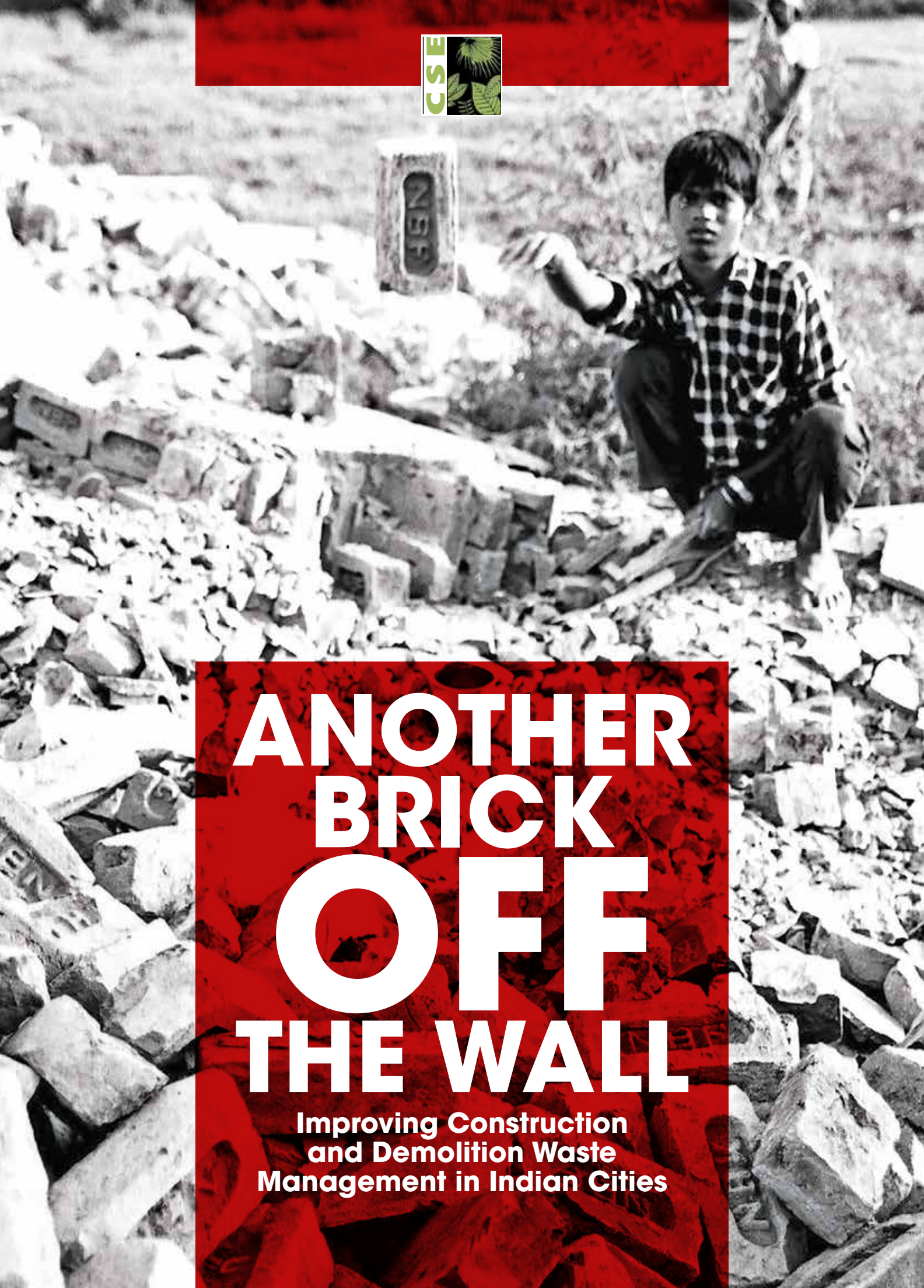

ANOTHER BRICK OFF THE WALL

Improving Construction and Demolition Waste Management in Indian Cities

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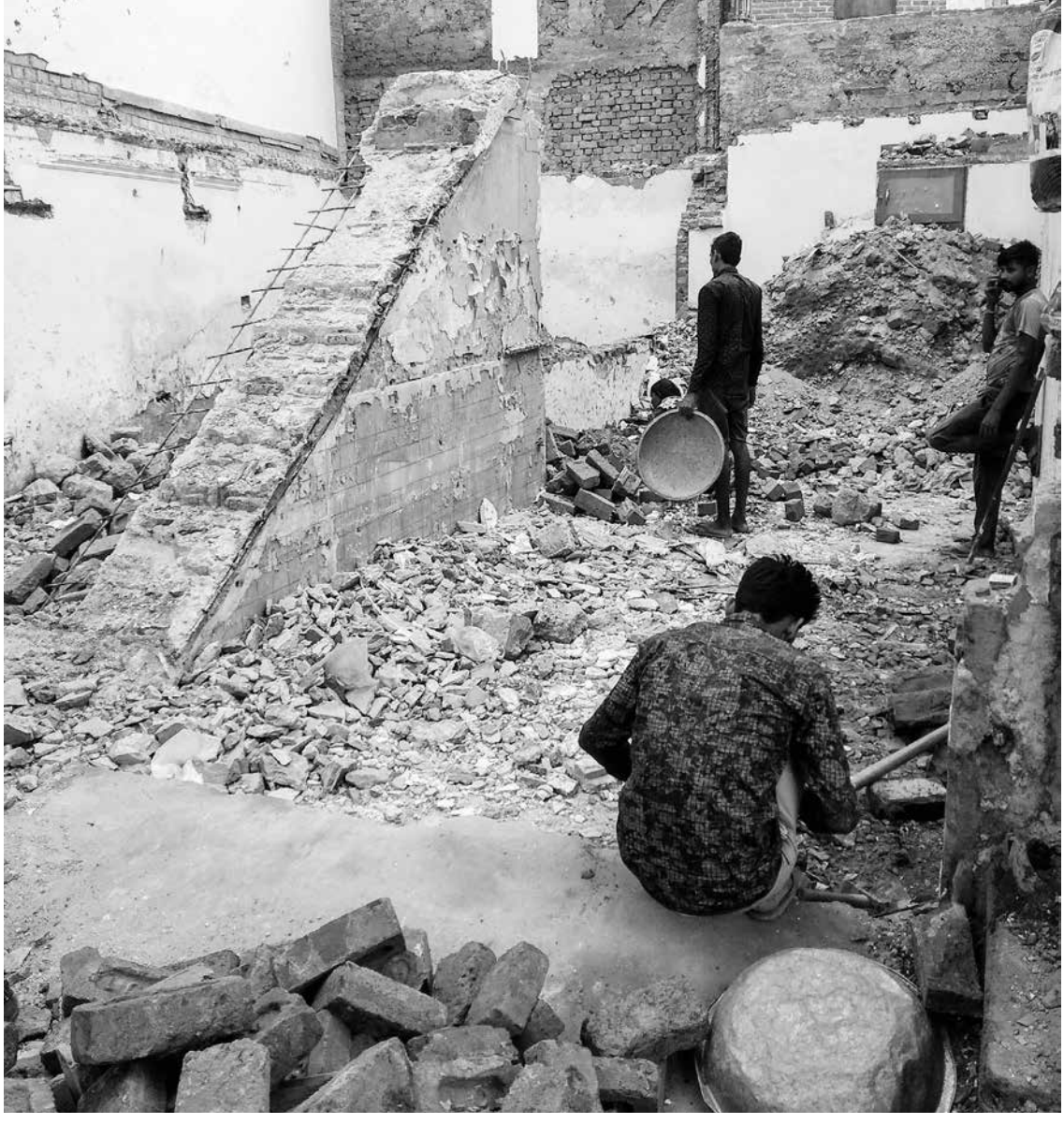


ANURAG VERMA/CSE

EXECUTIVE SUMMARY

Bring the bricks back home

Overview and recommendations

Construction and demolition (C&D) waste has become central to the environmental discourse for multiple reasons. Heaps of concrete, bricks, and metal waste from building construction and infrastructure choke our waterbodies, green areas and public spaces in cities and outside. Huge amounts of toxic dust particles from the debris pollute the air. In fact, cities and regions struggling to meet the National Ambient Air Quality Standards (NAAQS) face the daunting challenge of controlling emissions from this sector. Nearly all Clean Air Action Plans of cities under the ongoing National Clean Air Programme (NCAP) have included action strategies to control pollution from the construction sector.

The construction sector is facing the additional challenge of material crisis.

ANURAG VERMA/CSE

A demolition site in Delhi

Along with the construction industry generating huge amounts of material waste, its demand for primary material—minerals, stone, sand, iron ore, aluminum and timber—is growing at an unprecedented rate. This has exacerbated deforestation for timber, scarred hills and rivers for sand and minerals, and damaged floodplains.

A significant proportion of construction waste can be recycled and reused and brought back to construction to substitute a substantial part of naturally sourced material. This demands a circular economy that makes C&D waste a resource to be ploughed back. A circular economy can help address the cost of unsustainable extraction of virgin material and conservation pressure of mining. Implementing a well thought-out strategy for reduction, reuse and recycling of C&D waste in new construction can help reduce energy intensity and environmental footprint of the buildings and infrastructure.

