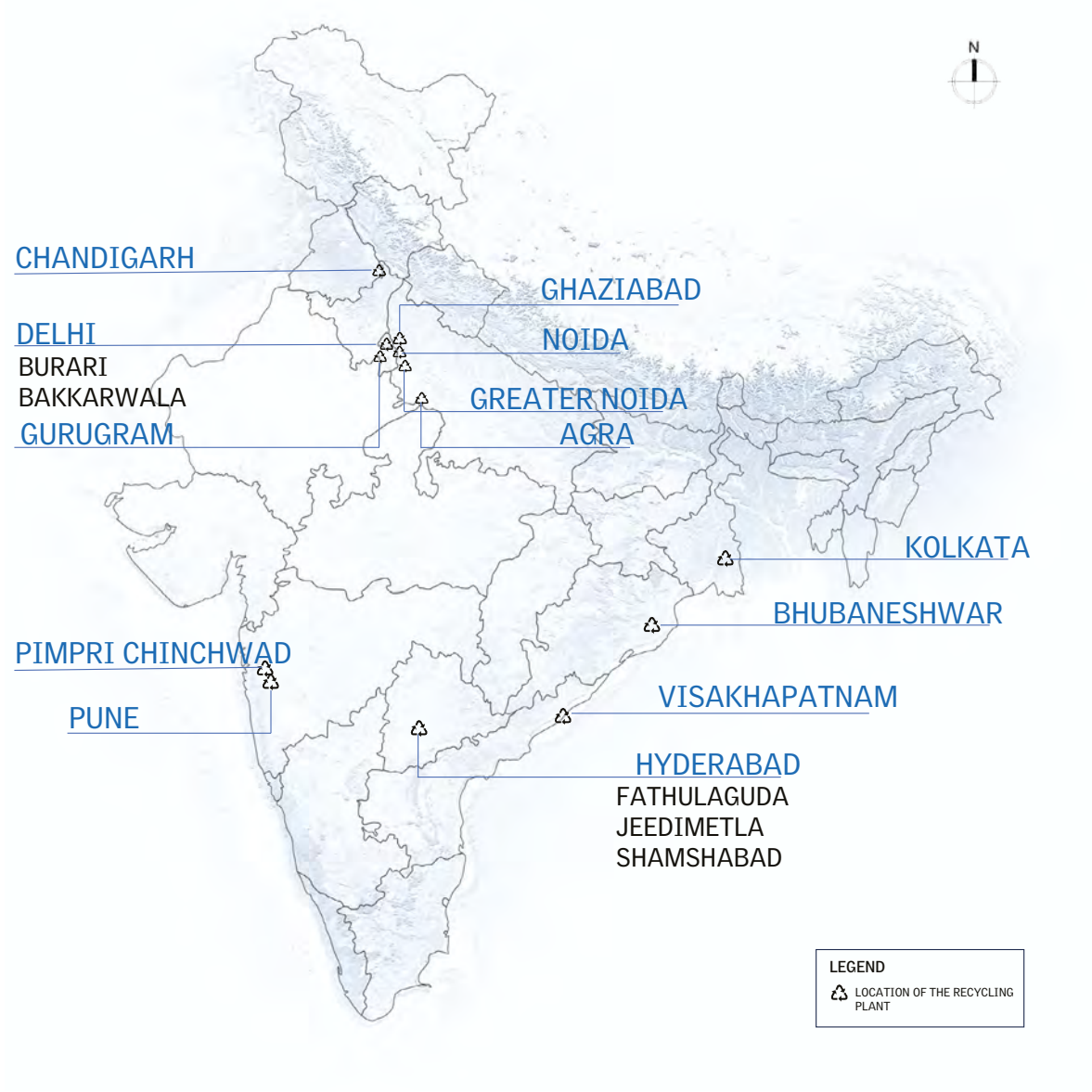
- The third step is enhancing material testing to ensure only high-quality recycled products enter the market, expanding their potential to replace natural materials. This requires collaboration among municipalities, plant operators and government construction companies. Construction companies should specify their product requirements to plant operators, who in turn need to supply products that meet those standards.

Government support for the initial phase has progressed well, with several successful public-private partnership (PPP) models emerging where the government has supplied land, access roads and infrastructure. The second phase, crucial for ensuring sustainable waste feed and boosting sales of recycled products, has not received adequate government backing. However, a few examples of good practices can be seen. In Pimpri-Chinchwad, the municipality is the largest purchaser of such products. Delhi has rigorous uptake mandates. Pune has integrated C&D waste management plans into building bye-laws These showcase successful ecosystems that have thrived with adequate government support. The third step is also something where the government construction companies need to contribute and work with the municipality and plant operators to bring out better quality products.

What did CSE study?

While CSE's prior research extensively covered the entire C&D waste management ecosystem, the current report focuses specifically on the recycling infrastructure leg needed to complete the loop. CSE has documented numerous C&D recycling plants nationwide and conducted interviews with various stakeholders engaged in tendering, establishing and operating these facilities. The report details the multifaceted processes inherent in a C&D recycling plant and explores the factors influencing its economic viability. It addresses challenges and concerns in the process and proposes policy interventions to streamline operations and transition towards recycling infrastructure models that can operate with limited government assistance. CSE visited over 16 recycling plants across India for the study.

Map 1: C&D recycling plants visited across India for the study



2. Status of C&D waste recycling infrastructure in India

The Construction and Demolition Waste Management Rules came out in 2016. They were formulated by the Ministry of Environment, Forest and Climate Change (MoEFCC) to provide a regulatory framework and guidelines for the effective management of C&D waste in India. These rules aim to promote sustainable waste management practices—including waste reduction, recycling and proper disposal—to minimize environmental impact and enhance resource efficiency in the construction sector.

The first C&D recycling plant in the country however predates the rules and opened in 2009–10 at a 7-acre site at Burari, Jahangirpuri in North Delhi. It was based on a financial model that involved private investment. Following Delhi's footsteps, Ahmedabad became the second city in India to adopt a C&D waste processing initiative, employing a similar PPP model. In 2014, a 300 TPD processing facility was inaugurated in the city.[14]

As of 2019-20, over 16 C&D recycling plants were operational in the country, mostly in cities with populations exceeding one million.[15] However, due to the support of various government schemes and initiatives, many more plants have since emerged across the country, even in smaller cities with lesser populations.

CSE collected data from various sources to compile a list of C&D recycling plants in the country. The sources included the Portal for Regulation of Air-pollution in Non-Attainment cities (PRANA) of the Central Pollution Control Board (CPCB), detailed project reports, and interviews with municipalities and plant operators. More than 34 plants of various capacities covering over 28 cities exist in the country. There are more C&D recycling plants in various stages of development. As per the data collected from various sources, over 36 C&D recycling plants are expected to come up over the next few years.

Table 1: Existing C&D recycling plants in the country

Sr. no.	City	State	No. of plants	Installed capacity (TPD)	Status of the plant
1	Vijayawada	Andhra Pradesh	1	200	Operations on hold
2	Vishakhapatnam	Andhra Pradesh	1	150	Operations on hold
3	Bhilai	Chhattisgarh	2	60	Unclear
4	Delhi	Delhi	5	5,150	Operational
5	Ahmedabad	Gujarat	1	1,000	Operational
6	Surat	Gujarat	1	300	Operational
7	Bhopal	Madhya Pradesh	1	100	Operations on hold
8	Jabalpur	Madhya Pradesh	1	50	Operational
9	Thane	Maharashtra	1	300	Operational
10	Hyderabad	Telangana	3	1,350	Operational
11	Ghaziabad	Uttar Pradesh	1	400	Operational
12	Noida	Uttar Pradesh	1	800	Operational
13	Raebareli	Uttar Pradesh	1	5	Operational
14	Kolkata	West Bengal	1	1,500	Operational
15	Prayagraj	Uttar Pradesh	1	400	Operational
16	Nagpur	Maharashtra	1	150	Operational
17	Tirupati	Tamil Nadu	1	80	Operations on hold
18	Indore	Madhya Pradesh	1	100	Operational
19	Chandigarh	Chandigarh	1	150	Operational
20	Agra	Uttar Pradesh	1	20	Operational, In process to be upgraded to 150 TPD
21	Pune	Maharashtra	1	250	Operational
22	Chennai	Tamil Nadu	1	1,000	Operational
23	Greater Noida	Uttar Pradesh	1	500	Operational
24	Pimpri-Chinchwad	Maharashtra	1	200	Operational
25	Gurugram	Haryana	1	1,000	Operational
26	Faridabad	Haryana	1	300	Operational
27	Bengaluru	Karnataka	1	500	Operational
		Total	34	16,015	

Table 2: Upcoming/in-development C&D recycling plants in India

Sr. no.	City	State	No. of plants proposed	Proposed capacity (TPD)
1	Kurnool	Andhra Pradesh	1	Unclear
2	Rajahmundry / Rajamhendravaram	Andhra Pradesh	1	25
3	Vishakhapatnam	Andhra Pradesh	1	200
4	Devanagre	Karnataka	1	Unclear
5	Gulbarga	Karnataka	1	Unclear
6	Hubli Dharwad	Karnataka	1	Unclear
7	Gwalior	Madhya Pradesh	1	Unclear
8	Nashik	Maharashtra	1	250
9	Navi Mumbai	Maharashtra	1	160
10	Ulhas Nagar	Maharashtra	1	Unclear
11	Vasai-Virar	Maharashtra	1	Unclear
12	Pune	Maharashtra	1	200
13	Solapur	Maharashtra	1	300
14	Angul	Odisha	1	Unclear
15	Bhubaneshwar	Odisha	1	150
16	Cuttack	Odisha	1	Unclear
17	Rourkela	Odisha	1	Unclear
18	Talcher	Odisha	1	Unclear
19	Ludhiana	Punjab	1	100
20	Patiala	Punjab	1	Unclear
21	Gorakhpur	Uttar Pradesh	1	Unclear
22	Jhansi	Uttar Pradesh	1	Unclear
23	Lucknow	Uttar Pradesh	1	300
24	Meerut	Uttar Pradesh	1	10
25	Moradabad	Uttar Pradesh	2	10
26	Jodhpur	Rajasthan	1	100
27	Kota	Rajasthan	1	100
28	Bikaner	Rajasthan	1	100
29	Ajmer	Rajasthan	1	50
30	Alwar	Rajasthan	1	50
31	Bareilly	Uttar Pradesh	1	Unclear
32	Agra	Uttar Pradesh	1	150
33	Amritsar	Punjab	1	Unclear
34	Dhanbad	Jharkhand	1	100
35	Hyderabad	Telangana	1	500
		Total	36	

Issues arising from the delayed formalization of C&D waste management

Although C&D waste has been generated for decades, formal systems for its management have begun to emerge relatively recently. For many areas, C&D waste was usually dumped on valuable land. This gap between the onset of C&D waste dumping and the delayed establishment of a C&D waste management system has led to several issues. There is pressing need for more timely and effective waste management solutions.

Legacy C&D waste acts as a source of dust

Legacy waste, often dumped on roadside or open plots, is a major source of fugitive dust pollution. This happens due to the natural weathering of materials and it gets propagated through wind. This is specially a significant issue around highways where the traffic movement further acts as a dispersal medium for the dust. As per source apportionment studies, roads, construction and soil dust was responsible for up to 42 per cent of PM10 generation in Delhi.[16]

Controlling this source of dust becomes especially vital for all non-attainment cities (NACs) under the National Clean Air Programme (NCAP) as they are required to reduce particulate pollution by 20–30 per cent from 2017 levels by 2024, and also meet the subsequent tighter target of 40 per cent reduction by 2026.

Images 1 and 2: C&D waste along roadsides leading to dust dispersal

Mixing up with municipal solid waste leads to inefficiencies and reduction in quality

Legacy C&D waste often gets mixed with municipal solid waste (MSW), complicating both MSW processing and C&D recycling. A study in Gurugram found that about 14 per cent of the waste was inert materials such as stone, brick, concrete, ceramics, sand and soil. Once mixed, it hinders composting and recycling of MSW and introduces hazardous substances such as sharps, broken glass, boulders, broken wooden logs, rusted metal and broken ceramics.[17] This not


Images 3 and 4: C&D waste mixed with municipal solid waste

only makes handling the waste dangerous, often causing injuries to waste workers, but also degrades the quality of recycled products.

The contamination of MSW with C&D waste complicates the recycling process while necessitating manual segregation at recycling sites, making the process labour-intensive, inefficient and costly. The mixing ultimately also reduces the purity and usability of recycled materials while limiting their application and value.

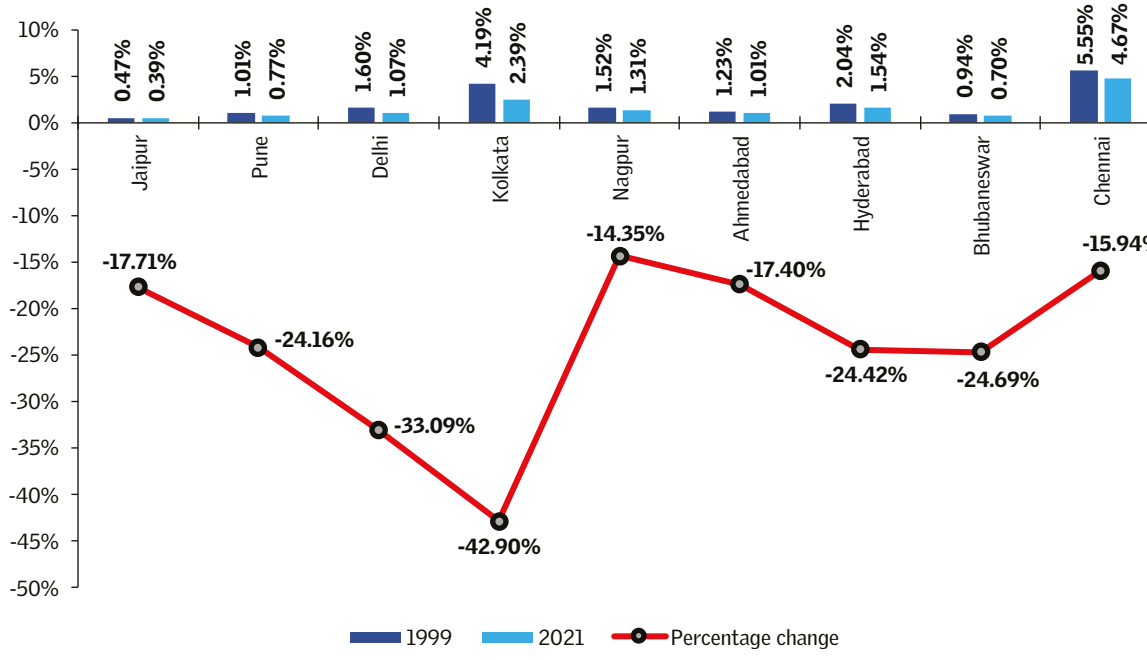
Choking of waterbodies

For decades, the incessant dumping of C&D waste has choked and caused the disappearance of waterbodies, thus reducing the natural sponges of cities. This practice clogs drainage systems, leading to urban flooding during rains. C&D waste is frequently dumped into or used illegally to fill wetlands, ponds, lakes, water channels and riverbeds. The disappearance of many urban waterbodies can be traced to C&D waste dumping.

In 2024, CSE conducted an analysis across nine cities to understand the variations in green and blue infrastructure over the years (from 1999 to 2021). The analysis revealed a decline in green and blue infrastructures in all the cities. In terms of waterbodies, Kolkata, Delhi and Bhubaneswar lost approximately 42.90 per cent, 33.09 per cent and 24.69 per cent, respectively. The incessant dumping of C&D waste into waterbodies is one of the reasons for the eventual decline of waterbodies across multiple Indian cities.

Image 5: C&D waste choking up a waterbody

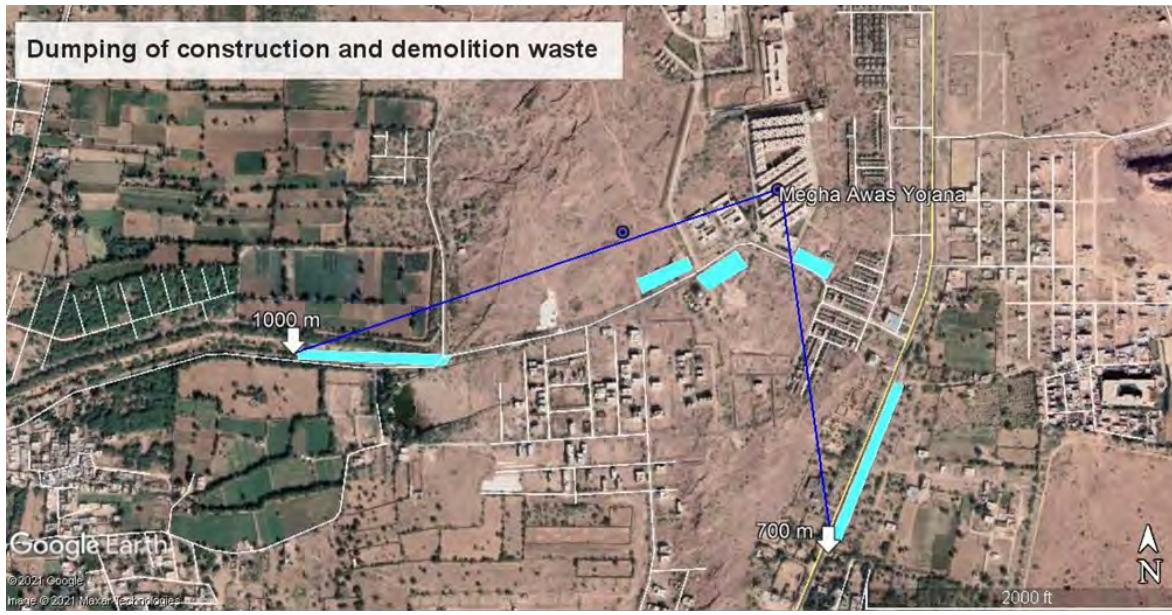
Graph 1: Changes in waterbodies (blue infrastructure) between 1999 and 2021



Source: Based on remote sensing interpretations by CSE

Disruption of natural contours

Dumping C&D waste disrupts natural land contours and alters watercourses, leading to obstructed hydrological channels and disrupted drainage patterns. This disturbance can increase surface runoff, erosion and sedimentation, which negatively impacts local ecosystems and water quality. Altered water flow can also exacerbate flooding in surrounding areas, posing significant risks to infrastructure and communities.



Images 6, 7, 8 and 9: CSE's field investigations revealed a trend of illegal C&D waste dumping occurring predominantly within a 1 km radius of construction sites

Loss of valuable land

Continuous dumping of C&D waste leads to the permanent loss of land that could otherwise be utilized for creating green spaces, parks or recreational areas. This practice not only diminishes potential urban greenery but also reduces opportunities for biodiversity conservation and public enjoyment of natural environments.

Energy and time intensive land reclamation

In the absence of a formal disposal mechanism, C&D waste gets dumped onto land and becomes compacted over the years. Once this land is taken up for construction activities, a lot of energy, time and resources is required to reclaim it and make it suitable for construction. This was witnessed in Bengaluru, where the lack of a formal C&D waste management system had severe repercussions


Images 10 and 11: C&D waste dumped on green cover area near Nathupur in Gurugram.

during the construction of the Kempegowda International Airport. During the first phase of its construction in early 2010s, the contractor disposed of waste on the site designated for the second phase. As a result, contractors for the second phase ended up facing challenges in cleaning up the site, leading to delays and additional expenses.[18]

Construction on reclaimed land involves risks

Building on reclaimed land poses significant challenges due to uncertainties about the land's bearing capacity and stability. These areas may not have undergone sufficient soil compaction, leading to potential hazards such as sinking, settlement or structural instability. For example, during the Bhuj earthquake in 2001, areas of Anjar that were developed on reclaimed land (dumped debris into waterbodies) experienced greater impact and damage compared to areas with stable ground.

Underutilization of a potential resource

A lot of C&D debris currently ends up in landfills, taking up a valuable volume of space. This is a waste of a potential resource that can be converted into recycled products. Products recycled from C&D waste are key components in the journey towards resource efficiency and circularity in built environment.

Hindrance to mobility

CSE's ground surveys have revealed a concerning trend where many footpaths are burdened with illegally dumped C&D waste. This accumulation not only obstructs pedestrian pathways but also compels pedestrians to use roads, putting them at risk of accidents and injuries. Moreover, the presence of debris frequently impedes vehicular movement, causing traffic congestion and snarls.

Image 12: C&D waste dumped on roadside

3. Setting up of C&D recycling infrastructure: Economics involved

Due to better feasibility, larger cities like Delhi, Pune, Gurugram, Noida, Greater Noida, Pimpri-Chinchwad, Thane, Ghaziabad, Kolkata and Hyderabad have predominantly established their recycling plants through private investments. Smaller cities with lesser waste generation, however, have struggled to find bidders for establishing C&D recycling plants as the quantum of waste generated by them is less. It is here that support from schemes such as the ongoing Swachh Bharat Mission (SBM) 2.0, NCAP and the 15th Finance Commission (XV-FC) have been supportive.

Smaller cities—such as Surat, Lucknow, Prayagraj, Jodhpur, Kota, Bikaner, Ajmer, Alwar, Moradabad, Bareilly and Rewari—have established or are currently in the process of setting up their C&D recycling plants with the assistance of these schemes. These initiatives have bridged the financing gap for recycling plants, especially where private investment is insufficient or unfeasible. To continue this progress, these schemes will need to be strengthened in future iterations.

3.1 Funding and operating of C&D recycling plant: Prevalent models

The PPP model has emerged as the dominant one with most recycling plants being setup in the country through this route. Very few municipalities have adopted the Engineering Procurement Principle (EPC) model. Cities which generate lesser amounts of C&D waste or where municipalities are unable to ensure the collection of 200–300 TPD of C&D waste, find it hard to secure private investment and often seek support of Viability Gap Funding (VGF). The Jodhpur Municipal Corporation faced this problem when it did not receive a bid for their recycling plant tender even after multiple attempts. The current plant is being setup through VGF received under Swachh Bharat Mission 2.0.

Under the PPP model, land is provided by the municipality, while the plant is setup and operated by a private party for a fixed number of years (generally, 15–25 years). After the set duration, the land is transferred back to the municipality. The risk lies with the plant operator to recover the cost of setting up of plant

GOVERNMENT SOURCES OF FUNDING

MoEFCC launched NCAP in 2019, in collaboration with various ministries and states, with the aim of improving air quality at the city, regional and national levels. NCAP targets 131 non-attainment cities to reduce particulate pollution by 20–30 per cent from 2017 levels by 2024, with a subsequent goal of achieving a 40 per cent reduction by 2026. C&D waste management is a vital element integrated into the clean air action plans of all non-attainment cities. A total of approximately Rs 9,650 crores has been allocated to these cities from FY 2019–20 to FY 2023–24 (until 15 December) under NCAP. A 200 TPD C&D recycling plant was setup at Pimpri-Chinchwad with the help of funding received through this scheme.