India had to initially fight a legal battle to allow use of recycled material in construction. The earlier IS:383-1970 of the Indian Standard specification relating to aggregates for concrete laid down by the Bureau of Indian Standard (BIS) had stated that concrete can be made only with 'naturally accessed material'. Based on this, construction agencies expressed their inability to use recycled material. It is notable that the BIS in response to civil society intervention and deliberations of the Environment Pollution (Prevention and Control) Authority (EPCA) modified this requirement in early 2016. Today it is legal to use concrete made from recycled material and processed C&D waste is recognized as an alternative to natural aggregates.

This development has opened up an enormous opportunity. The Construction and Demolition Waste Management Rules and Regulations, 2016 (referred as the Rules from here on) has further created the mandate for reuse of recycled material.

The Rules, the first-ever rules to formalize and streamline handling, management and recycling of C&D waste in the country, have created the legal handle for state governments as well as construction agencies to address one of the country's largest solid waste streams, which they had previously ignored. Implementation of the Rules has been weak so far and it begets revisiting the problem to understand the loopholes and undertake course correction.

The big challenges are to ensure that the Rules are followed, state governments and the construction industry create adequate infrastructure for recycling, and systems and incentives are in place for quick uptake of recycled materials. With growing urbanization and construction of buildings and infrastructure, there will inevitably be a C&D waste boom. According to the United Nations-Habitat programme, India's population is set to rise from the current population of 1.37 billion to 1.55 billion by 2050—half of this projected population will live in urban centres. The urban infrastructure will eventually put enormous strain on India's dwindling repository of natural reserves while waste will destroy the fragile ecology and contaminate the air.

It is another challenge that C&D waste generation has never been adequately quantified to even know the infrastructure preparedness in cities for its segregation, collection and recycling. In fact, when the Centre for Science and Environment (CSE) began its advocacy for a strong recycling policy for C&D waste during the earlier part of the last decade (2010s), it found that the official estimates for C&D waste generation had not changed in the official documents since 2000. The original annual generation estimate of 10–12 million tonnes (MT) by the Ministry of Urban Development in 2000 persisted in the official documents of the Central government until 2015 despite the Technology Information, Forecasting and Assessment Council (TIFAC) giving in 2001 a higher estimate of 12–14.7 MT and the construction boom in the country.

The science and techniques of such quantification and inventory have become critical to ensuring that adequate systems are created in cities to collect and recycle the entire material in a transparent and accountable manner. Construction agencies can be held accountable for inventories—including ensuring that the invisible unquantified debris is not used by land sharks to fill wetlands or low-lying lands for illegal reclamation of land.

It is also necessary to understand the nature of waste potential of new construction as well as of the New Age material flooding the construction sector to facilitate speed and ease of construction and to replace clay bricks. Use of these materials is expanding under Pradhan Mantri Awas Yojana (PMAY) for the affordable housing sector. It is important to assess this dimension for future preparedness.

CSE has carried out a detailed analysis of the current C&D waste challenge as well as technical and regulatory barriers to implementation of the Rules. It has identified strategies needed to accelerate the implementation of the Rules and market uptake of recycled material. The analysis is supported by ground-reality checks in cities. This case study-based approach has provided a more granular view of practical challenges that require attention.

This report is divided into two parts. Part 1 is an overview of the challenges and progress so far in different aspects of C&D waste management, and a review of policies and detailed recommendations on the way forward. Part 2 is a summary of case studies from cities, which examine the ground realities.

Key highlights

Slow progress: Assessment of the status of the C&D Waste Management Rules shows that despite the notification of the Rules in 2016 and related subsequent amendments to standards and schedule of rates needed to support it at the national level, implementation has not yet been streamlined in most cities, including the megacities. For instance, Mumbai, with the richest urban local body (ULB), is still waiting to have an operational C&D waste recycling facility even after additional pressure from the Bombay High Court, which has issued multiple orders asking for urgent setting up of a C&D waste recycling facility in the city. It is important to understand the challenges so that the objective of managing this waste and converting it into a resource can be met and upscaled.

Need stronger preparedness in states: The Government of India has also launched its flagship programme Swachh Bharat Mission to provide basic infrastructure and services for sanitation and waste. The Swachh Bharat Mission has recognized the need for C&D waste management. But initially, it was not included in Swachh Bharat Mission's Swachh Survekshan, a pan-India annual competition to encourage cities to improve the condition of urban waste and sanitation. Subsequently, in 2019, C&D waste management as a new indicator was introduced to reward ULBs with any mechanism to manage C&D waste as per the C&D Waste Management Rules, 2016. Cities were required to report on the C&D waste generation data, available infrastructure, public outreach and implementation of the Rules. But most ULBs could not respond adequately with data on all the criteria, including quantum of waste generation. As a result, the final report of the 2019 Swachh Survekshan used the blanket phrase 'C&D waste management as per C&D Rules 2016' to describe performance of the leading cities and states. Only Gujarat was acknowledged to have seven ULBs that were 'processing more than 70 per cent of C&D waste as per 2016 Rules', dubious claim as only Ahmedabad has a functional C&D waste recycling facility. It is therefore speculated that the definition of what qualifies as 'processing' C&D waste had to be altered. In 2020, the C&D waste marking scheme for ranking was changed. Instead of marking cities based on the percentage of waste managed, having the bare minimum infrastructure became the criteria.

Swachh Survekshan sets a new benchmark: The toolkit for Swachh Survekshan 2021 was launched by the Ministry of Housing and Urban Affairs (MoHUA) on 3 July 2020. Given the difficulty of assessing C&D waste management in cities in the previous two cycles, the criteria were revised. Ranking points for C&D waste management have been doubled to 100 points divided equally between management infrastructure and waste-processing efficiency. To get points under the management infrastructure criteria, cities need to have in place a C&D waste-collection system, notified charges for C&D waste services, and segregation of waste in five streams. Under the waste-processing efficiency criteria, ranking points will be awarded based on percentage of collected waste that is processed and reused. The reporting and documentation requirements are comprehensive as well. These criteria and indicators for C&D waste are not as detailed and ambitious as those framed for

VIKAS CHOUDHARY/CSE

A C&D waste dump at Shastri Park in Delhi

municipal solid waste (MSW) but are pragmatic and would be conducive to getting cities to start C&D waste management. Cities will need strong preparedness for this.

Constraint of finding land for collection and recycling: Nearly every city faces the crippling challenge of finding adequate land for collecting and recycling C&D waste. Setting up any kind of waste management or recycling facility requires a significant amount of land, and cities are often constrained by outdated zoning requirements and 'not in my backyard' sentiment among citizens. There is additional pressure of real-estate value capture that prevents land from being earmarked for waste disposal. Cities fear loss of revenue.

Several cities have begun to consider land from no-development zones or ecologically sensitive areas within or around the city. For instance, Gurugram's proposal to build its recycling facility in the Aravalli Hills and Kolkata's proposal to build it in a wetland were blocked by the respective state environment authorities for violating rules for environmentally sensitive areas. Pune has identified land that belonged to the state government outside the city limit. Land was leased out to the city by the state but the city was not allowed to develop the land under public–private partnership (PPP). There are legal hurdles in these cases.

Challenge of collection and transport of C&D waste: There is considerable diversity in C&D waste transportation practices among ULBs. C&D waste is transported from the site to disposal sites on the payment of a minimal fee to

transporters by the project owner or construction contractor. Many ULBs provide on-call pick-up services as well. For instance, the responsibility of transporting waste in cities such as Delhi lies with the waste generators, who are required to deliver C&D waste at their own expense to the ULBs' designated collection points. The ULBs then take the waste to the disposal sites. It was found that private and informal transporters in Delhi are often not aware of collection points. Even if they know where they are, the commute might be uneconomical. Also, sometimes they are stopped from dumping waste at the designated points by caretakers or asked to pay informal usage fees. As transporters work with tight profit margins, this added cost induces them to litter.

Kolkata in contrast provides on-call waste-collection services. Waste generators are allocated a day and time slot for the pickup, based on payment. This is a better model but also faces the challenge of capacity crunch and the service is not adequately extended citywide.

Concerns about finances and business case: Cities see this as additional financial risk and a possible burden. They have been found looking for ways to shield themselves from any financial liability while implementing the Rules. In some cases, ULBs have proposed that the contracted party for collection and transportation of C&D waste actually pay the ULB rather than receive a tipping fee for each tonne of C&D waste. Many have proposed that the recycling facility must share profits from selling recycled products with the ULB. These have deterred development of much needed new entrepreneurship in this sector.

Low involvement of state government agencies/departments: State urban departments are supposed to frame policies on C&D waste management, supplementing the 2016 Rules, to help implementation by taking local context into account. In most cases, their engagement has been poor. There has been some rekindling of interest from states after C&D waste management appeared as one of the major sectors for air pollution control intervention under the National Clean Air Programme (NCAP). Moreover, the active involvement of state urban development departments (sometimes with other related agencies) may be needed for financial assistance and suitable land identification for establishing waste processing facilities as cities struggle to find land under their jurisdiction. Also state government agencies such as Public Works Department (PWD), Housing Development Board/Authority, City Development Authorities, public sector utility companies etc. involved in significant construction and/or demolition work need to coordinate with ULBs for proper disposal of their C&D waste, implement in situ utilization of C&D waste in their own projects wherever feasible and adopt policies to buy recycled products.