Besides the specific funding earmarked for NCAP, the funding from XV-FC serves as a performance-based supplemental grant to address the critical funding gaps in clean air plans.[19] This allocation totals Rs 29,250 crore for urban local bodies (ULBs) and operates on a performance-linked basis. Disbursement of this grant occurs annually, dependent upon the performance of designated cities with populations exceeding a million. The city of Pune has utilized these funds to make C&D collection points in the city.

SBM 2.0 envisages a cost of Rs 600 crores for C&D waste management catering to a population of 17.14 crores. Out of these 600 crores, the central share is limited to Rs 378 crores, while state/ULB and private sector have a share of Rs 111 crores each. The guidelines list down 154 ULBs which constitute of non-attainment cities and remaining cities with population greater than 500,000. These cities can avail funding for procuring mechanized sweeping equipment and setting up processing facilities for effective management of C&D waste.

Under SBM 2.0, ULBs are encouraged to explore the possibility of implementing projects through the PPP model. However, in cases where it is not feasible, financial support in the form of VGF is available for the establishment of C&D recycling plants, which municipalities can access. The central share, allocated by the Ministry of Housing and Urban Affairs (MoHUA), is disbursed in three stages upon meeting specified conditions outlined in the guidelines. Central assistance covers 50 per cent of the funding gap, capped at 30 per cent of the project cost or in accordance with prevailing central government directives. However, if a project is deemed unsuitable for PPP by the state government, the Government of India's share may be treated as a grant to the ULB.

The latest initiative that can be availed by municipalities for securing funds for C&D recycling ecosystem is CITIIS 2.0. It is a collaborative effort between MoHUA, French Development Agency (AFD), KreditanstaltfürWiederaufbau (KfW), European Union (EU), and National Institute of Urban Affairs (NIUA)[20] to complement existing climate initiatives of the Government of India. This initiative presents an opportunity for cities to secure funding for projects that promote circular economy principles, particularly focusing on integrated waste management. Through Component 1 of CITIIS 2.0, financial and technical assistance will be provided to projects from up to 18 Smart Cities selected through a competitive challenge process.

Though the Swachh Survekshan (SVS) programme run by MoHUA does not provide funding, it has made C&D management more lucrative by including C&D waste management as a component. The programme not only evaluates cities based on waste management practices but also ranks them within a competitive framework, aiming to incentivize improvements in waste management. SVS 2024 guidelines provide marks for processing and selling of C&D waste. A total of 60 marks are earmarked for the C&D waste processed in the facility to make either products or raw-material.

and generating profit within the lease period. It is also called the Design-Build-Operate-Transfer model. A variation of this model has been recently applied in Hyderabad, which has four C&D recycling plants. In two of them, the land belongs to the municipality while in the latest two plants, it has been leased by the plant operator.

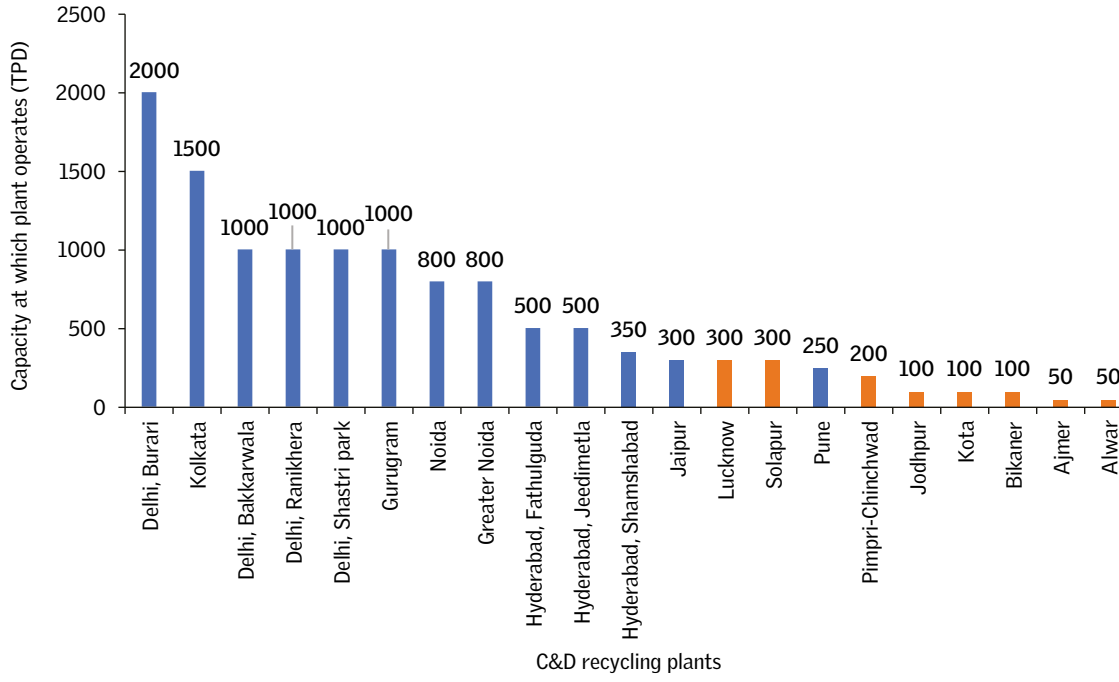
Cities establishing smaller recycling plants such as Pimpri-Chinchwad (200 TPD), Jodhpur (100 TPD), Kota (100 TPD), Alwar (50 TPD), Ajmer (50 TPD) and Bikaner (100 TPD) have been or are doing so with private funding but with the assistance of VGF.

Some municipalities, like Chandigarh, have adopted the Engineering Procurement Construction (EPC) model for their recycling plants. Upcoming C&D recycling facilities in Odisha are planned under a similar approach. In the EPC setup, a contractor assumes responsibility for designing, procuring materials and equipment, and constructing or installing the facility. Upon completion, the contractor hands over the plant to the municipality. Subsequently, the municipality may issue a separate tender for operating the plant, which could be managed either by a private entity or by the same contractor. The plant may directly be run by the municipality as witnessed in Chandigarh. Or as in the case of Bhubaneswar, the plant is proposed to be run by SHGs hired by the Bhubaneswar Municipal Corporation.

Table 3: Features of PPP and EPC models

Model	Features
PPP model	**Land provision:** Municipality provides the land for the recycling plant in most cases. **Private operation**: The plant is set up and operated by a private party for a fixed period (typically 15–25 years). **Risk management:** The private operator bears the risk of recovering the setup costs and generating profit within the lease period. **Ownership transfer:** After the lease period, the land is transferred back to the municipality. **Design-Build-Operate-Transfer (DBOT):** This model is also known as DBOT. Variations in Implementation: - In Hyderabad, some plants operate on municipal land. For the latest plants, the land has been leased by the plant operator.
EPC model	**Land provision:** Municipality owns the land. **Contractor responsibility:** A contractor is responsible for designing, procuring materials and equipment, and constructing or installing the facility. **Handover:** After completion, the contractor hands over the plant to the municipality. **Operational management:** - The municipality may run the plant directly (as seen in Chandigarh). - The municipality may issue a separate tender for operating the plant, potentially involving a private entity or the same contractor. - In Bhubaneswar, the plant is proposed to be operated by SHGs hired by the Bhubaneswar Municipal Corporation.

Graph 2: C&D recycling plants and their economic model



Note: Orange represents the plants that are supported by VGF

3.2 Component/Stage-wise cost breakup for setting up a plant

Establishing a C&D recycling facility demands significant capital investment due to the infrastructure, equipment and operational requirements involved. The key components/stages essential for setting up a C&D recycling facility include:

- **Site development:** Surveying of site, land levelling and setting up of boundary wall.
- **Building and civil works:** Machinery foundation, green belt, internal roads, store, workshop, office building, parking area, etc.
- **Vehicles and earth moving equipment:** Loaders, excavators, etc.

The costs associated with these components are significantly influenced by site conditions, groundwater levels, and the capacity and size of the recycling plant. For instance, a highly uneven site will require substantial investment in land levelling and landfilling to create a suitable base for construction. This process can be labour-intensive and costly, depending on the extent of the terrain's irregularity.

Moreover, sites with high groundwater tables present additional challenges that can escalate civil construction costs. Building foundations in such areas will need

to prevent water seepage and ensure structural stability. This requires specialized construction techniques and materials, further driving up expenses. The number and type of vehicles and excavators needed are also dictated by the scale of the recycling plant.

- **Auxiliaries:** Electrical connection, water connection, DG sets, anti-smog guns, etc.
- **Pre-operative expenses and interest during construction:** Salary for duration of construction of plant and interest on loans

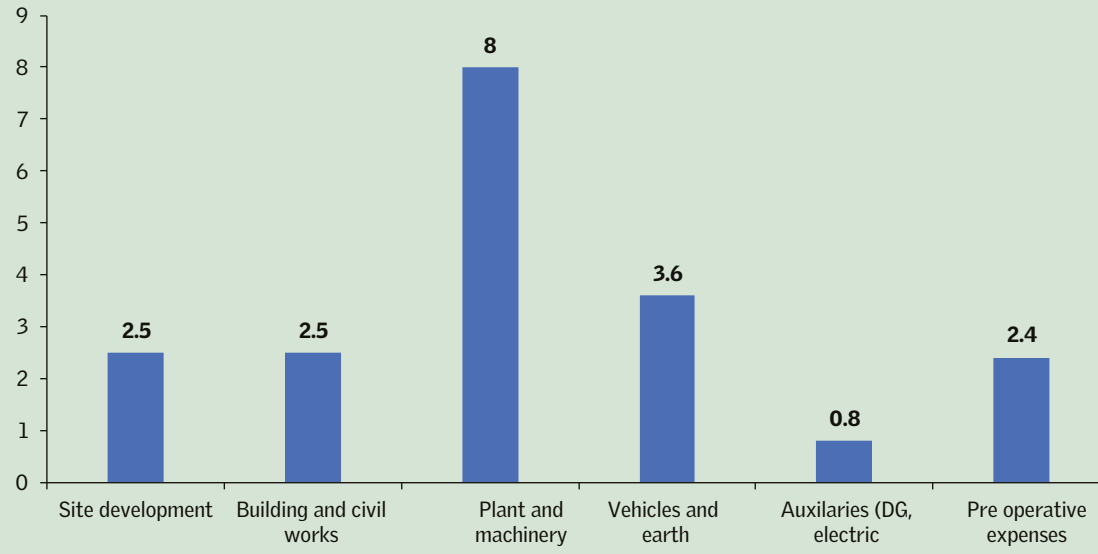
Auxiliaries such as electrical connections, water connections, diesel generators, and dust reduction machines like anti-smog guns and sprinklers remain relatively consistent and are not influenced by site or geographic conditions. Similarly, pre-operative expenses, including staff salaries during construction and interests on loans, are not affected by site conditions. These costs do not vary significantly based on the location of the project.

- **Plant and machinery:** Machinery such as crushers, screening and conveyor belts, etc.

This component can vary depending on the kind of equipment that the plant operator chooses to purchase. In a C&D recycling plant, two main processing technologies are used: dry and wet processing. Dry processing involves separating materials without using water, utilizing mechanical sorting techniques such as screening, air classification, magnetic separation and manual picking, which efficiently sorts materials like concrete, wood, metals and plastics. Wet processing, on the other hand, uses water to clean and separate materials through washing, rinsing processes, effectively removing contaminants such as dirt, dust and other impurities, making it particularly useful for cleaning materials like concrete and masonry. Wet technology does not leave behind light contaminants and fine particles. However, wet processing costs about 10–12 per cent more than dry processing.[21]

Economies of scale play a crucial role in reducing capital costs for larger recycling plants. When comparing a smaller plant with a processing capacity of 200 TPD to a larger plant with a capacity of 1,500 TPD, the corresponding increase in capital investment is only about 2.5 to 3 times. As the plant size increases, the per-unit capital cost decreases because fixed costs, such as those for land, equipment and infrastructure are spread over a larger volume of processed material. CSE interviewed multiple plant operators to understand the initial cost investment that goes into setting up a plant and received varied estimates (see *Graph 3: Processing capacity of plant and estimated initial investment*).

Estimated capital expenditure and breakup costs of a 1,000 TPD plant



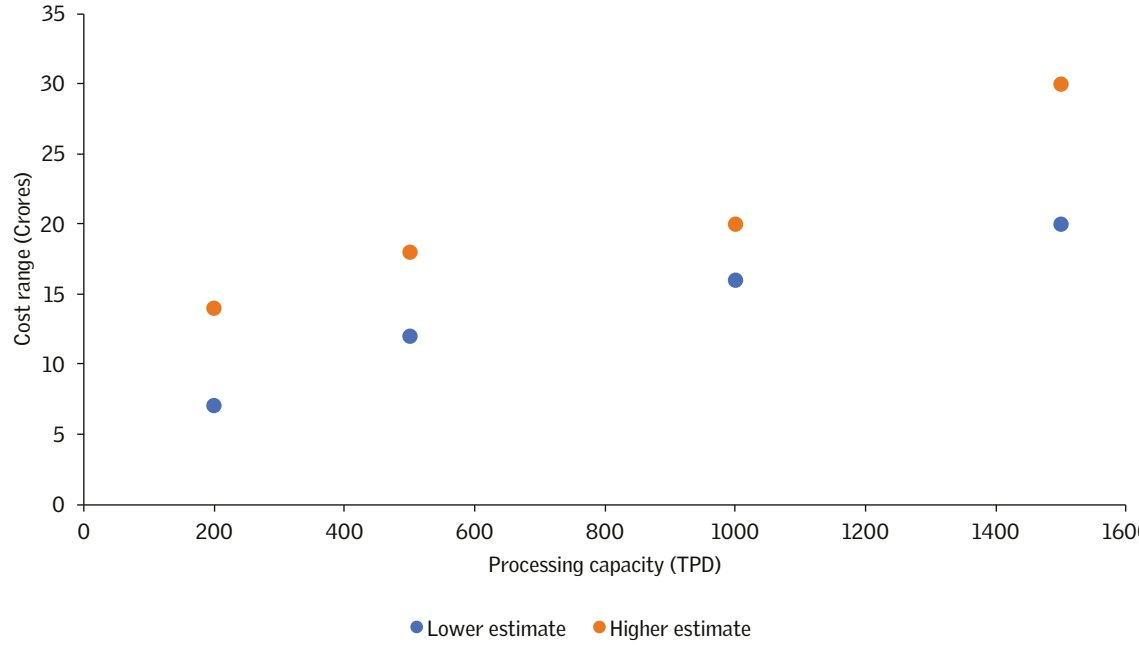
Source: As per estimates provided by multiple plant operators

The plant and machinery components are generally the most capital intensive, with costs varying from company to company. CSE carried out market research on the approximate prices of C&D recycling equipment. Estimates were sought from Cflo-CDE Asia, Picson Construction Equipments Pvt. Ltd, Terex India Private Limited and Puzzolana.

- The equipment requirements of a 100–200 TPD capacity plant with basic dry and wet processing technology ranges from approximately Rs 3.5–5.5 crores.
- A 1,000 TPD plant with dry and wet processing technology could cost upwards of Rs 6.5 crores.
- An 800–1,000 TPD dry processing plant without wet processing features is estimated to cost Rs 3.5 crores.

The different components involved in a C&D recycling plant and their functions have been discussed later in the report.

Graph 3: Processing capacity of plant and estimated initial investment



Source: Estimates based on data collected from various sources including interviews from plant operators

Table 4: C&D plants, their capacities and approximate capital cost

Plant/City	Maximum installed capacity (TPD)	Approximate capital expenditure (Crores)
Burari, Delhi	2,000	40+
Kolkata	1,600	22+
Bakkarwala, Delhi	1,000	20+
Gurugram	1,000	16+
Noida	800	22+
Greater Noida	500	12+
Jaipur	300	11+

3.3 Operational expenses of a C&D recycling plant

Consistent and high-quality supply of C&D waste along with an efficient transportation system can bring the operation costs down to Rs 350–450 per tonne. Without these, the operations cost can exceed Rs 600 per tonne. The expense can be categorized into two components each having their own push-pull factors: Collection-Transportation (C&T) and Processing.

The C&T component, which mainly involves vehicle charges for transporting C&D waste, constitutes a significant portion of the total cost in C&D waste

management despite being an overhead expense with no direct returns. As per interviews during the course of this study, the C&T cost was estimated to range approximately between Rs 245 per tonne to Rs 350 per tonne. However, these costs can be minimized through effective strategies such as ensuring an adequate number and strategic distribution of collection points to reduce hauling distances. Additionally, decentralizing C&D recycling facilities can enhance efficiency and cost-effectiveness. Utilizing optimally sized trucks can also play a crucial role in reducing transportation costs.

Processing costs include labour, maintenance and electricity required for handling waste within the recycling plant and may range from approximately Rs 230 per tonne to approximately Rs 400 per tonne, as gathered from various stakeholders during the course of this study. High-quality segregated waste reduces the need for labour and equipment, boosting processing efficiency. Additionally, plants processing larger quantities of C&D waste benefit from economies of scale, resulting in lower per-tonne costs. As waste volume increases, fixed costs are spread over more tonnes, reducing the average cost per tonne. This means the marginal cost of processing each additional tonne decreases.

3.4 Revenue models in recycling plants: Untapped possibilities

There could be several sources of income in C&D waste management. However so far, most plants are dependent majorly on two sources: 1) tipping fees paid by municipality or waste generator for collection and transportation of waste; and 2) sales of recycled products. Both the municipality and plants can expand their revenue streams for C&D waste management by exploring more options.

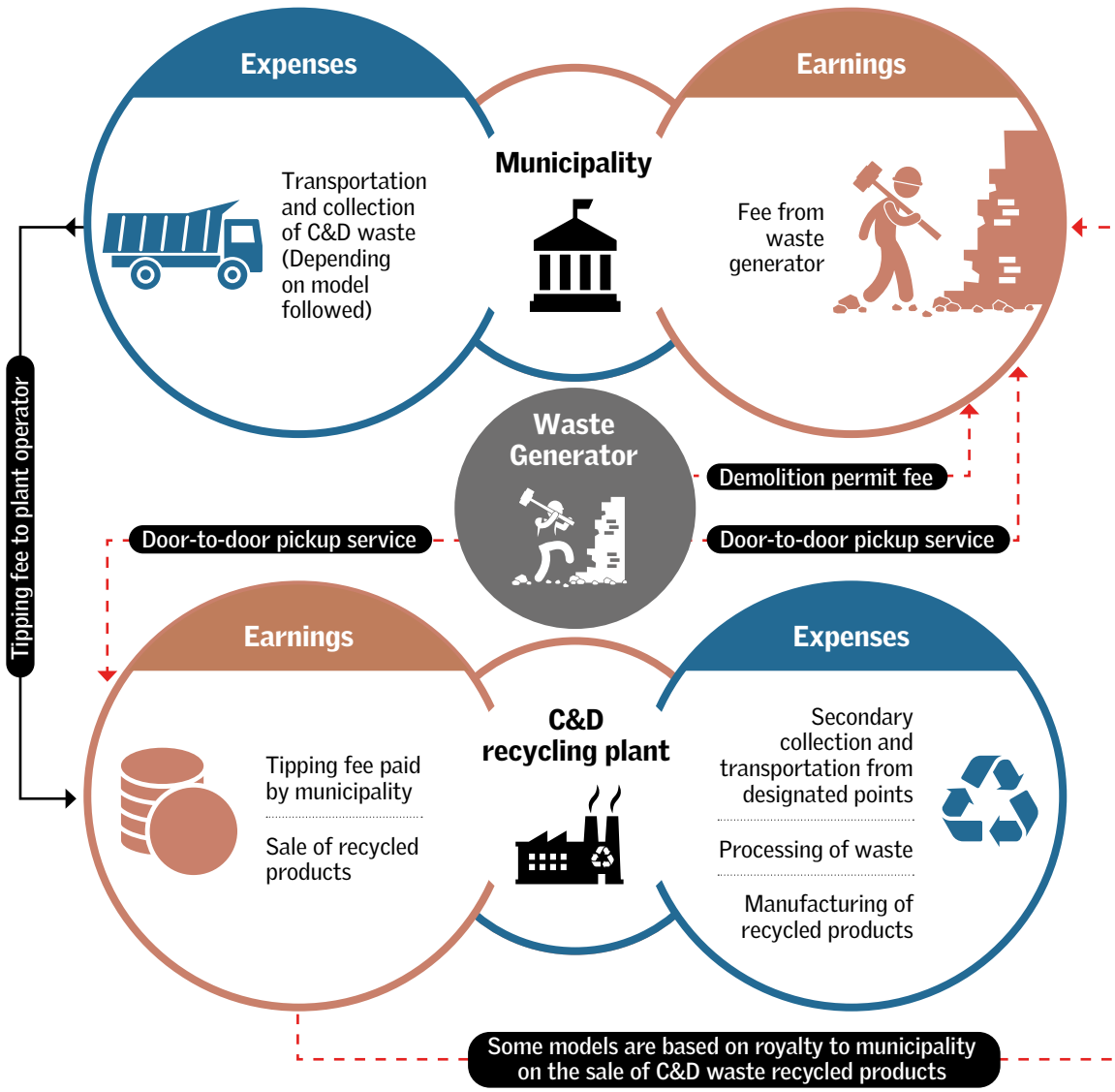
Sources of revenue that have not fully been tapped

Plants in Gurugram, Hyderabad and Delhi (Bakkarwala) offer a door-to-door service akin to the one provided by the informal sector. Such a door-to-door service for waste generators opens another possible stream of revenue for municipalities or plants. The service also provides the municipality a chance to ensure and control the segregation of waste at source.

Currently, there is no clear system for monitoring and regulating demolition contractors. The demolition sector should be formalized through an official permit system, which would improve management and material recovery, while also allowing for the better estimation of C&D waste. By formalizing demolition permits, the municipality will be able to better track the C&D waste produced on

site and ensure its transportation to the recycling plant while also curbing illegal dumping. It will also find it easier to ensure that several environmental safeguards such as dust mitigation measures (dust barrier sheets, wind breakers around site, etc.) are met. Additionally, the demolition permit fee represents an underutilized funding source for municipalities.

Figure 1: Expenses and earnings of municipality and recycling plant



The agreements between the municipalities of Gurugram, Lucknow and Kolkata and their respective plant operators have a clause wherein the plant operator additionally pays a certain royalty to the municipality on the profit from the sale of C&D waste recycled products. The plant in Gurugram pays an amount equivalent to 10 per cent of its sales to the Municipal Corporation of Gurugram. This opens another potential revenue source for municipalities.

3.5 The current setups

CSE's investigation indicates that non-bulk waste generators often resist paying fees for C&D waste management, resorting instead to illegal dumping. Tracking the waste produced by these small waste generators proves challenging, whereas monitoring waste from bulk generators, defined as those producing over 20 TPD or 300 tonnes per project per month, is more feasible. Consequently, systems that differentiate between bulk and non-bulk waste generators have proven more effective. Municipalities should keep this differentiation in mind when designing their systems.

Under the current setups adopted by municipalities, variations could be observed in terms of tipping fees paid by municipality, processing fee charges paid by bulk waste generator, and collection and transportation systems adopted (on-demand system, pickup from designated dumping points, etc.). Various approaches are employed for the collection and transportation of waste, with different stakeholders assuming responsibility. Some models delegate this task to the municipality, while others involve the plant operator, the informal sector, or even place the responsibility on the waste generator, who may employ various methods for disposal.

Transportation and collection carried out by municipality

The municipality of Chandigarh manages everything from collecting to transporting and processing waste without involving any private parties. They charge Rs 840 for each trip made by a tipper within a 5-kilometer radius.

Transportation of waste up to collection point in non-bulk waste scenario is the responsibility of generators

In the case of Delhi, Hyderabad, Noida, Greater Noida, Gurugram and Lucknow, the primary collection and transportation from site to designated collection points is carried out by the generator. This step is often carried out with the help of the informal sector.

Table 5: Various models adopted by different municipalities and plants

Recycling plant/city	Land provided by	Equipment provided by	Collection and transportation system	Tipping fees provision	Operations run by
Chandigarh	Municipality	Plant designed by private party, run by municipality	On-demand collection system run by municipality	No private party involved, municipality charges Rs 840 for a tipper per trip within 5 km. It charges Rs 50 extra for every extra km.	Municipality
Bakkarwala, Delhi	Municipality	Private party installation	On-demand collection system. Waste generator pays to municipality, waste picked up by plant operator. Bulk waste generator pays and delivers waste directly to plant operator.	Rs 124/tonne paid by municipality to plant operator. Rs 275/tonne paid by bulk waste generator to plant.	Private party
Burari, Delhi	Municipality	Private party installation	On-demand collection system. Waste generator pays to municipality, waste picked up by plant operator. Bulk waste generator pays and delivers waste directly to plant operator.	Rs 47/tonne paid by municipality to plant operator. Rs 275/tonne paid by waste generator if waste directly delivered to plant.	Private party
Noida	Municipality	Private party installation	Collection from dumping points	Approximately Rs 495/tonne paid by municipality to plant operator. Rs 175/tonne paid by waste generator if waste directly delivered to plant.	Private party
Greater Noida	Municipality	Private party installation	Collection from dumping points	Rs 407/tonne paid by municipality to plant operator (60% for transportation and 40% for processing)	Private party
Shastri Park, Delhi	Municipality	Private party installation	Collection from dumping points	Rs 466/tonne paid by municipality to plant operator. Rs 444/tonne paid by bulk waste generator to plant as processing fee.	Private party
Ranikhera, Delhi	Municipality	Private party installation	On-demand collection system. Waste generator pays to municipality, waste picked up by plant operator. Bulk waste generator pays and delivers waste directly to plant operator.	Rs 210/tonne paid by municipality to plant operator. Rs 215/tonne paid by waste generator if waste directly delivered to plant.	Private party

Recycling plant/city	Land provided by	Equipment provided by	Collection and transportation system	Tipping fees provision	Operations run by
Gurugram	Municipality	Private party installation	Collection from dumping points. On-demand collection system for bulk waste generators.	Rs 360/tonne paid by municipality to plant operator. Bulk waste generator can get C&D waste collected from plant operator by paying Rs 360 for segregated and Rs 720 for unsegregated waste. The plant operator can directly deliver the waste to the plant at Rs 205/tonne.	Private party
Bhubaneswar	Municipality	Private party installation	Unclear	No private party involved, municipality charges Rs 3,000 per truck and Rs 1,500 per tractor to the waste generator.	Self-help groups
Kolkata	Municipality	Private party installation	Collection from designated dumping points	Rs 369/tonne paid by municipality to plant operator	Private party
Jaipur (Upcoming)	Municipality	Private party installation	Collection from designated dumping points	Rs 390/tonne paid by municipality to plant operator	Private party
Pune	Municipality	Private party installation	On-demand collection system and collection from designated dumping points	Rs 226/tonne + Rs 24.62/km/tonne paid by municipality to plant operator	Private party
Pimpri-Chinchwad	Municipality	Private party installation	Collection from designated dumping points	Rs 245.75/tonne + Rs 13.5/km/tonne paid by municipality to plant operator. Rs 245.75/tonne paid by waste generator if waste directly delivered to plant.	Private party
Agra (Upcoming)	Municipality	Private party installation	Collection from designated dumping points	Processing and collection-transportation are two different tenders. Rs 205/tonne paid by municipality to plant operator for collection and transportation. Rs 176/tonne paid by municipality to plant operator for processing, same price paid by waste generator if waste directly delivered to plant.	Private party

Recycling plant/city	Land provided by	Equipment provided by	Collection and transportation system	Tipping fees provision	Operations run by
Lucknow	Municipality	Private party installation	Collection from designated dumping points	Rs 344/tonne paid by municipality to plant operator. Rs 325/tonne paid by waste generator if waste directly delivered to plant.	Private party
Solapur	Municipality	Private party installation	Collection from designated dumping points	Rs 149/tonne paid by municipality to plant operator for collection and transportation and Rs 215/ tonne for processing	Private party
Shamshabad, Hyderabad	Private, on lease	Private party installation	On-demand collection system and collection from designated dumping points	Approximately Rs 175/tonne paid by municipality to plant operator. Approximately Rs 450/ tonne paid by waste generator in case of door-to-door collection.	Private party
Jeedimetla and Fathulaguda, Hyderabad	Municipality	Private party installation	On-demand collection system and collection from designated dumping points	Approximately Rs 175/tonne paid by municipality to plant operator. Approximately Rs 450/tonne paid by waste generator in case of door-to-door collection.	Private party

Secondary transportation and collection carried out by plant operator; tipping fee charges paid by municipality to plant operator

The secondary transportation from collection points to the recycling plant is carried out by the plant operator and a tipping fee is paid by municipality to the plant operator. Gurugram, Noida, Greater Noida, Delhi, Lucknow and Hyderabad function on this model. However, the fee varies. For example, Burari charges Rs 47 per tonne, Bakkarwala charges Rs 124 per tonne, Ranikhera charges Rs 204 per tonne, and Shastri Park charges Rs 444 per tonne. In Greater Noida, the municipality pays Rs 407 per tonne to the plant operator, with 60 per cent allocated for transportation and 40 per cent for processing. Similarly, in Gurugram, the municipality pays Rs 360 per tonne to the plant operator. In Solapur, the municipality pays Rs 149 per tonne for collection and transportation, and Rs 215 per tonne for processing. In Noida, the fee hovers around Rs 495 per tonne.

Dynamic user charges based on transportation distance

Cities like Pune and Pimpri-Chinchwad have adopted a pricing model that considers the distance covered to transport C&D waste. Pune charges Rs 226 per tonne as the processing fee, with an additional Rs 24.62 per km per tonne paid by the municipality to the plant operator. In contrast, Pimpri-Chinchwad sets the processing fee at Rs 245.75 per tonne, with a transportation charge of Rs 13.5 per km per tonne paid by the municipality to the plant operator. Chandigarh has a similar system wherein Rs 840 is charged for each trip made by a tipper within a 5-km radius and an extra charge of Rs 50 is levied for every additional kilometre.

Separate processing fee for bulk waste generators

At the Burari, Bakkarwala and Ranikhera plants, bulk generators transport C&D waste directly to the facility and are charged a fee of Rs 275 per tonne for processing. Similarly, if bulk waste is delivered directly to the Noida plant, the operator charges approximately Rs 175 per tonne. In Gurugram, waste can be delivered directly to the plant by the operator at a processing charge of Rs 205 per tonne. In these scenarios, transportation charges are borne by the bulk waste generators.

C&D waste collection through on-demand service

The plants of Burari, Bakkarwala and Ranikhera in Delhi, and Shamshabad, Jeedimetla and Fathulaguda in Hyderabad offer an on-demand pickup service in addition to picking up waste from designated points. Gurugram also offers a similar system but for bulk waste generators.

Separate tenders for collection and processing

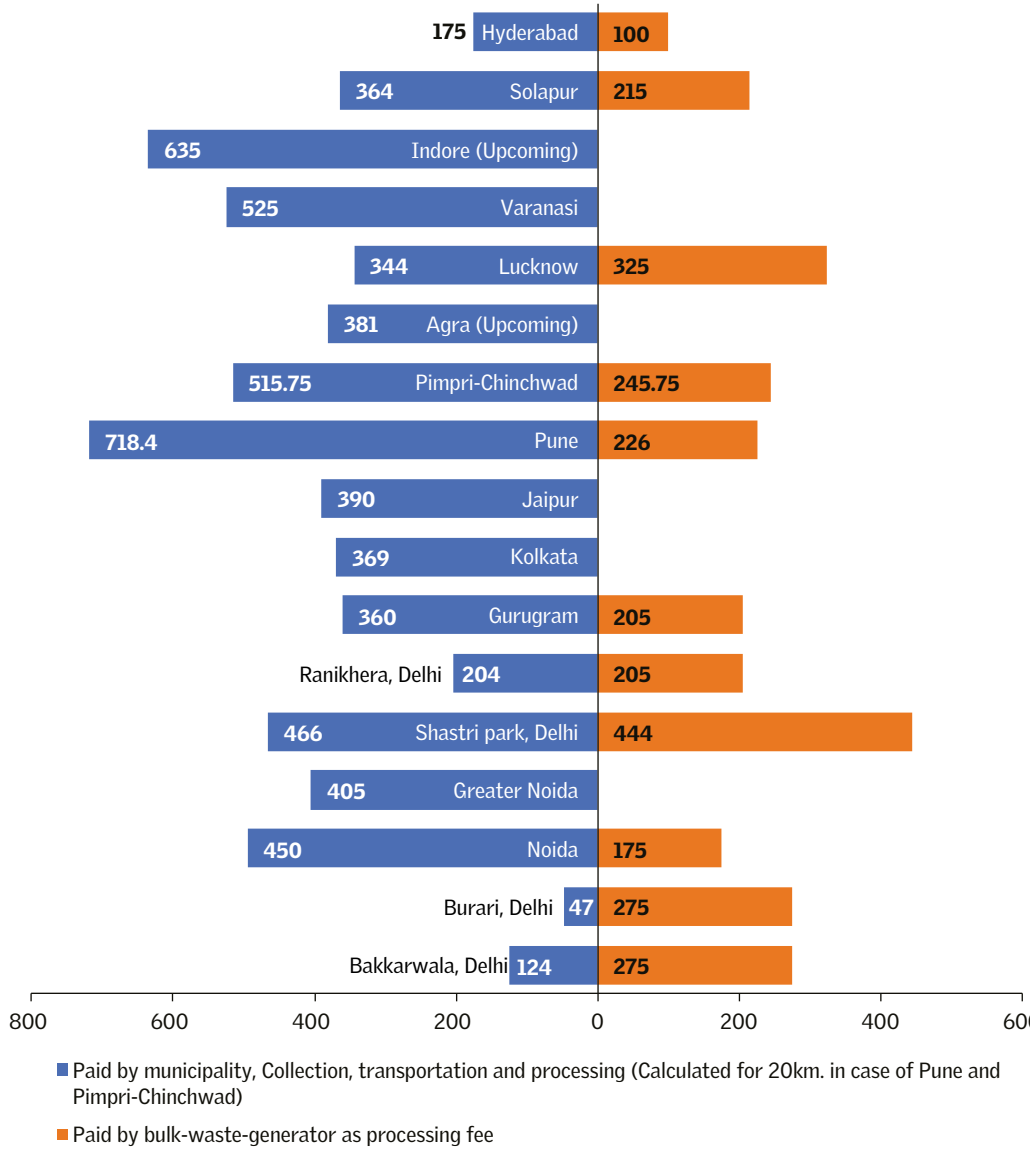
In Agra, the tender on collection and transportation of C&D waste has been kept separate from the tender on processing of waste. The operator charges the municipality Rs 205 per tonne for collection and transportation. A separate fee of Rs 176 per tonne is levied by the plant operator for processing of the C&D waste. A similar system exists in Pune and Pimpri-Chinchwad in which the two tenders have been kept separate.

3.6 Practices and learnings that maybe adopted

Lower tipping fee with the help of cross financing

Most of Delhi's plants have been successful in keeping the tipping fee charged from the municipality to a low rate. The average tipping fees charged by plants to the municipality in Delhi is Rs 210 per tonne, which is considerably lower than the tipping fees charged by other plants that are studied in this report (see *Graph 4:*

Graph 4: Fees charged by plants from municipality and bulk waste generators



Source: Multiple sources and interviews

Fees charged by plants from municipality and bulk waste generators). The latest two plants that opened in Delhi were in Bakkarwala with a tipping fee of Rs 124 per tonne and Ranikhera charging Rs 214 per tonne. A major reason for this is that Delhi has evolved a model wherein bulk waste generators pay a higher cost for processing than charged from the municipality. This essentially allows the plant operator to balance out the fee it charges, in essence keeping the tipping fee

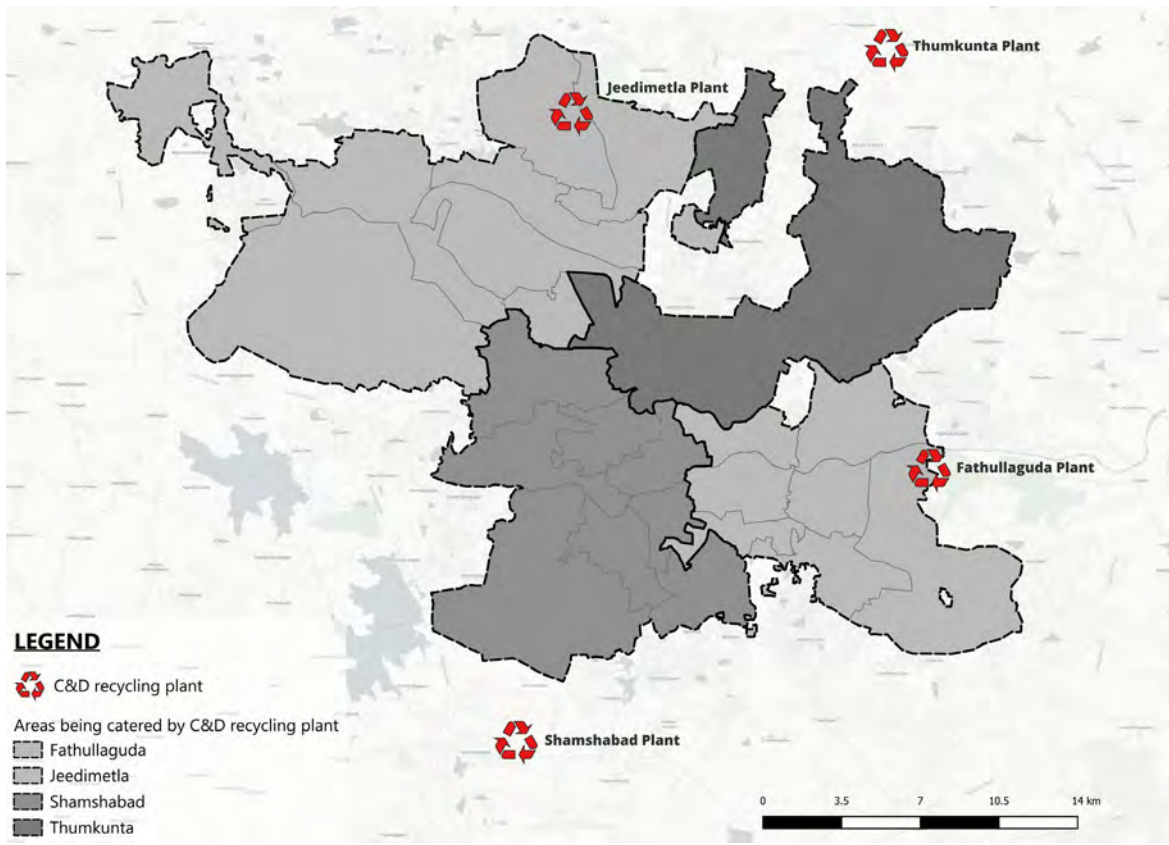
from the municipality to a minimum. This is a step in the right direction towards reducing the financial dependency on the municipality and making the financial model more self-sufficient.

Decentralized distribution of recycling plants cuts down transportation costs

Delhi and Hyderabad are the only cities with four or more operational recycling plants. This decentralization of C&D waste processing is beneficial as it reduces the need for waste to travel across the city to reach a recycling plant. Consequently, this cuts down on transportation costs and lowers the fee charged to the municipality/ waste generator. Keeping the fee low for waste generators encourages them to comply with the formal system of waste disposal. Consequently, the fee charged to waste generators for C&D waste disposal in Hyderabad is Rs 175 per tonne, which is amongst the lowest.

Setting up plants through the cluster approach

Map 2: Decentralized locations of the four recycling plants in Hyderabad



This cluster approach works very well for ULBs that generate small amount of waste as they can share the recycling plant with other such ULBs. The plant operator in turn gets enough feed to ensure the viability of running the plant.

The C&D recycling plant in Solapur is based on a model wherein it caters to other municipalities as well. It will take in 150 TPD waste from Solapur Municipal Corporation and 75 TPD each from Akkalkot Municipal Council and Mohol Municipal Council. Both these municipalities are within 40 km of Solapur.

The plant in Kolkata has a similar setup, Kolkata Municipal Corporation (KMC) commissioned a C&D waste recycling plant with a maximum processing capacity of 1,600 TPD. Of this capacity, 500 TPD is allocated for C&D waste from KMC, while the rest is reserved for other ULBs such as Bidhannagar Municipal Corporation, etc. However, it may be noted that the municipalities around Kolkata are adjacent to each other. The cluster solution might not work for areas where the municipalities are at a considerable distance and the cost of transportation becomes too high.

Integration of informal sector into the system for waste collection

Hyderabad has successfully integrated the informal sector into its waste management system, particularly for depositing household waste at collection points. This approach leverages the widespread presence and capabilities of informal waste collectors, enhancing the efficiency of waste collection and transportation. To further streamline the process and ensure compliance with legal standards, QR tags have been added to waste collection trucks. These tags enable authorities to easily distinguish between authorized and unauthorized vehicles, reducing illegal dumping and improving overall accountability within the system.

Incentivizing waste segregation

Gurugram has set up a system in which bulk waste generators can get C&D waste collected from plant operators by paying Rs 360 for segregated and Rs 720 for unsegregated waste. This system incentivizes C&D waste to be segregated, it is beneficial for both the waste generator who in turn has to pay lesser charges and for the plant which ends up receiving segregated waste.

Effective use of recycled products in municipal projects

In Pimpri-Chinchwad, the municipality has a clause in which they procure recycled C&D products from the plant at a discounted rate of 20 per cent in case of municipality construction. This benefits both the plant operator and the

Image 13: QR tags installed on C&D carrying vehicles in Hyderabad

municipality. While the municipality gets the product at a discounted rate, the plant operator gets an assured customer to whom the products can be sold. Most of the products produced by the plant get absorbed by the municipality.

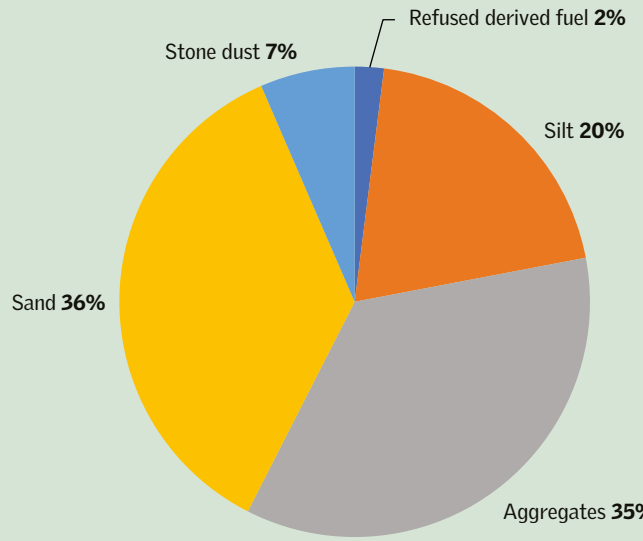
3.7 C&D waste composition impacts output and operational viability

The composition of C&D waste, a crucial determinant of the products generated by recycling plants, is subject to various external influences. These factors contribute to the quantity and quality of the waste feed received by recycling facilities, ultimately impacting their operational viability. Among the key variables affecting C&D waste composition are the predominant construction practices observed in the region, the level of awareness among waste generators regarding segregation practices, the maturity of the local waste management infrastructure, the stringency and enforcement of regulations governing C&D waste management, and the effectiveness of measures implemented to deter illegal dumping activities.

EVALUATING THE VALUE OF RECYCLED PRODUCTS

CSE gathered data from multiple recycling plants to understand the kind of products that come out of them, their proportions and the potential value that is held by these products in the market. The approximate proportions in which recycled C&D products come out are one-third aggregates of various sizes, one-third sand, and the rest a mixture between stone dust and silt.