Lukewarm response from construction industry, low awareness: NITI Aayog's 2019 C&D waste strategy report *Resource Efficiency & Circular Economy* notes a glaring lack of awareness of the Rules in the construction industry across the nation. In large projects where C&D waste management gets incorporated within the environmental clearance requirement, there is some sensitivity towards disposal of the waste but hardly in accordance with the Rules. Incorrect disposal cost Bengaluru heavily during the mega-construction of its Kempegowda International Airport. In its first phase the contractor took advantage of the massive project site

and dumped generated C&D waste on the vacant land meant for the second phase of the project. Now, the contractors of the second phase are struggling to clean the site of this waste and that has added to the project cost and time. The Rules stipulate that large projects should ideally adopt significant in situ utilization of C&D waste in their projects wherever feasible.

Poor accountability framework: The Rules make the waste generator responsible for managing waste. It has differentiated between small and big generators and set responsibilities accordingly. But the way a construction project is structured makes management of C&D waste complicated. The project owner is generally recognized as the generator, but the owner is rarely involved in actual construction. The standard practice is for the project owner to hire an architect and/or builder who hires the building contractor, who subcontracts disposal to transporters. This often leads to forged documents to show compliance with C&D waste disposal requirements by project owners as they themselves are not in direct control nor have knowledge of waste disposed. Requirements and responsibilities need to be spelled out clearly in all contacting and subcontracting agreements for a project with proof of proper disposal.

Lack of confidence in recycled products: The experience in Delhi and Ahmedabad has shown that the market for recycled products made from C&D waste is still quite limited. Potential buyers are hesitant and perceive these to be inferior in quality. Even when informed about the updated BIS standard (383) that allows recycled aggregates in many applications, potential buyers appear risk averse, pointing to their clients who seem to prefer 'conventional' products. There is also a problem of formal recyclers refusing to sell these products to small- and medium-scale buyers, who are most likely to experiment than established big players. It is expected that greater permeability of recycled products and use will help build confidence. It is therefore encouraging that the Central Public Works Department (CPWD), which has already adopted guidelines for use of recycled products, can help build confidence in the market. CPWD has used recycled aggregate products in the new building of the Supreme Court in Delhi.

Address pricing of recycled C&D waste products: The Ministry of Housing and Urban Affairs (MoHUA) has stipulated in many public forums that the cost of the recycled products needs to be at par or lower than the corresponding cost of conventional building material. But in reality, recycled C&D waste products are taxed higher than conventional building material. Currently, aggregates are taxed at 5 per cent and manufactured products from the recycled C&D waste are taxed at 18 per cent, making the use of recycled products economically unviable for most customers. CPWD purchased, for the construction of the Supreme Court Extension, recycled C&D waste blocks from Delhi's Burari C&D waste-recycling facility at a significantly higher price per block than conventional concrete blocks due to higher GST. Conventional red bricks are taxed at 5 per cent while recycled C&D waste blocks were taxed at 18 per cent.

CPWD could still go ahead as it was a mandate for them to use recycled C&D waste products in that specific project. But most construction projects do not have this flexibility and ability. GST must be relaxed for C&D waste recycled products, including tiles, paver blocks, bricks, sand and aggregates.

Role of informal sector: The Rules failed to take into account the informal economy and livelihoods attached with C&D waste handling. The new system of collection and disposal that was initially formalized reduced the scope of participation of the informal sector. Now, however, with Swachh Survekshan 2021's recognition of lower layers of road pavements, inner colony roads, filling of plinth and basement etc. as legitimate nonstructural applications of C&D waste, some of the policy roadblocks in involving the informal sector in the formal management of C&D waste have been removed. Now cities can engage with the community and plan how a symbiotic relation can be fostered. This has potential not only to substantially improve cities' waste management and reduce financial burden but also generate jobs and livelihood.

Every material in a demolished building has a value and there exists a well-established network of informal traders who are involved in recovery, recycling and selling of these materials. Cities would have to invest way less in C&D waste management infrastructure if they leveraged the existing informal infrastructure. In fact this would allow for a better and high-value resource recovery and livelihood generation then envisaged in the Rules. Usually, demolition contractors are the anchor of this informal circular economy and have established a thriving profession that feeds the informal market of used-recovered building materials. Materials that are salvaged during deconstruction generally include doors and windows, glass panels, partitions, furniture, bathroom fixtures, pipes, electric equipment and

VIKAS CHOUDHARY/CSE

Demolition in process in an 'informal' neighbourhood in Delhi

wires. Steel reinforcement and bricks are retrieved during demolition. The debris is the end-of-the-line product and contains soil, concrete, broken bricks and other mixed materials.