Approximate output composition of C&D recycled products after processing



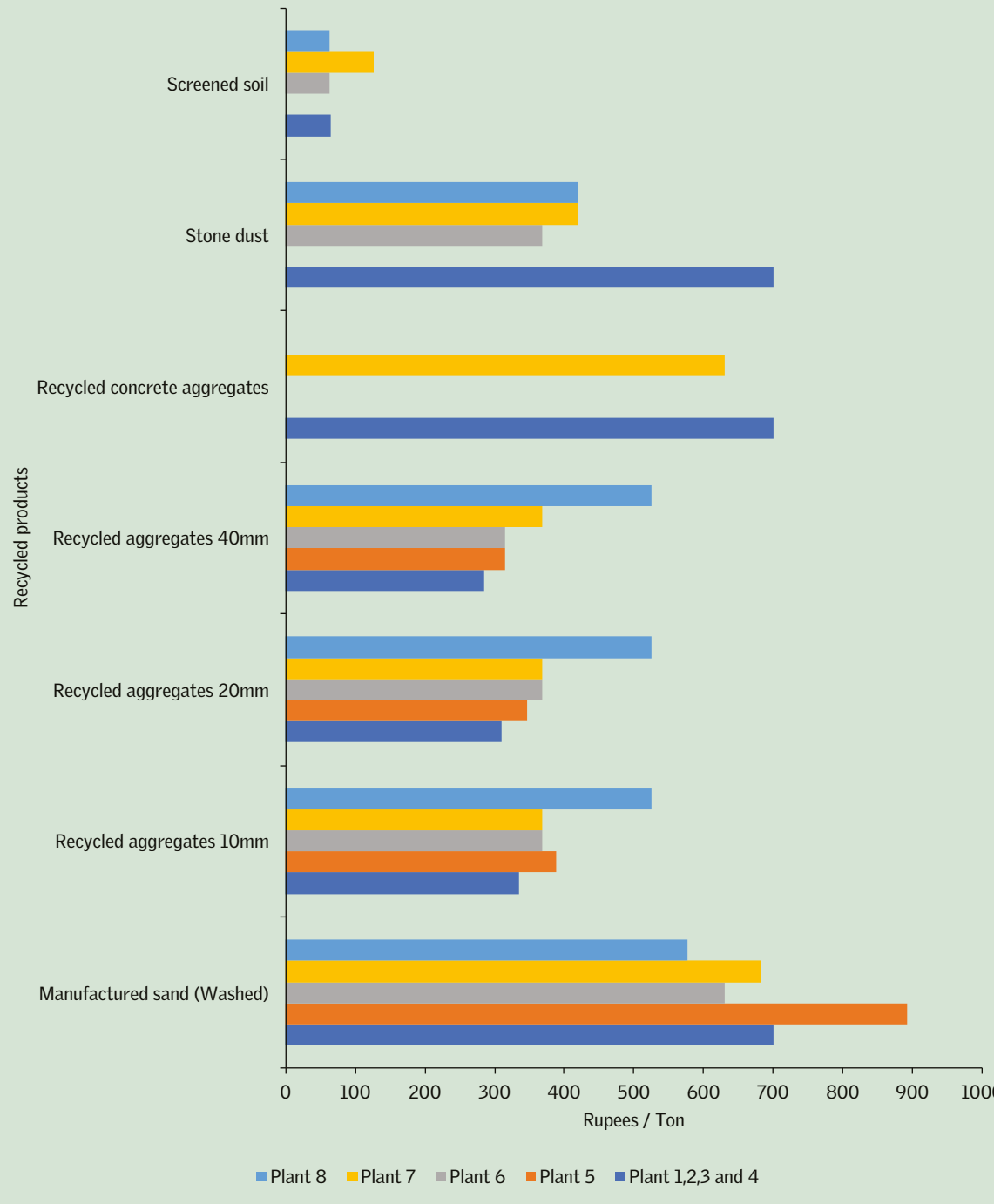
Source: Compiled from interviews with multiple C&D recycling plant operators.

CSE collected the rate lists of multiple products from the C&D recycling plants in Delhi, Noida, Greater Noida and Gurugram. Amongst the aggregates (mixed concrete and bricks), the prices of the 10 mm aggregates category were the highest, ranging from Rs 335–370 per tonne. The 40 mm aggregates were cheaper, with prices ranging from Rs 285–300 per tonne amongst different plants. However, recycled concrete aggregates, which are made only from concrete waste, demanded a rate of Rs 700 per tonne, which is more than double the rate of recycled aggregates. This also shows how effective source segregation can lead to better quality recycled products. Manufactured sand is the most in-demand product for the recycling plants and its price ranged from Rs 600–850 per tonne. The detailed plant lists can be seen in Annexure 1.

Assuming a 100-tonne feed into the plant, these are the approximate products and their tonnages that come out after recycling. These were multiplied by the average selling price of these products to get an estimate of the potential that the waste holds.

- 2 tonne RDF: No value
- 20 tonne silt: Negligible value (Rs 35–60/tonne)
- 35.5 tonne aggregates: Approximate value Rs 285–335/tonne
- 36 tonne sand: Rs. 600–850/tonne
- 6.5 tonne stone dust: Rs 350–700/tonne

Price of recycled products from eight C&D recycling plants



Materials derived	Quantity (Metric tonne)	Selling Price per tonne	Total price (Rs)
RDF	2	0	0
Silt	20	79	1,580
Aggregates	35.5	370	13,135
Sand	36	696.5	25,074
Stone dust	6.5	476	3,094
		Total	42,883

Recycling 100 tonnes of C&D waste can generate sales revenue of approximately Rs 40,000–43,000. This estimate excludes the costs of transporting the raw material, capital investment and operational expenses.

The output, however, is highly dependent on the kind and composition of waste received at the plant. In a scenario where the silt/soil content is higher, as experienced in plants where the C&D management system is not in a matured stage, the value of the derived products falls close to Rs 36,000. This emphasizes that a good feed to the plant is crucial to the economic viability of the system.

Materials derived	Quantity (Metric tonne)	Selling price per tonne	Total price (Rs)
RDF	2	0	0
Silt	35	79	2,765
Aggregates	28	370	10,360
Sand	28.5	696.5	19,850.25
Stone dust	6.5	476	3,094
		Total	36,069.25

These diverse factors collectively shape the nature of the waste stream processed by recycling plants, underscoring the need for tailored approaches to address regional variations in waste composition.

Understanding the intricacies surrounding the construction landscape of a region is important when considering the establishment and sustained operation of C&D waste recycling plants. An accurate assessment of various factors, including the types of construction prevalent in the area, the volume of existing legacy waste, and the projected influx of C&D waste over the next 25 years, is essential for determining the feasibility and effectiveness of such facilities. By comprehensively analysing these key factors, stakeholders can gain valuable insights into the potential demand for recycled materials, anticipate fluctuations in waste generation patterns, and devise strategies to optimize the operational efficiency and long-term sustainability of recycling plants.

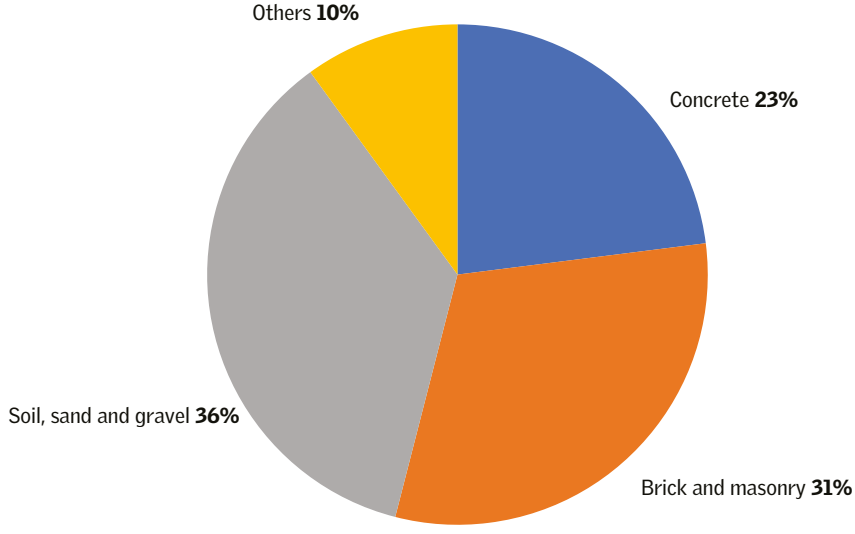
Existing estimates are outdated and need revision

A study conducted by the Technology Information Forecasting and Assessment Council (TIFAC) in 2001 estimated the composition of C&D waste in the country. According to the study, C&D waste comprises 36 per cent soil, sand and gravel; 31 per cent brick and masonry; and 23 per cent concrete. The remaining waste consists of metals, wood, bitumen and other materials.

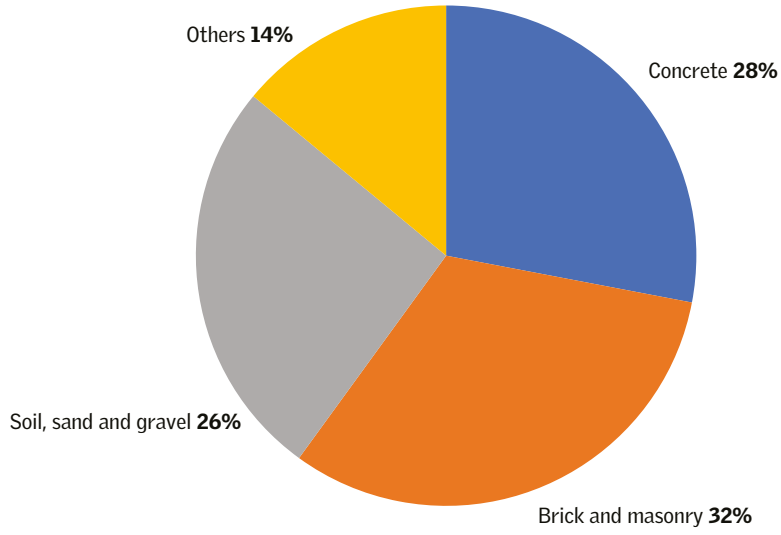
As per the 'Utilization of Recycled Produce of Construction & Demolition Waste – Ready Reckoner' by the Building Material and Technology Promotion Council (BMTPC), the representative C&D waste in urban areas of the northern plains is estimated to be 26 per cent soil, sand and gravel; 32 per cent brick and masonry; and 28 per cent concrete. The remaining waste consists of metals, wood, bitumen and other materials.

However, the composition of C&D waste received at recycling plants is different from these scenarios, with results varying from plant to plant (see *Graph 7: Composition of C&D waste received at Gurugram plant*). Calculations for Gurugram are based on total waste quantity of 855,231 MT received by the plant. The composition is as follows: 60 per cent soil, sand and gravel; 31 per cent brick and masonry; 9 per cent concrete; and the remaining 3 per cent consisting of metal, wood, bitumen, RDF and other materials.

Graph 5: C&D waste composition estimate in India as per TIFAC

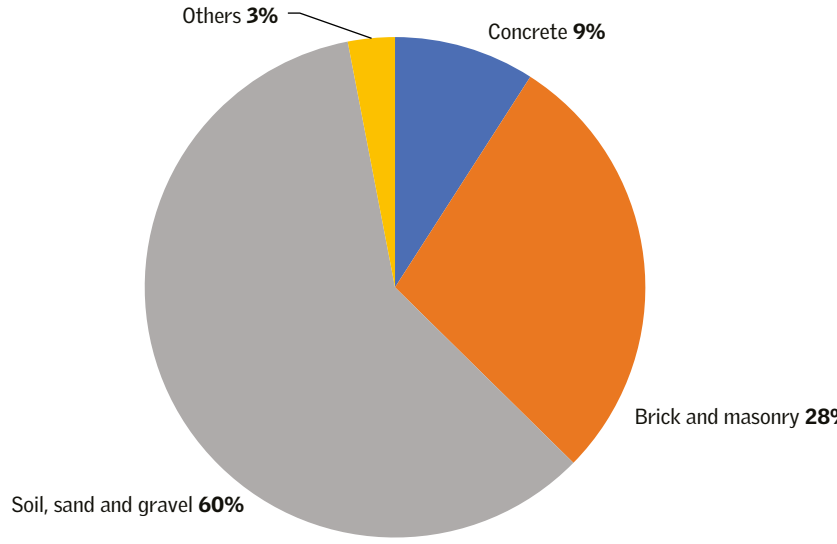


Graph 6: C&D waste composition estimate in India as per BMTPC



Source: As per 'Utilization of Recycled Produce of Construction & Demolition Waste – Ready Reckoner' by BMTPC

Graph 7: Composition of C&D waste received at Gurugram plant



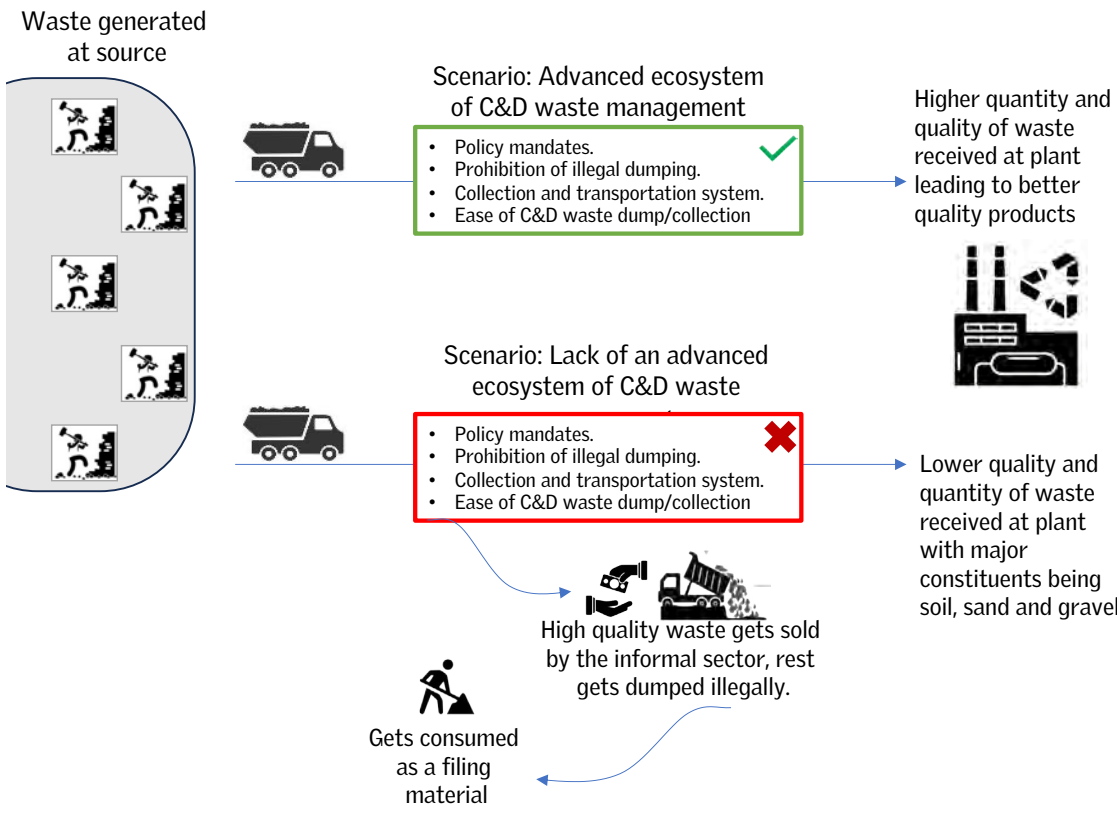
CSE conducted interviews with plant operators from Burari, Ranikhera, Shastri Park and Noida to gather estimates and understand the composition of waste received by their facilities. The estimates varied, indicating that the waste consisted of 40–60 per cent soil, sand and gravel; 30–40 per cent brick and masonry; 2–15 per cent concrete; and the remaining 3–5 per cent composed of RDF, metal and other materials.

It becomes apparent that the estimates by TIFAC differ majorly from the C&D waste received at the plants. While the percentage of soil-sand-gravel received at these plants is more than the ones predicted by TIFAC, the more sought-after concrete waste received at the plant is much lesser than estimated by TIFAC.

Illegal dumping and a dominant informal sector affect composition and quantity of C&D waste

In many cities, including Varanasi, establishing a robust waste management ecosystem remains challenging, leading to significant portions of generated waste not entering the recycling system. In these situations, the informal sector often plays a crucial role in removing debris from the waste stream, much of which gets dumped illegally. However, for recycling plants to function efficiently, a consistent supply of high-quality feedstock is necessary to produce superior recycled materials. To address this issue, robust surveillance measures, initiatives to deter illegal dumping, efficient collection systems and accessible collection points are crucial. Additionally, increasing awareness among waste generators

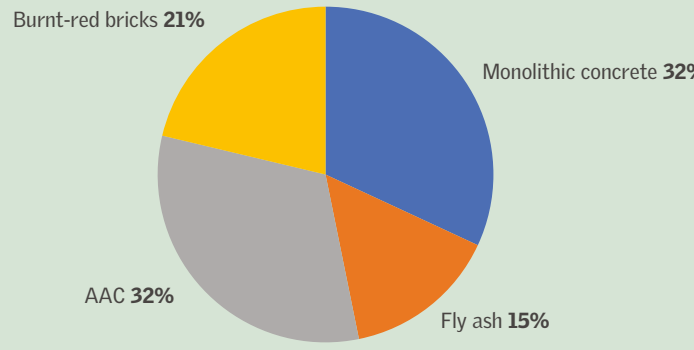
Figure 2: A good C&D waste management ecosystem ensures better quality waste reaches plants leading to better quality products



CONSTRUCTION MATERIALS AND TECHNOLOGIES IN THE PRIVATE HOUSING SECTOR

CSE conducted a study to understand the penetration of construction materials and technologies in the private housing sector in 2021–22. Over 100 projects were surveyed in the cities of Gurugram, Noida-Greater Noida, Ghaziabad, Faridabad, Panchkula-Mohali, Jodhpur, Kota, Jaipur, Udaipur, Bengaluru and Tumkuru.

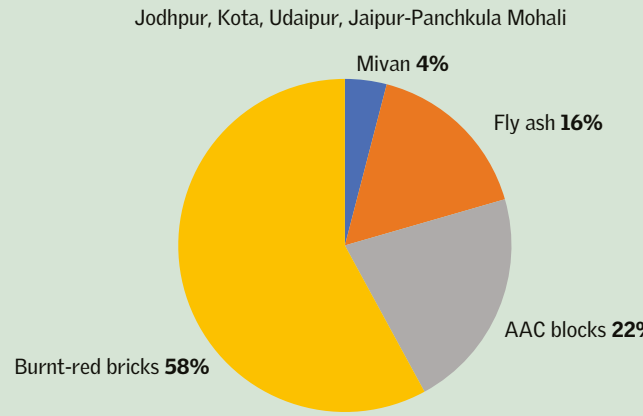
Walling material penetration in Tier 1 cities



In Tier 1 cities and their neighbouring towns, AAC blocks and monolithic concrete technologies (such as MIVAN and pre-fabricated concrete) are the most commonly used walling materials. These are followed by burnt red bricks and fly-ash bricks. In contrast, smaller cities show a different pattern of material usage, with traditional brick and blockwork being predominant, followed by AAC blocks and fly-ash bricks.

The study highlights significant variations in material usage across the surveyed cities, indicating that Tier 1 cities are adopting newer construction technologies, while smaller cities continue to rely on traditional materials. These regional differences in construction practices influence the composition of C&D waste, which must be considered when establishing a recycling system.

Walling material penetration in smaller cities



about designated C&D collection points, pertinent laws, regulations and potential fines can encourage the waste generator towards the proper and scientific disposal of waste.

The kind of construction prevalent in the region affects waste composition

Traditional construction in the region affects the debris composition. Regions where construction is majorly based on bricks receive more masonry and less concrete. Similarly, regions where the old construction used a lot of stone have high debris content. The aggregates formed from stones are of higher quality than those formed from concrete or bricks.

A relatively new material that is being encountered by C&D plants is Autoclaved Aerated Concrete (AAC) blocks, these blocks are lighter than water and hence float during wet processes. The material cannot be used to make aggregates either. AAC blocks are not currently dominant as they are primarily used in recent constructions. However, once these buildings reach the end of their life, AAC's composition in waste feed will increase. This shows that a thorough analysis of the technologies and materials prevalent in the region is important to judge the quality of recycled products that will be produced and how that is likely to affect the economics of the system.

Estimating the waste quantum can lead to smarter recycling models

A detailed estimation of the quantum of C&D waste produced maybe carried out by approximating the construction activities taking place in the city. Lists with sizes (based on built-up area) of construction projects exist in the form of datasets made by the Real Estate Regulatory Authority (RERA), Environmental Impact Assessment (EIA), etc. For more detailed estimations, government construction projects including infrastructure projects (roads, highways, metro, etc.) may be included in the calculations. Further, the future quantum of construction may be estimated by understanding the city master plan and how much more area is allocated to be urbanized under it.

4. Rules and guidelines governing the setting up and designing of C&D waste recycling plants

Construction and Demolition Waste Management Rules 2016 and CPCB guidelines on Environmental Management of Construction and Demolition wastes both give guidelines for setting up of C&D waste recycling plants.

Responsibility of state government and local authorities

As per C&D Waste Management Rules 2016

- The local authority is responsible to establish/get established the C&D waste processing plant functional within 18 months from the date of notification of C&D Waste Management Rules, 2016 for 1 million and above population cities, 24 months for cities with population of 0.5-1 million and 36 months for the cities with population less than 0.5 million

- **State government is responsible for providing suitable C&D recycling facility site:** The concerned department in the State Government dealing with land shall be responsible for providing suitable sites for setting up of the storage, processing and recycling facilities for construction and demolition and hand over the sites to the concerned local authority for development, operation and maintenance, which shall ultimately be given to the operators by Competent Authority and wherever above Authority is not available, shall lie with the concerned local authority.

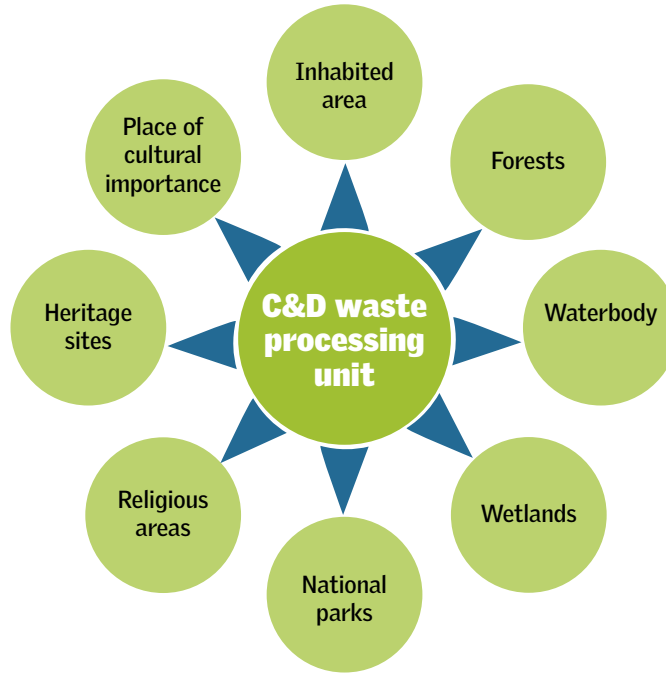
- **Local authority is responsible for giving necessary approvals:** The Local authority shall co-ordinate (in consultation with Department of Urban Development of the State or the Union territory) with the concerned organizations for giving necessary approvals and clearances to the operators.