Most of the waste already has a market. Debris is the only major waste component that requires specialized recycling outside the informal sector.

Demolition management: The Rules classify all building materials, debris and rubble resulting from construction, remodelling, demolition and reparation work as C&D waste. But if one were to factor in resource recovery, not everything needs to go to crushing units for recycling as stipulated in the Rules. TIFAC's 2001 assessment of C&D waste noted that of all the materials produced in demolition, about 25 per cent from old buildings and 75 per cent from new buildings can be recovered for reuse. Given that demolition is the most prominent waste-generating activity, it is worth accessing it to reduce the quantum of waste generated that requires additional processing to be brought back into the economy.

Demolition services: Demolition is assumed to be part of any brownfield construction project but there is not much recognition of the fact that it is a specialized activity of which architects and builders have little understanding. It is dominated by the unorganized sector, with small players that generally neither have professional expertise nor are registered with an ULB or other professional body. There are a handful of specialized companies whose niche is high-tech demolition related to large infrastructure projects but they don't even account for a fraction of demolitions undertaken in the cities. ULBs have not developed any system to monitor and regulate small demolition contractors nor do the 2016 Rules require them to do so. This would need to change for effective management of C&D waste.

Legal requirements for demolition: Some kind of official permit or NOC is needed for all building demolitions but these can vary with each city. For instance, the Chennai Municipal Corporation issues independent demolition permits to construction and/or demolition contractors. But only a few ULBs in the country do this. In most cases ULBs require developers to apply for sanction by submitting revised building plans to undertake reconstruction or alterations. ULBs in return issue reconstruction approvals that also account for demolition. Due to this clubbing of permits, data on demolition is very poor in cities. After the notification of the C&D Rules 2016, multiple ULBs across India have made it a requirement for owners and developers to manage their C&D waste responsibly. Generators are expected to submit a waste management plan to ULBs for approval and can be fined for not adhering to the plan. Lack of any official guidelines on what should be covered in these C&D waste management plans and how these are to be evaluated and monitored are major concerns.

Standards and guidelines for demolition: The National Building Code 2016 covers safety in demolition of buildings under Part 7 ('Construction management, practices and safety') in Section 4 ('Safety in construction'). It provides detailed guidelines on how to ensure safety while demolishing civil structures. Various ministries have issued separate guidelines and standards on demolition of buildings and structures relevant to their jurisdiction. For instance, the Ministry of Steel has developed a standard Safety Code for the iron and steel sector to provide a safe procedure for demolition of building and structures. The standard notes collapse of structure,

falling material, flying material, impact/hit by material, collapse of equipment/ machinery, noise, entrapment, fall from height, electrocution, fire, explosion etc. as associated hazards with the activity. But these don't cover demolition from the perspective of resource recovery and recycling that is needed to meet for C&D waste-management goals.

Poor monitoring and lack of resources: ULBs typically suffer from chronic shortages in both human and financial resources. They are hard-pressed to monitor, collect and dispose of waste as stipulated by the law. Interdepartmental coordination has been a difficult challenge too. With single-window building clearance adopted by most cities, establishing responsibility, accountability and revenue sharing among departments has been even more critical. ULBs also lack access to basic scientific tools for waste estimation and to adequate knowledge support and experience for feasibility planning, tendering and so on. In many cases, inexperience or prior negative experience with public–private partnerships (PPPs) has been additional causes of hesitation to proceed with implementation. Further, there is an availability crunch of qualified and experienced C&D waste management consultants and service providers in India. Guidance available for the scheme is weak.

Preparing for waste management from new generation material: The construction sector is witnessing rapid change in construction technology and material. The focus is shifting towards prefabricated concrete structures. In infrastructure projects, prefabricated building technologies use structural elements or reinforced concrete elements built in a factory setting and assembled later at the construction site such as slabs for flyovers and overhead tracks for Metrorail projects. These are designed for dismantling and can be reused in similar projects after the original structure has completed its life. However, each prefab block is designed to a specific size and load capacity unique to the project. It is difficult to find other projects with similar load profiles to reuse them. Even if a match is found there are no practical guidelines for assessing and classifying dismantled prefab blocks suitable for reuse. However, these are made of concrete which can be easily recycled using the convention C&D waste recycling facilities.