Choosing an appropriate site

As per C&D Waste Management Rules 2016

- **C&D recycling plant to be sized to last 20-25 years:** The processing or recycling shall be large enough to last for 20-25 years (project based on-site recycling facilities).

- **Site to maintain minimum distance from sensitive areas:** The processing or recycling site shall be away from habitation clusters, forest areas, water bodies, monuments, National Parks, Wetlands and places of important cultural, historical or religious interest.



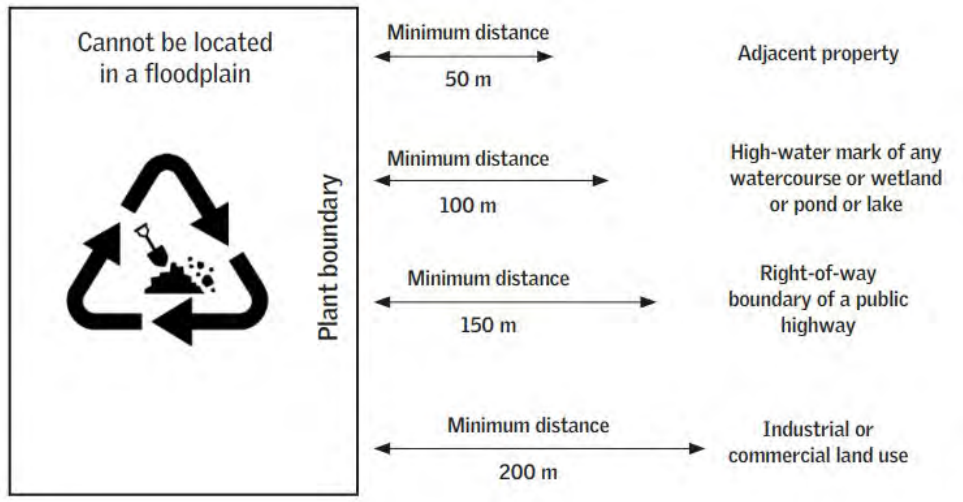
Source: CSE

As per CPCB guidelines on Environmental Management of Construction and Demolition wastes

Separation distances: The following restrictions be considered regarding setback distances from the outer boundary of such C&D facilities shall not be located within the following receptor setback distances:

1) 200 metres from any Industrial/Commercial land use property
2) 100 m from bank or high-water mark of any watercourse or wetland / pond / lake
3) 150 metres of the right-of-way boundary of a public highway
4) 50 metres from any other adjacent property.

Figure 3: Recycling plant to maintain minimum distances



Source: CSE

Preparing the site periphery

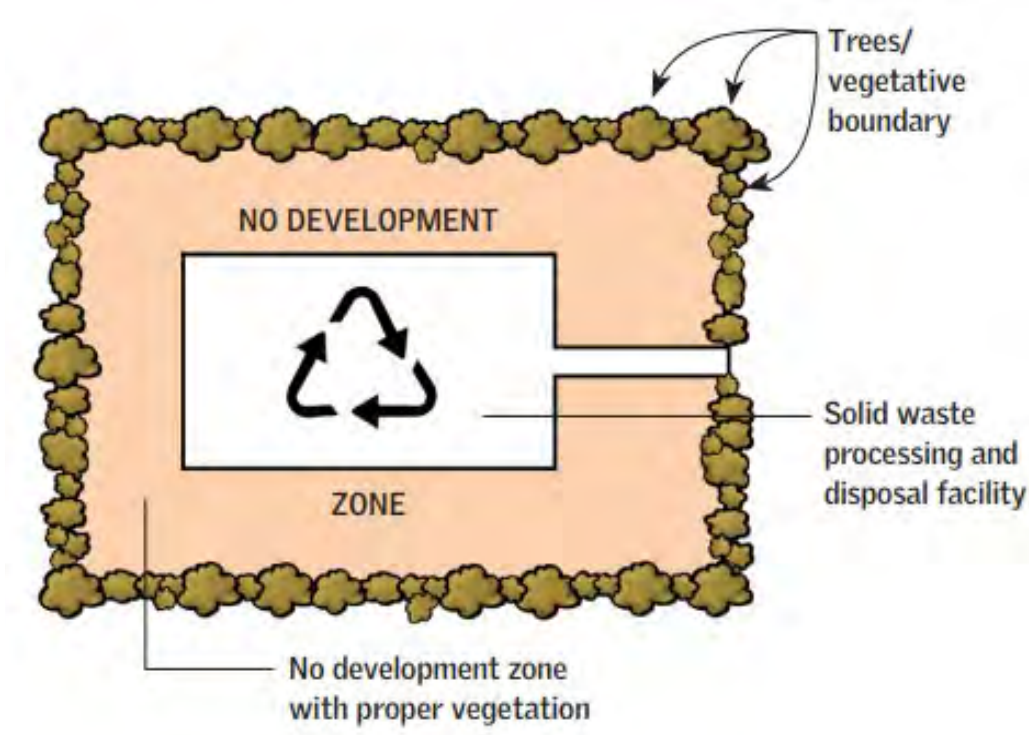
As per C&D Waste Management Rules 2016

- **Creating a buffer zone:** A buffer zone of no development shall be maintained around solid waste processing and disposal facility, exceeding five tonnes per day of installed capacity. This will be maintained within the total area of the solid waste processing and disposal facility. The buffer zone shall be prescribed on case-to-case basis by the local authority in consultation with concerned State Pollution Control Board.

- **Fence/hedge to be provided:** Processing or recycling site shall be fenced or hedged and provided with proper gate to monitor incoming vehicles or other modes of transportation.

- **Vegetative boundary:** A vegetative boundary shall be made around processing or recycling plant or site to strengthen the buffer zone.

Figure 4: Preparing boundary conditions and no buffer zone



Source: CSE

Pollution (dust, water, noise) mitigation measures to be applied

As per C&D Waste Management Rules 2016

- ***Storm water drains:*** Provision of storm water drains to prevent stagnation of surface water.

- **Paved surfaces:** Provision of paved or concreted surface in selected areas in the processing or recycling facility for minimizing dust and damage to the site.

- The approach and/or internal roads shall be concreted or paved so as to avoid generation of dust particles due to vehicular movement and shall be so designed to ensure free movement of vehicles and other machinery.

- Prevention of noise pollution from processing and recycling plant

- **Provision for treatment of effluent if any:** To meet the discharge norms as per Environment (Protection) Rules, 1986.

Pollution monitoring provisions

As per C&D Waste Management Rules 2016

- Work Zone air quality at the Processing or Recycling site and ambient air quality at the vicinity shall be monitored.

- Measurement of ambient noise shall be done at the interface of the facility with the surrounding area, i.e., at plant boundary.

Other criteria to be met

As per C&D Waste Management Rules 2016

- Provisions of weigh bridge to measure quantity of waste brought at landfill site, fire protection equipment and other facilities as may be required shall be provided.

- **Utilities to be provided:** Utilities such as drinking water and sanitary facilities (preferably washing/bathing facilities for workers) and lighting arrangements for easy landfill operations during night hours shall be provided and Safety provisions including health inspections of workers at landfill sites shall be carried out.

As per CPCB guidelines on Environmental Management of Construction and Demolition wastes

Environmental factors to be considered:

1) Site within compatible land uses
2) provide all weather access roads
3) providing access to a year-round suitable cover to the C & D waste material
4) no water collection within premises during rains / washings
5) providing controlled access to the site
6) providing a appropriate fencing and sign board outside at site (do's /don'ts)
5. C&D waste recycling equipment

5. C&D waste recycling equipment

A C&D recycling plant uses multiple kinds of equipment for processing, some of these are common in most plants. A basic processing line consists of a weighbridge, grizzly feeder, hopper, conveyor belt, a primary crusher (in most cases a jaw crusher), magnetic separator and a screen for segregation of aggregates and smaller particles.

Images 14-19: Major components of a basic dry processing unit

Grizzly feeder

Hopper

Jaw crusher

Conveyor belt

Magnetic separator

Multi tiered screen

However, there is other equipment that may be plugged into this processing line. Each additional piece of equipment in some way either enhances the quality of the product, saves time or helps in value addition to the final output. They have their own costs and benefits, and are employed by the plant operators depending on the quality of product that they would like to produce.

As an example, plants may add a secondary or tertiary crushing unit into their mix to get better aggregates. This is usually done with the help of cone crusher, granulator, roller crusher or Vertical Shaft Impactor.

Most large recycling plants work with wet processing technology. This technology has advantages as it produces washed sand and aggregates that are superior to those that come out of dry processing. This is because the smaller particles of silt (under 75 microns) get washed in wet processing. The resulting washed sand and aggregates are superior while forming bonds in concrete.

Equipment such as hydrocyclones, thickening tanks and sludge tank or filter press are used for separating out sand and silt. A logwasher is an equipment that helps in separating light-weight plastic and organic matter during processing and is employed to create products that are less contaminated. The cost of these equipment depends on how much of the waste they can process in an hour and is measured in tonne per hour (TPH). Additionally, plants require equipment such as shaking table, moulds, concrete mixers, brick making machines etc. to produce recycled products.

Figure 5: Common processes followed at C&D recycling plant

Magnetic separation

Manual Segregation of MSW

Smaller debris less than 60 or 80 mm

Unwanted waste such as wood, plastic & bituminous

Screening (uses water spray if wet processing applied)

Aggregates segregation

Dry processing only

Recycled aggregates

\+

Unwashed sand/ stone dust

Wet processing

Washed aggregates of different sizes

Slurry containing sand and silt

Hydro-cyclone

Washed Sand

Silt

Dust mitigation measures/ equipment

Fogging machines, sprinklers, etc.

Final Products

Soil

M-Sand

Recycled aggregates, various sizes

Recycled products: Blocks, tiles, kerb stones, etc.

5.1 Glossary of equipment used in a C&D recycling plant

Weighing bridge

The weight of the C&D waste carrying truck is measured upon entering the site. To facilitate this process, a dedicated weighing bridge control room is established, equipped with a weighing machine, computers and trained staff to ensure accurate weight measurements.

Image 20: Weighing bridge at Greater Noda C&D recycling plant

Feeding hopper

The feeding hopper serves as a container for holding the waste material and plays a crucial role in the waste processing operation. It ensures an equal and consistent distribution of the waste throughout the process. The waste is loaded into the feeding hopper, which then evenly dispenses it, allowing for a smooth and continuous flow of waste material during the processing phase.

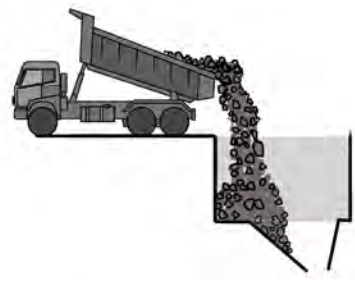


Image 21: Feeding hopper at the Noida C&D recycling plant

Vibrating grizzly screen

A vibrating grizzly screen is utilized to evenly distribute the waste, allowing for the segregation of silt and other forms of waste. The screen's vibrations help in the uniform distribution of waste material, facilitating the separation and removal of fine particles such as silt, ensuring a more efficient waste segregation process.

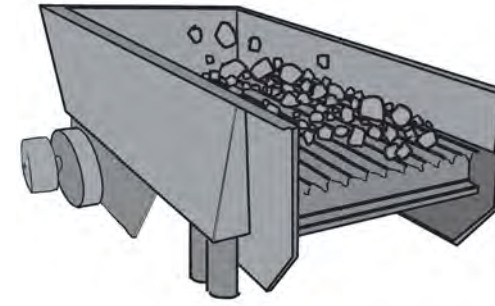


Image 22: Grizzly screen at Chandigarh C&D recycling plant

Jaw crusher

Jaw crushers employ pressure to break large materials into smaller pieces. They consist of two crushing jaws—one stationary and one moving—that exert mechanical force to crush the materials. These two vertical jaws form a V-shaped chamber where the materials are placed for crushing. The chamber starts wide and narrows into a V shape, allowing the crushed materials to exit. [22]

Approximate cost: Rs 30 lakh (60 TPH) to 1 crore (300 TPH)

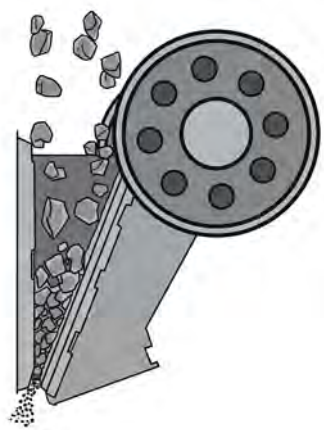


Image 23: Jaw crusher

Roller crusher

A roller crusher is a machine designed to decrease the size of materials. It consists of two identical crushing rolls that rotate towards each other. Material is fed into the space between the rollers and gets crushed as it passes between them. The crushing process relies solely on compressive force.

Approximate cost: Rs 25 lakh

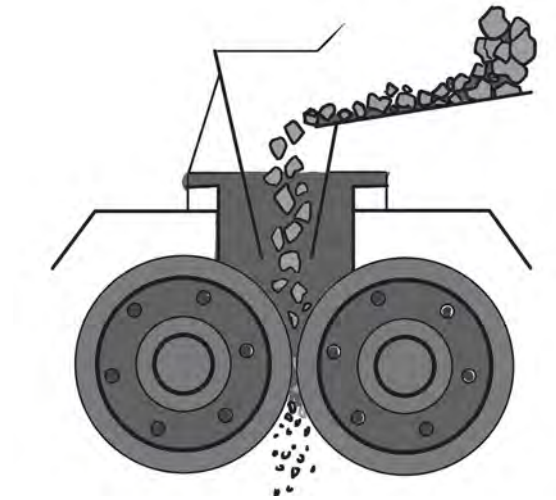


Image 24: Roller crusher installed at Greater Noida C&D recycling plant

Cone crusher

Within the machine, a steel component called the mantle rotates, pressing material against a fixed piece called the bowl. As material moves through the crusher, the gap between the mantle and bowl decreases, gradually reducing the size of the material. To achieve the desired size of the final material, the gap between the mantle and bowl can be adjusted, either increased or decreased accordingly.
Approximate cost: Rs 40 lakh (60 TPH) to Rs 1.3 crore (300 TPH)

Conveyor belt

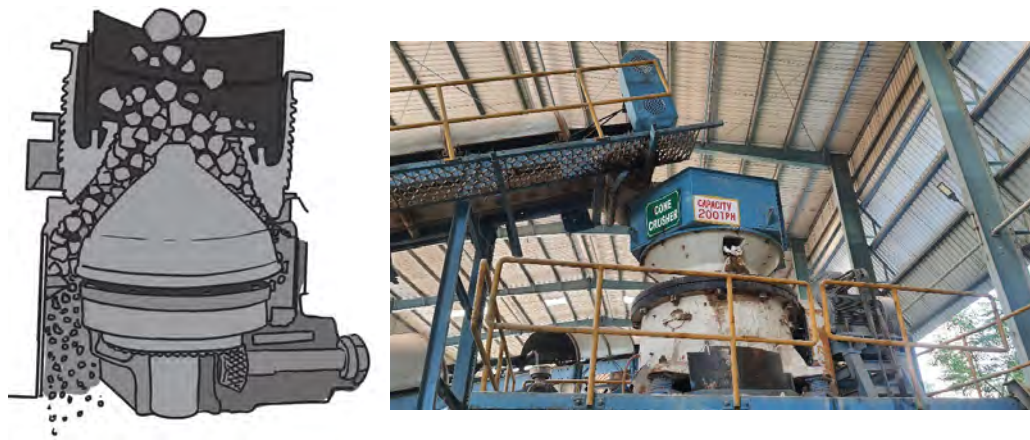


Image 25: Cone crusher at Noida plant

Vertical Shaft Impactor (VSI)

VSI crushers employ high-speed rotors and anvils to achieve impact crushing, rather than relying on compression force for size reduction. In these crushers, material is propelled outward by centrifugal force from the rotor towards the outer anvil ring. It fractures and breaks along natural fault lines. The resulting product typically exhibits a uniform cubical shape. The speed of the rotor determines the final particle size.[23]

Approximate cost: Rs 60 lakh to Rs 1.5 crore

Image 26: Vertical Shaft Impactor at Fathulaguda plant, Hyderabad

A system of moving conveyor belts is utilized to transport waste material from one machinery to another within the processing facility. Each size of particle or waste category typically has its dedicated conveyor belt to ensure efficient and organized movement throughout the process. This setup enables the smooth transfer of waste between different stages or machines, facilitating the overall waste management process.

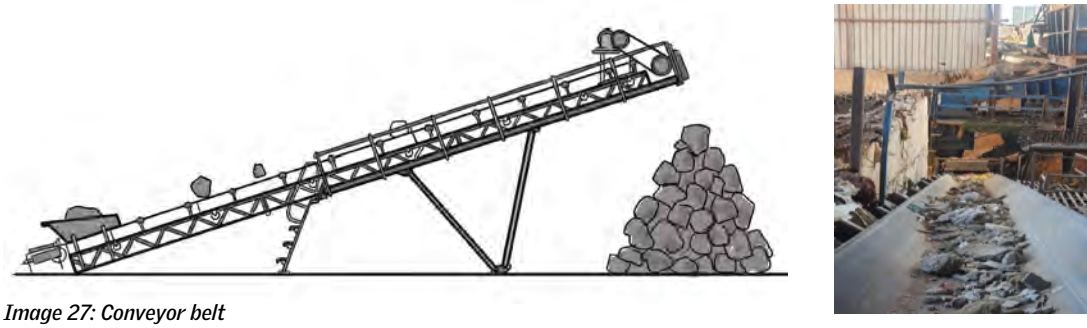


Image 27: Conveyor belt

Magnetic separator

A magnetic separator is employed in the waste processing system to effectively separate iron or metal pieces from the waste stream. There are three broad categories of magnetic separators.

Overhang magnets: Approximately Rs 2–4 lakh
Over band magnets: Approximately Rs 10 lakh
Metal detectors: Approximately Rs 2–4 lakh

Image 28: Overhang magnetic separator installed at Greater Noida (Left) and Over band magnetic separator in Burari, Delhi (Right)

Multiple deck screen

A multiple deck screen is a type of screening equipment that consists of three separate screens or decks stacked vertically one above the other. Each deck has a different mesh size or opening, allowing for the classification and separation of different-sized materials.

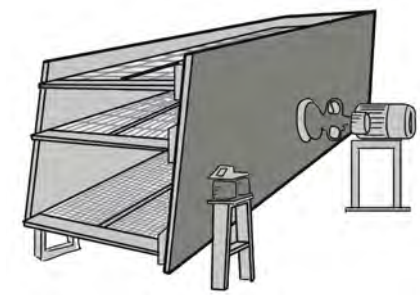


Image 29: Multiple deck screen

Log washer

A log washer separates light contaminants such as wood and plastic. In the log washer, aggregate and dirt-bound materials get cleaned. Plastics and organics are floated off from the rear of the log washer and passed to a small trash screen that recovers any water and fine material. The IS 383 code defines that aggregates cannot have deleterious materials (impurities that affect the strength and durability of concrete) above a certain percentage. A log washer is a key tool to generate aggregates with minimal contaminants. These aggregates also fetch a better price in the market.

Approximate cost: Rs 2–2.5 crore

Image 30: Wood and other lightweight plastics getting separated in a log washer in Burari, Delhi

Image 31: Light weight contaminants getting separated by a log washer at Jeedimetla, Hyderabad

Hydrocyclone

Hydrocyclones work by spinning to separate light particles using force. They are better at getting rid of extra small bits than regular sand washing systems because they force the particles apart instead of letting them settle down naturally.

Approximate cost: Rs 1–1.5 crore

Image 32: Hydrocyclone at Gurugram plant

Thickener tank/water treatment tank

Debris of size less than 75 micron is passed to a thickener tank where chemicals in controlled quantities are added. This leads to formation of a dense slurry. The water from the slurry is recycled. A water recycling tank/thickener tank can help recover 90 to 95 per cent of the water used.

Approximate cost: Rs 1–2 crore

Image 33: Thickener tank/water treatment tank at Burari, Delhi

Filter press

C&D waste processing produces a slurry or sludge that has sub 75 microns particles dissolved with water. Filter press separates these solids (below 75 microns particles) from the liquid (water). The sludge/slurry is squeezed and solids come out in the form of soil cakes.

Approximate cost: Rs 75 lakh to Rs 1 crore

Image 34: Filter press at Greater Noida plant

Image 35: Output from a filter press

Equipment for dust mitigation

Anti-smog gun: An anti-smog gun, also referred to as a spray or mist gun, is a device connected to a water tank mounted on a vehicle. It emits fine nebulized water droplets into the atmosphere, binding and bringing down dust particles and particulate matter. These electronic devices resemble cannons and help disperse suspended dust particles, ultimately reducing smog formation.

Image 36: Anti-smog gun at Greater Noida plant and Burari, Delhi

Water sprinkler system: A water sprinkler system for dust mitigation consists of pipes or hoses with sprinkler heads placed strategically to release water in controlled sprays or mists. These systems can be activated manually, automated or programmed to operate at specific intervals. When activated, the water droplets settle dust particles, reducing airborne dust emissions and improving air quality in dusty environments.

Image 37: Water sprinklers at Noida plant

Figure 8: Common equipment used in C&D recycling plants

Hopper

Grizzly feeder

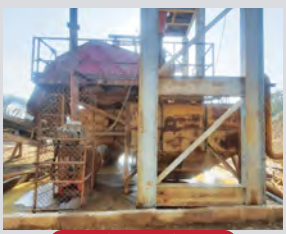
COMMON EQUIPMENTS IN A BASIC DRY PROCESSING LINE

Wet process additions

Log-washer

Approx. cost: Rs. 2-2.5 crores

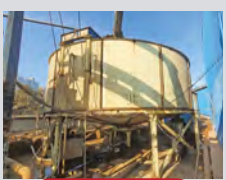
Separates out lightweight contaminants such as wood & plastic. The IS 383 code defines that aggregates cannot have deletirious materials (impurities that affect the strength and durability of concrete) above a certain percentage. A logwasher is a key tool to generate aggregates with minimal contaminants. These aggregates also fetch a better price in the market.