In the building sector, fast-track technology is used in monolithic constructions, with walls, floors and slabs forming a single unit with the concrete poured on-site in formworks. Other technologies like autoclaved aerated concrete (AAC) and fly ash bricks are also gaining acceptance. Most of these are concrete-based and can therefore be recycled after demolition using conventional C&D waste recycling facilities. But expanded polystyrene insulation (EPS), styrofoam, plastic spacers, bituminous material and asbestos embedded within them are a challenge for most concrete recyclers. EPS is utilized in many of these technologies and materials to provide insulation in the buildings. The material is light-weight and has a lot of air content. After its useful life, EPS can be densified through machines called densifiers which can convert them into EPS ingots. These ingots find application in the frame and furniture industry and can also be granulated and reused to make other plastic products. Internationally, recycling of EPS is not popular as it is primarily constrained by transport costs due to its dispersed disposal and short useful lifetime. This low-density bulky material results in high transport cost per unit weight, thus making its recycling economically unfavourable. This will emerge as a challenge with expansion of its market in India.

There are also composite materials like thermoplastics, which have gained favour in the construction industry. Thermoplastics (polycarbonate, polyethylene, polypropylene, PVC etc.) can be recycled but like EPS their recycling involves high costs, while thermosets (epoxy adhesives) are difficult to recycle. The lack of adequate markets, high recycling cost and lower quality of the recyclates are the major commercialization barriers in recycling of composite materials. PVC-U sourced mostly from window and door fabricators is being recycled into wiring accessories and cable management systems, including skirting and trunking. Composite materials can mostly be downcycled, not recycled.

Addressing infrastructure waste: Mega-urban infrastructures such as Metrorail, roadwork, drainage etc. are big generators of waste. Data available from the Delhi Metro Rail Corporation (DMRC) notes that the Delhi Metro construction disposed of approximately 225,000 tonnes of C&D waste to the recycling facility at Burari, Delhi, till March 2017.

Delhi's estimated C&D waste generation is about 3,000–4,000 tonnes per day (TPD). DMRC, which has been fined multiple times by NGT for unlawful disposal of its C&D waste in the eco-sensitive Yamuna floodplains, has adopted management of C&D waste. It has set up an in-house C&D waste recycling plant of 150 TPD capacity to process the waste being generated during construction of Phase-IV metro lines.[1] DMRC is still struggling to sustainably manage its excavation waste. Other infrastructure projects like highway and roadwork where bituminous material forms a considerable portion of the waste, recycling is challenging. No data is available from roadwork agencies on how they are managing their waste. Globally, it has been noted that the proactive prevention of waste through modification of existing on-site construction practices rather than retroactive management of waste after it has been generated is more effective and efficient.

Way forward

Environmental and material challenges associated with the C&D problem needs urgent nationwide attention. Two recent critical policy developments are now expected to have strong bearing on acceleration of C&D waste management in cities. One is the requirement of NCAP, which has set a target of 20–30 per cent reduction in particulate pollution in 122 cities that do not meet the National Ambient Air Quality Standards (NAAQS) by 2024. Clean air action plans in these cities have included C&D management as part of the clean air strategy. They need detailed indicators based on the regulations to quantify C&D waste generation and accordingly plan infrastructure for collection and recycling for effective and verifiable improvement.

The other big development is the 15th Finance Commission's direct allocation of Rs 4,000 crore to ULBs for air pollution control. In fact, based on this recommendation the Union Budget for 2020–21 has earmarked this fund for the ULBs of class I cities. C&D management is the direct responsibility of the ULBs and this funding can catalyse transformation in cities. But this requires detailed indicators for implementation so that all aspects can be adequately planned and tracked for progress and monitoring and effective impact. Funding of cities to incentivize C&D management can strongly support Swachh Bharat Abhiyan and Swachh Survekshan.

This assessment identifies key gaps in the implementation strategy that need urgent attention. On this basis and city-based granular views of ground reality, next steps are recommended. The assessment takes into account NITI Aayog's 2019 Strategy for Promoting Processing of Construction and Demolition (C&D) Waste and Utilisation of Recycled Products as it is the official guidance framework for states. This report has gone beyond NITI Aayog's strategy and has built up the assessment to address practical undercurrents that are dragging the implementation of C&D Waste Rules, including the inadequacy of the Rules themselves.

Define robust estimation of C&D waste: Cities need comprehensive assessment and quantification of C&D waste generation, utilization and disposal to plan adequate infrastructure and systems for management. ULBs to some extent have documentation of quantum of C&D waste that is hauled to the landfills or dumped in locations under their direct jurisdiction. However, a significant portion of the waste is diverted to informal markets and for illegal filling before construction and/or disposed of in places beyond the municipal jurisdiction. To improve future action, cities must create easily accessible databases of buildings and their physical and legal attributes. Construction/demolition permits need to be inventoried with associated waste management plans attached. Also, characterization of the C&D waste is necessary for the management plan, including collection, transportation and storage, processing techniques and technologies used, and products to be manufactured out of recycled waste.