Hydrocyclone

Approx. cost: Rs 1-1.5 crores

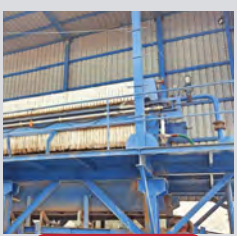
A hydrocyclone is a separation device used for separating slurry particles based on particle weight. Helps in production of high quality washed sand that is separated from dust particles. This sand fetches a better price in market as compared to unwashed sand.



Thickening tank/Water recycling tank

Approx. cost: Rs 1-2 crores

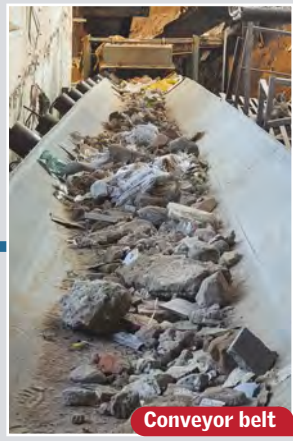
Chemicals are added in controlled quantities in thickener tank. This leads to formation of a dense slurry. The water from this slurry is recycled and can be reused in the system.The device can help recover close to 90 per cent of water used in the wet process. This helps in cutting down operational cost.



Filter press

Approx. cost: Rs 75 lakh-1 crore

Filter press separates sub 75 microns particles from liquid slurry (water with dissolved particles). The sludge/slurry is squeezed and solids come out in the form of soil cakes. A filter press takes up less space than a sludge tank. The process of separating sub 75 microns particles is also faster when compared to sludge tank.


Conveyor belt


Magnetic separator


Multi-tiered screen

Jaw crusher

ADDITIONAL EQUIPMENTS THAT MAYBE ADDED TO THE PROCESSING LINE

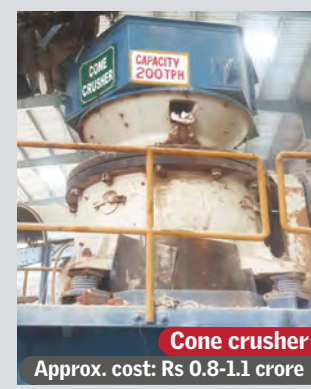
Secondary and tertiary crushers

Jaw crusher
Approximate cost: Rs 0.3-1 Crore

Granulator
Approximate cost: Rs 18 lakh


Vertical Shaft Impactor
Approximate cost: Rs 0.6-1.5 crores

Roller crusher
Approx. cost: Rs 25 lakh



Cone crusher
Approx. cost: Rs 0.8-1.1 crore

Equipment for making recycled products

Concrete mixture unit: A mixing unit is used to combine recycled aggregates, cement, sand, water, etc. to produce concrete which is further used to make recycled products.

Image 38: Concrete mixture unit

Vibrating tables: Vibrating tables are devices employed to facilitate the settling of concrete moulds or forms by inducing vibration. This vibration action helps the concrete mixture to settle evenly, expelling any trapped air bubbles in the process. By ensuring thorough consolidation, vibrating tables contribute to the production of high-quality concrete products with improved strength and durability.

Image 39: Vibrating table

Plastic paving moulds

The concrete mixture is added to moulds or forms specifically designed for interlocking tiles and paver blocks. During this time, the concrete mixture takes the shape of interlocking tiles or paver blocks as it hardens and gains strength.

Image 40: Plastic paver moulds at Agra C&D recycling plants

Image 41: Tiles being manufactured with the help of plastic moulds, Bakkarwala, Delhi

Brick manufacturing machine

The concrete produced from recycled aggregates and sand is poured into the cavity or mould of a brick machine. Vibration is applied to help the concrete settle, while hydraulic pressure is used to compress it into the desired shape. Following this step, the brick or block is left for solidification and curing.

Image 42: Brick/Block manufacturing machine

Image 43: Brick/Block manufacturing machine at the Chandigarh plant

Vehicles for transportation

Multiple vehicles might be used for hauling C&D waste, each with its own loading capacity. These approximate loading capacities are provided in the table below.

Table 4: Vehicles, their approximate loading capacities and cost

Type	Approximate loading capacity (tonnes)
10 tyre	22
12 tyre	28–30
6 tyre	14
4 tyre	6–7

6. C&D recycling plants: Case studies

CSE studied multiple C&D recycling plants ranging from small C&D recycling plants of less than 300 TPD capacity to larger ones exceeding 1,500 TPD. The basic processes and flow of materials remain the same in most plants. However, the equipment and technologies employed in larger plants had multiple variations. These technologies, processes and material flows have been captured in the case studies.

The case studies have been divided into three sections—installed capacity less than 300 TPD; installed capacity between 300–1,000 TPD; and installed capacity exceeding 1,000 TPD.

Case studies of plants with installed capacity above 1,000 TPD
- Gurugram
- Bakkarwala, Delhi
- Burari, Delhi
- Kolkata

Case studies of plants with installed capacity from 300 TPD to 1,000 TPD
- Greater Noida
- Noida
- Pimpri-Chinchwad
- Shamshabad-Hyderabad
- Fathulaguda-Hyderabad
- Jeedimetla-Hyderabad

Case Study of plants with installed capacity up to 300 TPD
- Agra
- Chandigarh
- Vishakhapatnam

C&D RECYCLING WASTE PLANT, GURUGRAM, HARYANA

LOCATION
Sector-100, Basai, Gurugram

PLANT CAPACITY
1,000 TPD

PLANT AREA
3.5 acres

PLANT RUN BY
Ever Enviro Resource Management Pvt. Ltd.

ESTABLISHMENT YEAR
2019

TYPE OF PROCESSING
Dry and Wet

Noteworthy features

- Processing area has been partially submerged into ground.
- Use of fans to separate away lightweight contaminants such as plastic.

Presence of sludge tank: **Yes**

Use of filter-press: **No**

Covered processing unit: **Yes**

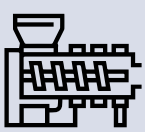
Hydrocyclone: **Yes**

Water recycling tank/Thickener: **Yes**

Use of log-washer: **No**

Type of crushers in the plant

Jaw



Granulator

Vertical Shaft Impactor

C&D RECYCLING WASTE PLANT, BAKKARWALA, DELHI

LOCATION
JJ colony, Bakkarwala, Delhi

PLANT CAPACITY
1,000 TPD

PLANT AREA
5 acres

PLANT RUN BY
Rise Eleven concrete product private limited

ESTABLISHMENT YEAR
2020

TYPE OF PROCESSING
Dry and wet

Noteworthy features

- In-house materials testing facility available in the plant.
- Tests carried out: sieve analysis, grading, silt content, water absorption, impact value, crushing value, specific gravity, etc.

Sludge tank

No

Use of filter-press

Yes

Covered processing unit	Hydrocyclone	Water recycling tank/Thickener	Use of log-washer
Yes	**Yes**	**Yes**	**Yes**

Type of crushers in the plant

Jaw

Roller

C&D RECYCLING WASTE PLANT, BURARI, DELHI

LOCATION
Burari, Jahangirpuri, Delhi

PLANT CAPACITY
2,000 TPD

PLANT AREA
7 acres

PLANT RUN BY
Ever Enviro Resource Management

ESTABLISHMENT YEAR
Renewed in 2023 for 15 years

TYPE OF PROCESSING
Dry and Wet

Noteworthy features

- Biggest C&D recycling facility in India at 2,000 TPD processing capacity
- The plant began operations in 2009 making it the oldest such facility in India
- The facility has received a major upgrade and was reopened in October 2023
- The upgraded plant has been estimated to cost over Rs 40 crores
- A multi-layered plantation boundary

Sludge tank
No

Use of filter-press
No

Covered processing unit
No

Hydrocyclone
Yes

Water recycling tank/ Thickener
Yes

Use of log-washer
Yes

Type of crushers in the plant

Jaw

Cone

C&D RECYCLING WASTE PLANT, KOLKATA, WEST BENGAL

LOCATION
Patharghata, New Town, Kolkata, West Bengal

PLANT CAPACITY
1,600 TPD

PLANT AREA
5 acres

PLANT RUN BY
Re Sustainability and Recycling Pvt. Ltd

ESTABLISHMENT YEAR
2023

TYPE OF PROCESSING
Dry and wet

Noteworthy features

- It is one of the largest C&D recycling facilities in the country with a capacity of 1,600 TPD.
- The plant runs on a cluster approach with waste coming from multiple municipalities.
- C&D waste has been used to build a ramp using Honeycomb Gravel Stabilizer Grid Plastic technology. The ramp utilizes 20,000 tonnes of C&D waste for its construction.

Sludge tank
Yes

Use of filter-press
No

Covered processing unit
Yes

Hydrocyclone
Yes

Water recycling tank/Thickener
Yes

Use of log-washer
No

Type of crushers in the plant

Jaw

Cone

C&D RECYCLING WASTE PLANT, GREATER NOIDA, UTTAR PRADESH

LOCATION
Ecotech III, Greater Noida, Uttar Pradesh

PLANT CAPACITY
800 TPD

PLANT AREA
4.5 acres

PLANT RUN BY
Rise Eleven concrete product private limited

ESTABLISHMENT YEAR
2023

TYPE OF PROCESSING
Dry and Wet

Sludge tank
No

Use of filter-press
Yes

Covered processing unit
Yes

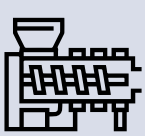
Hydrocyclone
Yes

Water recycling tank/Thickener
Yes

Use of log-washer
No

Type of crushers in the plant

Jaw



Granulator

Roller

C&D RECYCLING PLANT AT NOIDA, UTTAR PRADESH

LOCATION
Sector 80, Noida, Uttar Pradesh

PLANT CAPACITY
800 TPD

PLANT AREA
5 acres

PLANT RUN BY
Re Sustainability and Recycling Pvt. Ltd

ESTABLISHMENT YEAR
2020

TYPE OF PROCESSING
Dry and Wet

Noteworthy features

- Use of high pressure sprinklers for pathways.
- Wetting of debris before unloading.
- Use of permeable pavers
- Demonstration park made from C&D waste recycled products.

Presence of Sludge tank	Yes
Use of filter-press	No

Covered processing unit	Use of log-washer	Water recycling tank/Thickener	Hydrocyclone
Yes	No	Yes	Yes

Type of crushers in the plant

Jaw

Cone

C&D RECYCLING WASTE PLANT, PIMPRI-CHINCHWAD, MAHARASHTRA

LOCATION
Pimpri-Chinchwad

PLANT CAPACITY
200 TPD

PLANT AREA
5 acres

PLANT RUN BY
SSN innovative Infra LLP

ESTABLISHMENT YEAR
2020

TYPE OF PROCESSING
Dry and wet

Noteworthy features

- In-house materials testing facility available in the plant.

Covered processing unit: No	Hydrocyclone: Yes	Water recycling tank/Thickener: Yes	Use of log-washer: Yes

Sludge tank: Yes

Use of filter-press: No

Type of crushers in the plant

Jaw

Granulator

C&D RECYCLING WASTE PLANT, SHAMSHABAD, HYDERABAD, TELANGANA

LOCATION
Shamshabad, Hyderabad, Telangana

PLANT CAPACITY
350 TPD

PLANT AREA
5 acres

PLANT RUN BY
Soma Srinivasa Reddy Engineers and Contractors

ESTABLISHMENT YEAR
2023

TYPE OF PROCESSING
Dry and wet

Noteworthy features

- The plant has a dedicated station for manual municipal solid waste segregation.

Sludge tank
Yes

Use of filter-press
No

Covered processing unit
No

Hydrocyclone
Yes

Water recycling tank/Thickener
Yes

Use of log-washer
Yes

Type of crushers in the plant

Jaw

Cone

Sander

C&D RECYCLING WASTE PLANT, FATHULAGUDA, HYDERABAD, TELANGANA

LOCATION
Fathulaguda, Hyderabad, Telangana

PLANT CAPACITY
500 TPD

PLANT AREA
8 acres

PLANT RUN BY
Re Sustainability and Recycling Pvt. Ltd

ESTABLISHMENT YEAR
2021

TYPE OF PROCESSING
Dry and wet

Noteworthy features

- The plant has 4 types of crushers: Jaw crusher, cone crusher, roller crusher and a Vertical Shaft Impactor.

Sludge tank **Yes**

Use of filter-press **No**

Covered processing unit **No**

Hydrocyclone **Yes**

Water recycling tank/Thickener **Yes**

Use of log-washer **Yes**

Type of crushers in the plant

Jaw

Cone

Roller

Vertical Shaft Impactor

C&D RECYCLING WASTE PLANT, JEEDIMETLA, HYDERABAD, TELANGANA

LOCATION
Jeedimetla, Hyderabad, Telangana

PLANT CAPACITY
500 TPD

PLANT AREA
15 acres

PLANT RUN BY
Re Sustainability and Recycling Pvt. Ltd

ESTABLISHMENT YEAR
2019-20

TYPE OF PROCESSING
Dry and wet

Noteworthy features

- In-house materials testing facility available in the plant.
- Oldest recycling facility in Hyderabad

Covered processing unit: **Yes**	Hydrocyclone: **Yes**	Water recycling tank/Thickener: **Yes**	Use of log-washer: **Yes**

Sludge tank: **Yes**

Use of filter-press: **Yes**

Type of crushers in the plant

Jaw

Cone

C&D RECYCLING WASTE PLANT, AGRA, UTTAR PRADESH

PLANT AREA
2.13 acres

PLANT RUN BY
Rise Eleven concrete product private limited

LOCATION
Agra

ESTABLISHMENT YEAR
2019

TYPE OF PROCESSING
Dry processing

PLANT CAPACITY
5-20 TPD

Type of crushers in the plant

Jaw

Covered processing unit Partial
Hydro cyclone N.A for dry process
Water recycling tankThickener N.A for dry process
Use of log-washer N.A for dry process
Use of filter-press N.A for dry process
Sludge tank N.A for dry process

C&D RECYCLING WASTE PLANT, CHANDIGARH

LOCATION
Chandigarh

PLANT CAPACITY
150 TPD

PLANT AREA
2.13 acres

PLANT RUN BY
Chandigarh Municipal Corporation

ESTABLISHMENT YEAR
2019

TYPE OF PROCESSING
Dry processing

Noteworthy features

- The plant is run by the municipality along with the rest of the waste management system in Chandigarh.
- The plant was awarded the ISO 9001:2015 certificate in October 2022

Sludge tank
N.A for dry process

Use of filter-press
N.A for dry process

Covered processing unit Partial	Hydro cyclone N.A for dry process	Water recycling tank/ Thickener N.A for dry process	Use of log-washer N.A for dry process

Type of crushers in the plant

Jaw

Granulator

C&D RECYCLING WASTE PLANT, VISAKHAPATNAM, ANDHRA PRADESH

LOCATION
Visakhapatnam

PLANT CAPACITY
150 TPD

PLANT AREA

PLANT RUN BY
Re Sustainability and Recycling Pvt. Ltd

ESTABLISHMENT YEAR

TYPE OF PROCESSING
Dry and wet

Sludge tank
No

Use of filter-press
No

Covered processing unit
No

Hydro cyclone
Yes

Water recycling tank/ Thickener
No

Use of log-washer
No

Type of crushers in the plant

Jaw

Table 5: Summarization of equipments in the C&D recycling plants captured in the case studies

C&D recycling plant	Types of crushers installed					Cover over processing unit
Noida, Uttar Pradesh	Jaw		Cone			Yes
Gurugram, Haryana	Jaw	Granulator	-	-	Vertical Shaft Impactor	Yes
Greater Noida, Uttar Pradesh	Jaw	Granulator	-	Roller	-	Yes
Burari, Delhi	Jaw	-	Cone			No
Chandigarh	Jaw	Granulator	-	-	-	Partial
Agra, Uttar Pradesh (Existing)		-	-	-	-	No
Pimpri Chinchwad, Maharastra	Jaw	-	-	-	-	No
Bakkarwala, Delhi	Jaw	-	-	Roller	-	Yes
Jeedimetla, Hyderabad	Jaw	-	Cone	-	-	Yes
Shamshabad, Hyderabad	Jaw	-	Cone and Sander	-	-	No
Fathulaguda, Hyderabad	Jaw	-	Cone	Roller	Vertical Shaft Impactor	Yes
Visakhapatnam, Andhra Pradesh	2 x Jaw	-	-	-	-	No
Kolkata, West Bengal	Jaw		Cone			Yes

	Processing technology used	Hydrocyclone	Water recycling plant/ Thickener	Use of logwasher	Use of filterpress	Presence of Sludge tank
	Dry and wet	Yes	Yes	No	No	Yes
	Dry and wet	Yes	Yes	No	Planned to be installed soon	Yes
	Dry and wet	Yes	Yes	No	Yes	No
	Dry and wet	Yes	Yes	Yes	No	Yes
	Dry	N.A for dry process	N.A for dry process	N.A for dry process	N.A for dry process	N.A for dry process
	Dry	N.A for dry process	N.A for dry process	N.A for dry process	N.A for dry process	N.A for dry process
	Dry and wet	Yes	Yes	Yes	No	Yes
	Dry and wet	Yes	Yes	Yes	Yes	No
	Dry and wet	Yes	Yes	Yes	Yes	No
	Dry and wet	Yes	Yes	Yes	No	Yes
	Dry and wet	Yes	Yes	Yes	No	Yes
	Dry and wet	Yes	No	No	No	Yes
	Dry and wet	Yes	Yes	Yes	Planned to be installed soon	Yes

7. Maximizing reuse and uptake: Focus on testing, codes and policies

The 1970 version of the Indian Standard specification IS:383-1970, established by the Bureau of Indian Standards (BIS), stated that concrete could only be produced using 'naturally sourced materials'. Consequently, construction agencies cited this restriction as a reason for their reluctance to utilize recycled materials. The 2016 revision of IS: 383 allowed for the utilization of C&D waste as partial replacements for natural aggregate in construction activities.[24] This revision formally recognized recycled aggregates as viable substitutes for natural aggregates in construction projects. The code refers to the two types of aggregates produced in a recycling plant: Recycled Aggregates (RA) and Recycled Concrete Aggregates (RCA).

RAs typically consist of brick masonry waste, cement mortar waste, tiles waste, and other similar materials.[25] RCAs are produced from demolished concrete waste, undergoing a screening process using various filtering mediums. RCA typically comprises of parent aggregates mixed with aggregates containing hydrated cement mortar adhering to their surfaces.[26]

Image 44: Recycled aggregates (Left) Recycled concrete aggregates (Centre) and Sand (Right) at Burari plant, Delhi

The fine version of these aggregates, which is between 4.75 mm and 75 microns, is sand. It is essential that a wet processing technology is used for production of sand. The wet processing technology removes the particles below 75-microns, which prohibit the sand's bonding property in concrete.

A C&D recycling plant produces a multitude of the aggregates:

- Granular sub-base
- Recycled aggregates 10mm
- Recycled aggregates 20mm
- Recycled aggregates 40mm
- Recycled concrete aggregates 10mm
- Recycled concrete aggregates 20mm
- Recycled concrete aggregates 40mm
- Washed sand (4.75mm to 75 microns)
- Plaster sand
- Stone dust: Unwashed particles below 4.75mm
- Silt (less than 75-micron particles)
- Screened soil

Image 45: A variety of aggregates and products manufactured at Noida plant

These aggregates are either sold directly or used by the plant for production of recycled products used in non-structural applications, which include:

- **Bricks and blocks of various dimensions**

Image 46: Bricks/Blocks made at Bakkarwala, Delhi plant

- **Kerb stone**

Image 47: Kerb stones produced in Jeedimetla, Hyderabad

- **Tiles of various dimensions**

Image 48: Tiles produced in Jeedimetla, Hyderabad

- **Paver blocks**

Image 49: Paver blocks of various sizes and shapes at Vishakapatnam C&D recycling plant

- **Drain covers**

7.1 Potential to increase use of RAs and RCAs by updating codes

The use of RCAs in India is limited by IS:383 to 20 per cent for reinforced cement concrete (RCC) in M25 grade concrete and 25 per cent for non-structural applications. However, many other places such as Australia, Portugal, Hong Kong and Germany allow higher maximum substitution limits for C&D recycled aggregates (see *Table 6: Provisions for using C&D waste aggregates in concrete in different countries*).[27] Technological advancements can also significantly improve the quality of recycled aggregates, and several experiments in India have also demonstrated that recycled aggregates have a higher potential to replace natural aggregates. Updating existing codes and standards is essential to fully realize this potential.

The properties of RCAs are primarily determined by the amount and quality of mortar adhering to the natural aggregates. This factor significantly influences characteristics such as density, water absorption and porosity of the RCA. Essentially, the composition and condition of the mortar surrounding the natural aggregates play a crucial role in defining the overall performance and suitability of the recycled material for various construction applications.

Typically, RCAs exhibit a lower density, ranging from 7 to 17 per cent less than natural aggregates. This variance arises from the presence of adhered mortar, which is inherently less dense.[28] Additionally, the water absorption capacity of RCA is approximately three to five times greater than that of natural aggregates. This increased absorption capability is attributed to the greater porosity of the adhered mortar on RCA compared to the underlying natural aggregate. Consequently, such aggregates have the capacity to retain more water within their pores or absorb more water compared to their natural counterparts. Nonetheless, several studies and international codes suggest higher percentages of RCA as substitutes for natural aggregates, varying based on the material's composition.

Furthermore, advancements in technology have enhanced the quality of recycled aggregates. In Japan, specialized methods have been devised, including mechanical scrubbing with an eccentric tubular vertical mill and the application of heat, to remove mortar adhering to aggregate pieces. These techniques result in the production of high-quality recycled aggregate.[29]

In India, the National Council for Cement & Building Materials (NCCBM) has carried out experiments to remove the adhered mortar from recycled concrete aggregates using abrasion machines. The study found an improvement in water

Table 6: Provisions for using C&D waste aggregates in concrete in different countries

Country/ Organisation	C&D Type	Maximum Substitution Allowed	Maximum strength of Concrete that can be made using C&D	Other Restrictions
United Kingdom	RCA	20%	20 to 40 MPa	No Chloride Exposure, No Freeze thaw
	RA	Not Specified	16 MPa	Only Mild Exposure
Australia	RCA	30%	40 MPa	
	RA	100%	20 MPa	
RILEM	RA	100%	16 MPa	Masonry Aggregate
	RCA	100%	50 MPa	
Korea	RCA	30%	27 MPa	
Germany	RCA	35%	25 MPa	In dry or low humidity environments
		25%	30 MPa	
Portugal	RCA	25%	35 MPa	
		20%	40 MPa	
Hongkong	RCA	20%	35 MPa	
		100%	20 MPa (Non Structural Concrete)	

Source: IRC:121-2017

absorption values in the range of 4–20 per cent as well as other parameters such as the specific gravity value.[30] It demonstrates that the ability of RCAs to act as replacement depends on their quality, which in turn can be enhanced with mechanical treatment involving abrasion. The experiment also concluded that even the untreated coarse recycled concrete aggregate can replace natural aggregates up to 40 per cent.[31]

In another such study, RCA concrete was used in a precast concrete factory for the affordable housing project of the City and Industrial Development Corporation of Maharashtra (CIDCO). The project applied 50 per cent of fine RCA, which is significantly above the 20 per cent limit specified in IS: 383.[32] The fine RCA replaced the crushed stone sand fraction in the grade slab (M-20) and in lean concrete (M-10) at replacement levels of 50 per cent and 100 per cent, respectively. These studies suggest that IS: 383 should be revisited to enhance the utilization of recycled C&D aggregates in construction.

Use of RAs to be included in codes pertaining to precast concrete blocks and masonry units

The testing for C&D recycled blocks/bricks currently happens through IS:2185 part-1 which applies for concrete masonry units while the code governing concrete paving blocks is IS:15658. Both these codes do not mention RAs. Products made

USE OF RECYCLED AGGREGATES AS PER IS:383

IS:383 code defining the extent for usage of RAs and RCAs in concrete

Table 1 Extent of Utilization
(*Clause* 4.2.1)

Sl No.	Type of Aggregate	Maximum Utilization		
		Plain Concrete Percent	Reinforced Concrete Percent	Lean Concrete (Less than M15 Grade) Percent
(1)	(2)	(3)	(4)	(5)
i) Coarse aggregate:				
a)	Iron slag aggregate	50	25	100
b)	Steel slag aggregate	25	Nil	100
c)	Recycled concrete aggregate[1)] (RCA) (*See* Note 1)	25	20 (Only upto M25 Grade)	100
d)	Recycled aggregate[1)] (RA)	Nil	Nil	100
e)	Bottom ash from Thermal Power Plants	Nil	Nil	25
ii) Fine aggregate:				
a)	Iron slag aggregate	50	25	100
b)	Steel slag aggregate	25	Nil	100
c)	Copper slag aggregate	40	35	50
d)	Recycled concrete aggregate[1)] (RCA) (*See* Note 1)	25	20 (Only upto M25 Grade)	100

Use of coarse RCA
- Up to 25 per cent has been permitted in plain concrete.
- Up to 20 per cent has been permitted in reinforced concrete but only up to M-25 grade
- Up to 100 per cent can be used in lean concrete (less than M-15 grade)

Use of coarse RA
- Up to 100 per cent can be used in lean concrete (less than M-15 grade)

Use of fine RCA
- Up to 25 per cent has been permitted in plain concrete.
- Up to 20 per cent has been permitted in reinforced concrete but only up to M-25 grade
- Up to 100 per cent recycled can be used in lean concrete (less than M-15 grade)

from recycled C&D waste can achieve desired strength by using the correct concrete mix but have more absorption capacity when compared to the ones made from virgin materials. Hence, the future iterations of the code will need to investigate whether these products, which inherently display higher water absorption rates, can be designated for specific applications with different water absorption benchmarks to enhance their acceptance and utilization.

According to C&D Waste Management Rules 2016, a certain amount between 10 to 20 per cent of materials from C&D waste is mandated to be used in government or municipal contracts. However, the next step should be to review and increase this 20 per cent limit as the Indian standard codes get updated.

7.2 Material testing crucial for wider uptake

A major reason for C&D recycled products not finding wider uptake in the market is distrust among the construction community about the quality of the recycled products. The Supreme Court annex project faced a tricky situation when the initial lot of bricks received from the plant did not adhere to the desired strength of 10 MPa. However, this changed once the concrete mix and proportion of concrete was tweaked to reach and even exceed the desired strength.

The building eventually opened in 2019 and has used recycled blocks made from C&D waste aggregates. The project utilized 1.8 million C&D recycled blocks, saving close to 25 thousand tonnes of fertile soil.

This demonstrates that adjusting the proportions of constituents in recycled C&D products can significantly impact product quality. However, establishing infrastructure for product testing is essential to address concerns about product quality and enhance product uptake. The C&D recycling plant at Bakkarwala, Delhi and Jeedimetla in Hyderabad have such material testing laboratories.

Both the plants have put their laboratories to good use, the Bakkarwala plant has their own ready-mix concrete unit while the Jeedimetla plant sells their aggregates to concrete manufacturers as well.

Images 50 and 51: The Supreme court annex building utilized 1.8 million C&D recycled blocks

Image 52: C&D aggregates and products testing lab at Bakkarwala, Delhi recycling plant

Most recycling plants which were studied, however, get their products tested through third parties, indicating a dearth of understanding on the kind of products being manufactured.

General tests carried out on C&D recycled products

Tests for aggregates

Sieve analysis test: The sieve analysis test is used to determine the particle size distribution of a granular material. The apparatus requires a set of screens stacked on top of each other from coarse to fine. The sample of the aggregate is poured on top and the screens are shaken to allow the particles to pass through multiple sieves with the finest particles being collected at the bottom in a pan while each sieve retains different sizes of the larger particles as per the mesh size.

Images 53-55: Sieve analysis equipment at the Jeedimetla C&D recycling plant in Hyderabad

Images 56 and 57: Apparatus used in water absorption test

Source: https://www.iricen.gov.in/LAB/res/html/Test-17.html

At the end, the material collected in each sieve is weighed to determine the percentage of particles of a particular size in the sample. This helps determine material suitability for various applications (for example: grading of aggregates for concrete).

Water absorption test: The water absorption test is used to determine the amount of water absorbed by a material under specific conditions. The apparatus needed is a container for holding the sample, dry cloth and a measuring scale. First, the dry weight of the sample is measured, after which the sample is immersed in water for 24 hours at room temperature. After the soaking period, the sample is removed from water and any excess surface water is wiped off using a dry cloth. The weight of the sample is again obtained and is compared to the initial sample weight to determine the percentage of moisture absorbed by the sample.

Specific gravity test: The test is conducted with the same apparatus as the water absorption test consisting of a container, mesh basket for holding the sample, dry cloth, distilled water and a measuring scale. The specific gravity value obtained indicates the density of the aggregate relative to the density of water. Typically,

aggregates with higher specific gravity values are denser and stronger, making them suitable for heavy-duty applications such as concrete production.

Dry loose bulk density test: The dry loose bulk density test is used to determine the density of dry, coarse or granular materials such as aggregates. The test requires a container of known volume, weighing scale and a scoop for transferring the sample into the container. The bulk density value obtained represents the mass of the material per unit volume in its loose, uncompacted state. This measurement is important in construction as it provides information about the weight of the material per unit volume and helps in determining storage, transportation and handling requirements.

Impact value and crushing value tests: The impact value or crushing value of coarse aggregate is a measure of the resistance of aggregate to sudden shock or impact, which may vary from its resistance to gradually applied compressive load. It is determined by subjecting the aggregate to a standard amount of impact or crushing under standardized conditions.

Impact value test: The impact value test evaluates the toughness or impact resistance of coarse aggregates. It requires an impact testing machine, a weigh balance, a cylinder test cup, measuring cylinder and a tamping rod. A lower impact value indicates better resistance to impact and shock loads, suitable for heavy-duty applications.

Crushing value test: The crushing value test assesses the resistance of coarse aggregates to crushing under gradually applied compressive load. A lower crushing value indicates higher strength and durability of the aggregate, ideal for road construction and pavement materials.

Aggregate abrasion value test: Aggregate abrasion value test is a measure of the resistance of an aggregate to abrasion or wear caused by rubbing or friction. A dry sample of coarse aggregate of a specified range is loaded with steel spheres into a rotating drum called the Los Angeles abrasion machine. The machine is run for a specified number of revolutions, and the resultant material is passed through a specified sieve to calculate the abrasion value based on weight loss. A lower abrasion value indicates higher resistance to abrasion and better durability. This test helps in selecting aggregates suitable for high-traffic road surfaces and other demanding applications.

Flakiness Index and Elongation Index: Flakiness Index (FI) and Elongation Index (EI) are tests used to assess the shape characteristics of coarse aggregates,

Image 58: Apparatus for carrying out concrete cube test at Jeedimetla plant, Hyderabad

Source: https://dailycivil.com/los-angeles-abrasion-test-on-aggregates-abrasion-test-on-aggregates/

particularly their ability to compact and interlock in construction materials like concrete and asphalt.

The Flakiness Index measures the percentage of aggregate particles that are flat and elongated in relation to their thickness. A lower FI indicates a higher proportion of cubical or equidimensional particles, which are preferred for good interlocking in concrete.

The Elongation Index measures the percentage of aggregate particles that are elongated in relation to their width. A lower EI indicates a higher proportion of equidimensional particles, which contribute to better workability and strength of concrete.

Fine aggregates passing percentage (**less than 75 microns**): The percentage of fine aggregates less than 75 microns refers to the portion of material that passes through a sieve with openings of 75 micrometers (μm) or less. This fraction is crucial in concrete and mortar mixes because particles in this size range significantly influence the workability, cohesion and surface finish of the mixture. Excessive fine aggregates can lead to reduced workability, increased water demand, and cause potential issues with segregation and bleeding in concrete. Therefore, controlling and monitoring the percentage of fine aggregates less than 75 microns is essential to ensure the desired performance and durability of construction materials.

Image 59-60: Apparatus for carrying out concrete cube test at Jeedimetla plant, Hyderabad

Image 61: Curing of concrete cubes taking place at the Bakkarwala plant, Delhi

Tests for concrete blocks and pavers

Compressive strength test: The compressive strength test measures the ability of concrete to withstand loads without cracking or deflection. This test is crucial for ensuring the quality and durability of concrete structures, and determining their capacity to bear forces and loads. The compressive strength test for concrete involves preparing a concrete specimen using cubic moulds, typically 15 cm x 15 cm x 15 cm, and ensuring the concrete is properly tamped to minimize air voids.

After allowing the concrete to set for 24 hours, the moulds are removed, and the specimens are soaked in water for curing. Before testing, the upper surface of the specimens is made even and smooth by applying a thin layer of cement paste. The cured specimen is then placed in a compression testing machine, where a load is gradually applied until the specimen fails. The compressive strength is calculated by dividing the load at failure by the cross-sectional area of the specimen. This test is essential for ensuring the quality and durability of concrete structures.

8. Fly ash lessons: Insights from India's construction sector

For the last two decades, India has been managing fly ash waste and integrating it into the construction sector with some success. The journey to promote construction products based on fly ash began in 1999 and has since seen incremental updates over time.[33] The ecosystem development aimed at promoting the utilization of fly ash in India has been implemented through a methodical and continuous approach (see *Figure 6: Journey of fly ash notifications*).

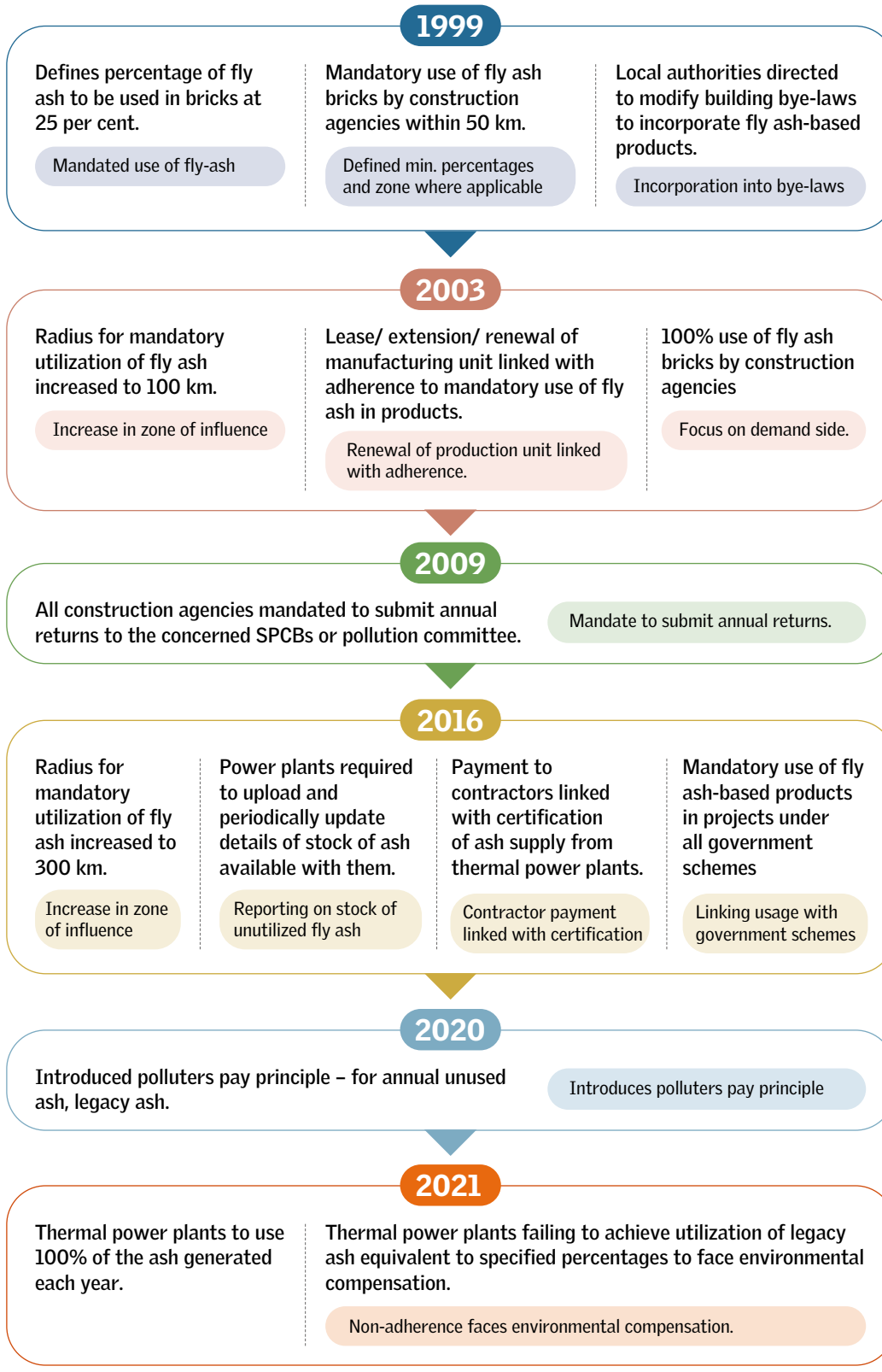
The challenges faced by the C&D waste management ecosystem are similar to the ones faced by the fly ash ecosystem. The issue of utilizing legacy waste, uptake of recycled products, assigning responsibilities, etc. can find parallels between both these ecosystems. There are valuable lessons to be learned from the journey of fly ash that can be incorporated into the ongoing effort of promoting C&D recycled products.

- Linking contractor payments to the certification of C&D product utilization can ensure uptake of these products.

- Projects associated with government schemes such as Pradhan Mantri Awas Yojana and Pradhan Mantri Gram Sadak Yojana may also establish higher targets for the utilization of C&D recycled products beyond the minimum requirements.

- Implementing measures such as regular updates on the quantity of unsold C&D waste can help municipalities monitor product demand and manage inventory effectively.

Figure 6: Journey of fly ash notifications



9. Recommendations and way forward

Estimates of C&D waste composition need to be recalculated

The last TIFAC study on C&D waste composition dates to 2001, which is before the first C&D plant in India became operational in 2009. The study does not reflect the current scenario of waste composition. India's C&D waste composition estimate needs updating to get a more realistic evaluation representing the current C&D scenario. This information is crucial in getting the financial feasibility correct for setting up and operating a C&D recycling plant.

The capacity of recycling plants should be calculated according to legacy waste and future construction potential

To comply with Construction and Demolition Waste Rules 2016, upcoming recycling facilities need to be adequately sized to manage the expected increase in C&D waste over the next 25 years. This requires careful assessment of the region's construction and demolition activity trends. Moreover, existing piles of legacy waste in many cities must be addressed, as they also need processing. These existing waste quantities should be factored in when determining the size of new recycling plants.

Recycling plants to be set-up closer to the expected construction hotspots

The site of upcoming C&D recycling plants should be close to the expected future construction hotspots. This will reduce the distance and time travelled by these vehicles, consequently reducing their transportation costs. Strategic positioning of the plant can also prevent C&D waste transport vehicles from transversing through the city while being a source of fugitive dust.

Adopt decentralized approach for siting multiple recycling plants

In larger cities where multiple C&D recycling plants are being established, it is important to locate these plants in a decentralized manner. This minimizes the distance that waste must travel across the city to reach a recycling facility, which translates to lower transportation costs. This subsequently decreases

the fees charged to municipalities or waste generators. By keeping these fees low, waste generators are more likely to comply with the formal waste disposal system, reducing instances of illegal dumping and ensuring more waste is properly recycled.

Location of recycling plants to take sensitive receptors into account

Receptor mapping of sensitive zones and environmental hotspots needs to be carried out before setting up a C&D recycling facility. Several rules, acts and notifications need to be adhered to before allocating land for the plant.

Smaller plants may require capital expenditure support for establishment

Mega cities have sufficient waste feed for sustaining the operations of large recycling plants. However, the Tier 2/3 cities might not generate enough waste feed to be able to sustain the operations of the plant. Municipalities have circumvented this issue by setting up plants in a cluster approach. However, it may be noted that the cluster solution might not work for areas where the municipalities are at a considerable distance, because then the the cost of transportation becomes too high. In such scenarios, the plants may require financial support for their establishment in the form of viability gap funding which may come through various government schemes. These financial streams should be augmented so that the establishment of more such plants can be supported.

Government support vital to ensure flow of waste for recycling

The role of the government in ensuring that a sufficient quantity and quality of debris becomes part of recycling ecosystem needs to be internalized. Successful models have been ones where government support in this aspect has been strong. Improving surveillance and cracking down on illegal dumping has been effective in cities where third-parties are engaged, as exemplified by Gurugram. Additionally, measures such as video-fencing with remote connectivity, as implemented in Delhi, show promise in arresting illegal dumping. The next step is having a strong and convenient collection system. This involves setting up helpline for generators, user awareness systems, online payment option, notification of dumping points for generators, IEC activities, issuing demolition permits, etc.

Rationalize user charges for non-BWGs by using tools like cross-financing

Most cities have struggled to get their primary waste collection processes right. The high disposal fee creates a significant burden for small waste generators,

discouraging them from using scientific disposal methods and often leading to illegal dumping. To address this issue, fees for non-BWGs should be rationalized and kept within reasonable limits. Innovative approaches, such as cross-financing, can be utilized to achieve this. Delhi has developed a model where bulk waste generators pay a higher processing fee than the municipality, allowing the plant operator to balance the costs and keep the tipping fee for the municipality to a minimum.

Ensure recycling plant receives adequate C&D waste

The economics of running a C&D recycling system depend on receiving an adequate amount of C&D waste. Therefore, municipalities need to implement strong measures to prevent illegal dumping and establish a robust ecosystem that ensures C&D waste is directed to recycling plants. Ensuring a minimum guaranteed quantity of raw material reaching the plant will help maintain the steady supply necessary for the plant's viability and proper functioning.

Incentivize C&D waste segregation

Most of the C&D waste feed comprises of unsegregated waste, resulting in low-quality recycled aggregates and products. Gurugram has introduced a solution to address this challenge by providing a facility for waste collection from bulk waste generators. These generators have the option to have C&D waste collected by the plant operator, with a fee of Rs 360 for segregated waste and Rs 720 for unsegregated waste. This incentivizes bulk waste generators to segregate their waste at source, ensuring that segregated feed becomes integrated into the recycling system.

C&D Rules should define management of other building materials such as glass, insulation, etc.

A demolition site produces a variety of materials. Apart from masonry, concrete, etc., insulation materials, glass wool, wood, plastic, glass, etc. also end up at the recycling facility. The next iteration of the rules should define what can be done with these products as they cannot be recycled by the C&D recycling facility.

A mature recycled products market is key for smarter business models

The revenue of the plant operators consists of two components, tipping fee obtained from municipality and the revenue generated from sales of recycled products. Most plants, however, are dependent on the tipping fee provided by the municipality as a major revenue component.

Creating a sustainable business model for C&D recycling plants hinges on ensuring that revenue from the sale of recycled products becomes the dominant source of income.

Successful models demonstrate that a healthier C&D recycling business model paves the way for increased competition and the establishment of more recycling plants within cities. A better distribution of recycling facilities, specially in large urban areas, in turn cuts down travel distances and associated costs, eventually making the system more economic to run. The transition requires strategic steps and policy initiatives to cultivate a mature market for these products.

Mandate use of recycled products in construction

The Construction and Demolition Waste Management Rules of 2016 recommend substituting 10–20 per cent of construction materials with recycled C&D waste in municipal and government contracts. However, among the cities studied, only Pune, Pimpri-Chinchwad and Delhi have notified the same. A mandate for ensuring reuse of recycled products as per the 2016 Rules should be fast-tracked. This mandate should eventually extend beyond just government construction works to include all construction activities.

Additionally, projects associated with government schemes such as Pradhan Mantri Awas Yojana and Pradhan Mantri Gram Sadak Yojana may also establish higher targets for the utilization of C&D recycled products beyond the minimum requirements.

Provision of Non-Availability Certificate

The provision of Non-Availability Certificate from plants can support and strengthen the implementation of this mandate. If a recycling plant cannot supply enough recycled C&D waste, the builder may be issued a Non-Availability Certificate. Approval for construction utilizing insufficient quantities of recycled C&D waste products should only be granted under such circumstances. This certificate serves as a validation for the unavailability of the required recycled materials, justifying the use of non-recycled alternatives in the construction process. Chandigarh has been successful in implementing this provision.

Linking payments and occupancy certificate to proof of recycled products usage

To ensure that construction companies comply with the local regulations regarding the use of recycled products in their building projects, C&D recycling plants should provide a document verifying the quantity of recycled material purchased.

This document serves as proof for the construction company to obtain building occupancy certificates or other necessary clearances. In cases where a municipality or public works department (PWD) hires a private contractor for construction, the contractor should receive payment from the government construction company only after meeting this requirement. This measure helps enforce the use of recycled materials in construction projects. Chandigarh has successfully implemented this provision.

Reduce tax levied on recycled C&D products

Recycled aggregates produced by the C&D plant are subjected to a 5 per cent tax rate, while concrete recycled products like tiles, blocks and bricks face a higher tax rate of 18 per cent. In comparison, a conventional red brick is taxed at only 5 per cent. The market competitiveness of recycled products in comparison to their virgin material counterparts is significantly influenced by their pricing. An elevated tax rate on recycled products serves as a deterrent for potential buyers, hindering their inclination to purchase these environmentally-friendly alternatives. In essence, a higher tax burden on recycled items negatively impacts their market appeal and adoption.

Collaborative effort required between construction companies, municipalities and plants for enhancing product specification

Construction firms must communicate their product needs to the plant operators, who need to respond by supplying products with necessary specifications. This effort involves coordination between the municipality, plant operators and government construction companies. An example of such an association bearing fruit is the case of the Supreme Court annex building. An iconic building such as this has the potential to earn the market's trust, hence penetration of these materials into such projects should be promoted by local authorities.

Material testing should be widely adopted by recycling plants

Improving material testing procedures is essential to guaranteeing the highest quality of recycled products entering the market, thereby expanding the scope for replacing natural materials. New recycling plants must account for material testing laboratories and associated equipment in their budgets.

Existing codes need to be revisited to enhance application of recycled materials

The current Indian codes such as IS:383 have been rather conservative on the use of recycled C&D waste products, majorly limiting their use in non-structural

applications. However, several studies suggest the need to revisit these existing codes and explore how the use of C&D recycled products can be enhanced.

Future versions of the codes governing concrete masonry units (IS 2185 part-1) and concrete paving blocks (IS:15658) should include separate benchmarks for products made from recycled aggregates.

States should include recycled products in their Schedule of Rates (SOR)

Incorporating recycled products into the SOR is instrumental in building trust within the building community and promoting the adoption of recycled products derived from C&D waste. A notable example is the CPWD Schedule of Rates 2023 for Delhi, which has successfully implemented this approach. Including recycled products in the SOR provides official recognition and endorsement, instilling confidence among builders and contractors about the quality and reliability of these materials.

List C&D recycled products on government material portals

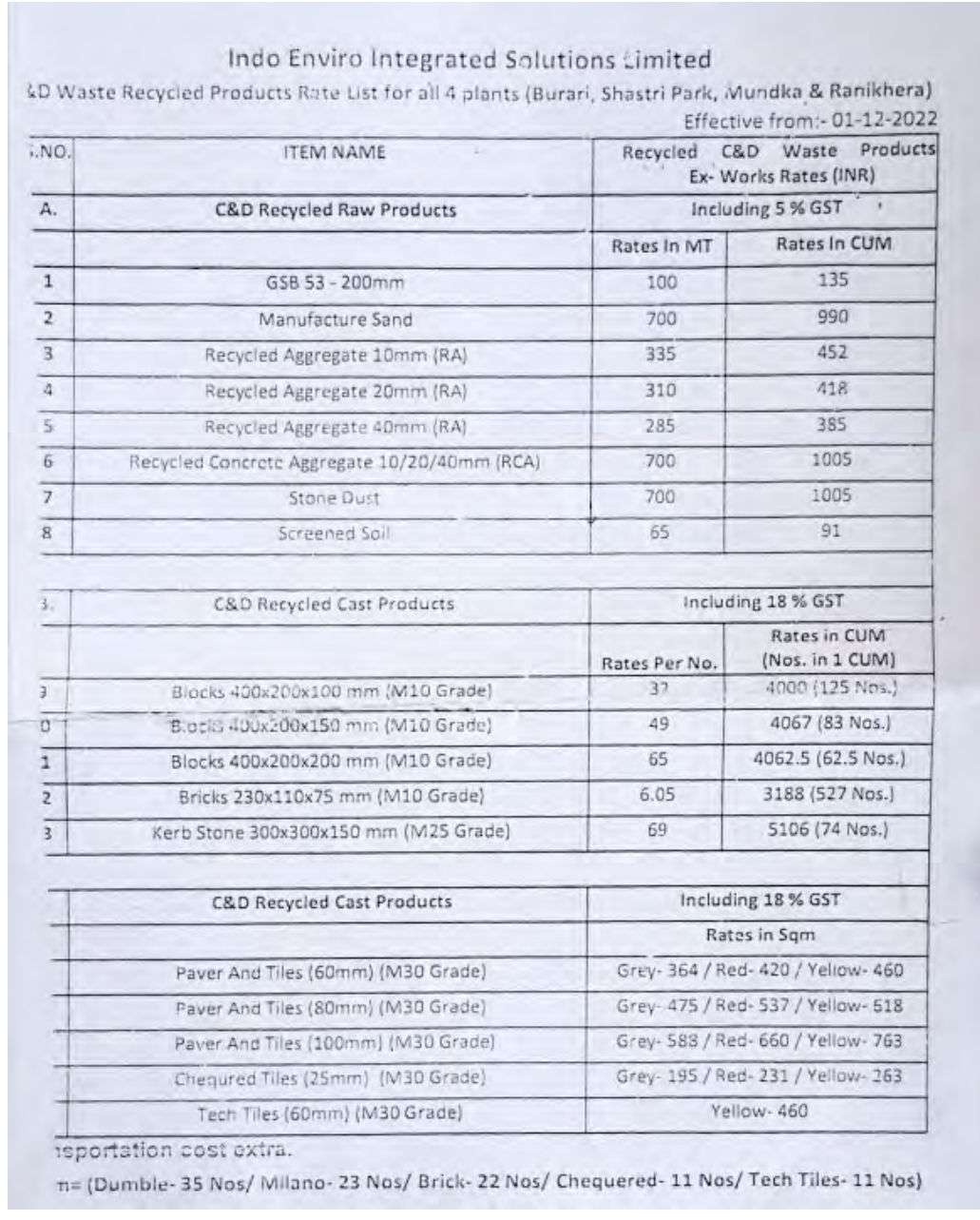
Currently, government construction companies struggle to ascertain the availability of materials at different recycling plants, hindering timely procurement during construction projects. Establishing a portal that provides real-time information on the quantities and locations of C&D recycled materials can streamline this process.

Additionally, integrating C&D recycled materials into government material portals, such as the Platform for Infrastructure and Materials Providers (INAM-Pro), would enable prospective buyers, including government contractors, to easily compare prices and availability, thereby simplifying the procurement process.

Recycled products may be given at a discounted rate to bulk waste generators

Recycled products may be discounted for those bulk waste generators that provide C&D waste for recycling. This can solve multiple issues. The bulk waste generator will get an incentive to dispose of the waste to the recycler. The recycler will get a stream of material for creating recycled products. This will also encourage the bulk waste generator to use recycled products in their construction projects. Some plant operators even offer a percentage of recycled products for free, based on the amount of waste provided.

Annexure



Indo Enviro Integrated Solutions Limited

&D Waste Recycled Products Rate List for all 4 plants (Burari, Shastri Park, Mundka & Ranikhera)

Effective from:- 01-12-2022

.NO.	ITEM NAME	Recycled C&D Waste Products Ex- Works Rates (INR)	
A.	C&D Recycled Raw Products	Including 5 % GST	
		Rates In MT	Rates In CUM
1	GSB 53 - 200mm	100	135
2	Manufacture Sand	700	990
3	Recycled Aggregate 10mm (RA)	335	452
4	Recycled Aggregate 20mm (RA)	310	418
5	Recycled Aggregate 40mm (RA)	285	385
6	Recycled Concrete Aggregate 10/20/40mm (RCA)	700	1005
7	Stone Dust	700	1005
8	Screened Soil	65	91

3.	C&D Recycled Cast Products	Including 18 % GST	
		Rates Per No.	Rates in CUM (Nos. in 1 CUM)
9	Blocks 400x200x100 mm (M10 Grade)	32	4000 (125 Nos.)
0	Blocks 400x200x150 mm (M10 Grade)	49	4067 (83 Nos.)
1	Blocks 400x200x200 mm (M10 Grade)	65	4062.5 (62.5 Nos.)
2	Bricks 230x110x75 mm (M10 Grade)	6.05	3188 (527 Nos.)
3	Kerb Stone 300x300x150 mm (M25 Grade)	69	5106 (74 Nos.)

	C&D Recycled Cast Products	Including 18 % GST
		Rates in Sqm
	Paver And Tiles (60mm) (M30 Grade)	Grey- 364 / Red- 420 / Yellow- 460
	Paver And Tiles (80mm) (M30 Grade)	Grey- 475 / Red- 537 / Yellow- 618
	Paver And Tiles (100mm) (M30 Grade)	Grey- 588 / Red- 660 / Yellow- 763
	Chequred Tiles (25mm) (M30 Grade)	Grey- 195 / Red- 231 / Yellow- 263
	Tech Tiles (60mm) (M30 Grade)	Yellow- 460

isportation cost extra.

n= (Dumble- 35 Nos/ Milano- 23 Nos/ Brick- 22 Nos/ Chequered- 11 Nos/ Tech Tiles- 11 Nos)

Ramky Reclamation & Recycling Limited
Construction & Demolition Waste Recycling Process Plant, Noida, Sec-80, Uttar Pradesh
Rate List Of Recycling C&D Waste Products
Excisable Products

			RATE/PIECE GST EXTRA 18%				
S.NO.	ITEM NAME	THICKNESS	GREY	RED	Strength		
1	Zig Zag Tile	60MM	11.00	11.50	M-25 to M30		
2	Dumble Shape Tile	60MM	10.50	11.50	M-25 to M30		
3	Milano tile	60MM	11.00	12.00	M-25 to M30		
4	Zig Zag Tile	80MM	12.50	13.50	M-25 to M30		
5	Dumble Shape Tile	80MM	12.50	13.50	M-25 to M30		
6	Milano Tile	80MM	12.50	13.50	M-25 to M30		
7	CC BLOCK (400*200*100)	Rs.32/- PER PC			M10		
8	Cement Brick (230*110*75)	Rs.5/- Per PC			M10		

S.NO.	ITEM NAME	Rates per Ton and 5% GST Extra	REMARKS
1	Recycled aggregate 10mm	370	Loading is included
2	Recycled aggregate 20mm	330	Loading is included
3	Recycled aggregate 40mm	300	Loading is included
4	Recycled aggregate 5 mm	750	Loading is included
4	M-sand	850	Loading is included

RV ENVIRONMENT INFRASTRUCTURE PVT. LTD.

C & D Waste Processing Plant (Under MCG-Indo Enviro)
Basai, Sec-100, Gurugram-122001
Rate List of Recycled Materials & Concrete Products W.E.From 01-04-2023

Recycled Materials

Sl. No.	Item Name	Basic Rate (Rs./MT)	GST@5% (Rs./MT)	Total Rate (Rs./MT)		
1	Aggregate- 10 mm	350	17.50	367.50		
2	Aggregate- 20 mm	350	17.50	367.50		
3	Aggregate- 40 mm	300	15.00	315.00		
4	Stone Dust	350	17.50	367.50		
5	Washed Sand	600	30.00	630.00		
6	Screened Soil	60	3.00	63.00		

Interlocking Pavers

S.No.	Shape	Size (mm)	No of pcs/SQM	Basic Rate (Rs./SQM)	GST @18% (Rs./SQM)	Total Rate (Rs./SQM)
1	Milano - 60 mm thickness	270 outer	23	311	56	367
2	Rectangular Shape-60 mm thickness	350*150	22.2	311	56	367
3	Zigzag - 60 mm thickness	250*125	32	311	56	367
4	Dumble - 60 mm thickness	200*160	35	311	56	367
5	Dumble - 80 mm thickness			411	74	485
6	Dumble - 100 mm thickness			511	92	603

Note - 1. Above mentioned rates are for Grey color Pavers.
2. Pavers of any other shape, texture or color can be manufactured based on required design and order quantity.

Concrete Products

Sl. No.	Item Name / Shape	Size (mm)	No. Of units/CUM	Basic rate (Rs./Pcs)	GST @18% (Rs./Pcs)	Total Rate (Rs./Pcs)
1	Concrete Block - solid (Grade-M-10)	400*200*100	125	27.12	4.88	32.00
2	Concrete Block - solid (Grade-M-10)	400*200*200	62.5	54.24	9.76	64.00
3	Kerb Stone (Grade-M-25)	300*300*150	74	60	10.80	70.80
4	Brick (Grade-M-10)	230*110*75	527	5.5	0.99	6.49

Note - Hollow / Solid concrete blocks and other concrete products like Boundary Wall Panels, Drain Covers etc. of any shape and size can be manufactured based on required design and order quantity.

Other Terms & Conditions-

1. The above mentioned price are ex-factory.
2. We can also arrange transportation up to customer's site.
3. Payment should be deposited in advance.

For Sales information please contact:
Mr. Rahul Tiwari - 9999740462/Mr. Ashish-9711341603

Rise Eleven Concrete Products Pvt. Ltd.

Plot no.F-1, Ecotech-3, Gr. Noida

Products	Rate/M.T
Screen Soil	120
Washed Screen Soil	120
10 MM	350
20 MM	350
40 MM	350
Dust	400
M-Sand	400
Super 10 MM	600
Super 20 MM	600
Super M-Sand	650
Super Dust	500
Washed Aggregate	350
Washed Coarse Sand	700
Washed Fine Sand	600
Note: Gst Extra.	

Rise Eleven Delhi Waste Management Co.

C & D Waste Processing Plant (Under SDMC)

Bakkarwala, New Delhi-110041

Rate List of Recycled Materials & Concrete Products W.E.From 01-01-2024

Recycled Materials

Sl. No.	Item Name	Basic Rate (Rs./MT)	GST (Rs./MT)	Total Rate (Rs./MT)		
1	Aggregate- 10 mm	500	25.00	525.00		
2	Aggregate- 20 mm	500	25.00	525.00		
3	Aggregate- 40 mm	500	25.00	525.00		
4	Stone Dust / CRF	400	20.00	420.00		
5	Super M.Sand	600	30.00	630.00		
6	M SAND	450	22.50	472.50		
7	PLASTER SAND	500	25.00	525.00		
8	WASHED SAND	550	27.50	577.50		
9	SCREENED SOIL	60	3.00	63.00		
10	GSB (Mix. With 40MM)	200	10.00	210.00		

Interlocking Pavers

S.No.	Shape	Size (mm)	No of pcs/SQM	Basic Rate (Rs./SQM)	GST (Rs./SQM)	Total Rate (Rs./SQM)
1	Milano - 60 mm thickness	270 outer	23	311	55.98	366.98
2	Rectangular Shape	300*150	22	311	55.98	366.98
3	Zigzag - 60 mm thickness	250*125	32	311	55.98	366.98
4	Dumble - 60 mm thickness	200*160	35	311	55.98	366.98
5	Dumble - 80 mm thickness			411	73.98	484.98
6	Dumble - 100 mm thickness			511	91.98	602.98

Note - 1. Above mentioned rates are for Grey color Pavers.
2. Extra Rate for Red Color Pavers @ Rs.30/SQM and for Yellow Color Pavers @ Rs.60/SQM
3. Pavers of any other shape, texture or color can be manufactured based on required design and order quantity.

Concrete Products

Sl. No.	Item Name / Shape	Size (mm)	No. Of units/CUM	Basic rate (Rs./Pcs)	GST (Rs./Pcs)	Total Rate (Rs./Pcs)
1	Concrete Block - solid	400*200*100	125	28	5.04	33.04
2	Concrete Block - solid	400*200*200	62.5	56	10.08	66.08
3	Kerb Stone	300*300*150	74	60	10.80	70.80
4	Brick	230*110*75	527	5.5	0.99	6.49
	Ready Mix Concrete of all grades delivered at site including Pumping, if required.					

Note - Hollow / Solid concrete blocks and other concrete products like Boundary Wall Panels, Drain Covers etc. of any shape and size can be manufactured based on required design and order quantity.

Other Terms & Conditions-

1. The above mentioned price are ex-factory.
2. We can also arrange transportation up to customer's site.
3. Payment should be deposited in advance.

For C&D Waste

In Case We are receiving C&D Waste from other then MCD then We are charging upto 275/MT. + Gst 18% Extra

For sales information please contact:

Dhiraj Jha - 8285102624

Image 45: Recycled products list from various plants.

References

1. Anon 2022, *From the Ground up,* RMI, National Insititute of Urban Affairs
2. Ibid
3. Ibid
4. Thibaut Abergel, Brian Dean and John Dulac 2017. *Towards a zero-emission, efficient, and resilient buildings and construction sector, Global Status Report 2017,* UNEP and IEA, Paris
5. B Catriona, Kuwamura S, Din A and Hamot L, 2021, 'An integrated approach to a sustainable built environment: the co-benefits of resources & circularity', *World Green Building Council*, https://worldgbc.org/article/an-integrated-approach-to-a-sustainable-built-environment-the-co-benefits-of-resources-circularity/
6. The Economist 2017. *Why There Is a Shortage of Sand*, The Economist Explains. Available at https://www.economist.com/the-economist-explains/2017/04/24/why-there-is-a-shortage-of-sand, as accessed on 02 August 2024
7. Ishan Kukreti 2018. *India can rely on sand imports till the time it is viable,* Environment, Down to Earth. Available at https://www.downtoearth.org.in/environment/india-can-rely-on-sand-imports-till-the-time-it-is-viable-60892 as accessed on 05 August 2024
8. UNEP 2022. *Our Use sand brings us against wall, Says UNEP Report*, Press Release, UNEP. Available at https://www.unep.org/news-and-stories/press-release/our-use-sand-brings-us-against-wall-says-unep-report as accessed on 07 August 2024
9. Daniel Hoornweg, Perinaz Bhada-Tata 2012. *What a Waste: a global review of solid waste management,* World Bank's Urban Development and Local Government Unit of the Sustainable Development Network, Washington
10. Anon 2018, *Strategy for Promoting Processing of Construction and Demolition (C&D) Waste and Utilisation of Recycled Products,* Niti Ayog, New Delhi
11. https://www.cseindia.org/india-manages-to-recover-and-recycle-only-about-1-per-cent-of-its-construction-and-demolition-10326
12. Ellen MacArthur Foundation 2016. *Circular economy in India: rethinking growth for long-term prosperity,* Ellen MacArthur Foundation

13. Anumita Roychowdhury, Rajneesh Sareen and Mitashi Singh 2023. *Construction and Demolition Waste: Closing the waste loop for sustainability,* Centre for Science and Environment, New Delhi
14. Anon 2018, *Strategy for Promoting Processing of Construction and Demolition (C&D) Waste and Utilisation of Recycled Products,* Niti Ayog, New Delhi
15. Anumita Roychowdhury, Avikal Somvanshi and Anurag Verma 2020. *Another Brick off the Wall: Improving Construction and Demolition Waste Management in Indian Cities,* Centre for Science and Environment, New Delhi
16. TERI and ARAI 2018. *Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources,* TERI and ARAI
17. Anumita Roychowdhury, Avikal Somvanshi and Anurag Verma 2020. *Another Brick off the Wall: Improving Construction and Demolition Waste Management in Indian Cities*, Centre for Science and Environment, New Delhi
18. Avikal Somvanshi 2019. *India Drowns in Construction Demolition Debris,* Waste , Down to Earth. Available at https://www.downtoearth.org.in/news/waste/india-drowns-in-construction-demolition-debris-65110 as accessed on 10 August 2024
19. Portal for Regulation of Air Pollution in Non-Attainment Cities. *About,* Portal for Regulation of Air Pollution in Non-Attainment Cities. Available at https://prana.cpcb.gov.in/#/about as accessed on 05 August 2024
20. Ministry of Housing and Urban Affairs 2023. *Press Release of Approval of the City Investments to Innovate and Sustain 20. (CITIIS 2.0) ,* Press Information Bureau. Available at https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1945495 as accessed on 03 August 2024
21. Anumita Roychowdhury, Rajneesh Sareen and Mitashi Singh 2023. *Construction and Demolition Waste: Closing the waste loop for sustainability,* Centre for Science and Environment, New Delhi
22. Oreflow. *What are Jaw Crushers and How does it Work,* OreFlow. Available at https://oreflow.com.au/what-is-a-jaw-crusher-and-how-does-it-work/ as accessed on 11 August 2024
23. Eric Marcotte. *What Is A Vertical Shaft Impactor (VSI) Primer,* Stedman Machine. Available at https://www.stedman-machine.com/vsi-primer-article.html as accessed on 11 August 2024
24. Bureau of Indian Standards 2016. *Coarse and Fine Aggregate for Concrete Specification (Third Revision),* Bureau of Indian Standards, New Delhi

25. P N Ojha , Puneet Kaura , Brijesh Singh and B N Mohapatra 2023. "Management and Classification of Construction and Demolition Waste in India", *Sustainable Structures and Materials, Vol.6, No. 1,* National Council for Cement & Building Materials, India
26. Ibid
27. Indian Roads Congress 2017. *Guidelines For Use Of Construction And Demolition Waste In Road Sector*, Indian Roads Congress, New Delhi
28. K. McNeil and H. K. Kang 2013. *Recycled Concrete Aggregates: A Review*, International Journal of Concrete Structures and Materials
29. Indian Roads Congress 2017. *Guidelines For Use Of Construction And Demolition Waste In Road Sector*, Indian Roads Congress, New Delhi
30. P N Ojha , Puneet Kaura , Brijesh Singh and B N Mohapatra 2023. "Management and Classification of Construction and Demolition Waste in India", *Sustainable Structures and Materials, Vol.6, No. 1,* National Council for Cement & Building Materials, India
31. P N Ojha , Puneet Kaura and Brijesh Singh 2023. "Studies on mechanical performance of treated and non-treated coarse recycled concrete aggregate and its performance in concrete-an Indian case study", *Research on Engineering Structures and Materials,* Centre for Construction Development & Research, National Council for Cement and Building Materials, India
32. Christian John Engelsen, Kshemendra Nath P. and Sivakumar Kandasami 2022. "Recycled Concrete Aggregates In New Concrete – Full Scale Demonstration In Navi Mumbai", *Indian Concrete Journal,* Sintef Community
33. Sugandha Arora 2020. *An Ashen Legacy: India's thermal power ash mismanagement,* Centre for Science and Environment, New Delhi

Currently, India has over 34 operational C&D recycling plants, with more than 35 additional facilities planned in the coming years. However, there is a notable gap in the market's understanding of the financial mechanisms, challenges, processes, and economic viability of establishing and running these facilities.

Through a comparative study of 16 recycling plants across India, supplemented by interviews with key stakeholders, this report by the Centre for Science and Environment (CSE) seeks to bridge this knowledge gap for all the stakeholders involved in C&D waste management.

Along with exploring potential policy interventions necessary to establish a robust and sustainable C&D recycling ecosystem, the report offers valuable insights into how these facilities can operate effectively, even with limited government support.

Case studies of C&D waste management city ecosystems can be accessed at:

Case studies of C&D waste recycling facilities can be accessed at:

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phone: 91-11-40616000 E-mail: cse@cseindia.org
Website: www.cseindia.org