Identify land for collection and recycling: Cities need to prioritize identifying land for intermediate collection points and storage of C&D waste instead for a recycling facility. They also need innovative methods to reduce the requirement of land. Innovative approaches like providing waste containers to construction sites as part of the building permit as proposed by Pune can be adopted. This would allow for temporarily storing the waste generated, which the city or the generator can periodically haul and transfer to the final disposal site. The city can charge a fee for this as part of building permit itself.

Set up transportation system for collection and transfer of C&D waste: The most effective way of doing this would be to reduce distances to recycling and disposal sites as that adds to the expense of the generators. This needs a dense network of collection points. Transportation of waste from collection points to its final destination can be managed by the city or by a private party at the city's behest. This system is in place in the North Delhi Municipal Corporation, where the recycling facility operator is responsible for picking up the waste from the collection points. The cost of the final transportation is paid from the waste-handling fee charged as part of building permit.

There are not many C&D waste management firms in India that can undertake consolidated operation of collection, transportation and recycling in a city. Repeat failure of tenders seeking such arrangement in cities such as Bengaluru and Mumbai has highlighted the need for cities to have a different approach. Based on the experience in Bengaluru, breaking up operations of collection, transportation and recycling facilities can attract startups and new entrepreneurs and develop healthy competition that might bring down costs for the city. There is an existing network of informal transporters in every city for transportation of C&D waste; cities need to find ways to leverage this to cut cost of new infrastructure creation.

Strengthen governance framework: NITI Aayog's strategy has suggested that the Ministry of Housing and Urban Affairs (MoHUA) may empanel suitable expert agencies/consultants who can provide handholding assistance to cities for waste mapping, by-law drafting, and public procurement policy for recycled products to identifying financial assistance. It also recommends linking C&D waste management facilitation to fiscal support to states.

But most of the emphasis has been on developing hard infrastructure and very little on soft infrastructure needed to help cities sustain the hard infrastructure. Given C&D waste management draws a complete vacuum in the current education system and professional skill-pool this will likely be a herculean task. There is a need to invest in developing knowledge, templates, guides, manuals and standards for a gamut of waste applicable to the Indian context. These would need to be further incorporated in the education system.

Further, most efforts are centred on propping up a system that will be super dependent on governments and cities' ability to pay for it. The goal needs to focus on minimization of waste and not monetization of it, and addressing this may require revisiting the Rules themselves.

To avoid spurts in illegal dumping as means to escape high disposal fees, fiscal incentives would be required. Pune proposed a waste fee refund scheme as incentive for reducing waste generation. The scheme proposed to charge a hefty C&D waste fee as part of the building permit fee. The generator has to produce proof of on-site waste reduction, reuse and recycling. This requires extensive monitoring and tracking.

AVIKAL SOMVANSHI/CSE

A pile of recycled aggregate manufactured from recycled C&D waste at Delhi's recycling facility

Introduce financial pull for the construction industry: NITI Aayog's strategy is the weakest when it comes to engaging the construction industry. It recommends organizing awareness seminars and workshops for professional and industry associations such as CII, FICCI, Builders Association of India (BAI), Indian Institute of Architects (IIA), CREDAI, etc. It is also pushing for private green building ratings to incorporate waste management as an incentive for the construction industry.

The current system provides no incentive to the construction agencies for managing their own waste via waste reduction and on-site reuse and recycling. Globally, the construction industry has been slow to reform its practices despite evidence to support the economic and business benefits of waste reduction and management. The Rules have created a push by creating a legal requirement for waste management but the financial drivers at the project level that can pull the industry are missing. Waste management financial benefits are related to the direct costs of both waste disposal and raw material purchase, this needs to be made explicit and pronounced in management of construction projects vis-à-vis a fiscal policy.

Learn from global practices: In some European countries, high waste tax has achieved a significant level on C&D waste reduction. High level of landfill taxes in Denmark and the Netherlands demonstrated a low dependency on landfill and a high level of waste recovery. EU has also supported waste minimization with on-site recovery and reuse by developing extensive waste management tools and guides (see Section '*Informing design and construction practices*' later in the chapter). This also has been made possible by extremely strict enforcement in these countries.

Similar high waste taxation policy in Hong Kong has given mixed results. Hong Kong has one of the most aggressive C&D waste fee regimes in the world that was adopted as means to reduce waste generation in the city. The Construction Waste Disposal Charging Scheme (CWDCS) was implemented in 2006 and regulated that all construction waste must be disposed of at government waste facilities if not otherwise properly reused or recycled. While the CWDCS has significantly improved construction waste management in Hong Kong, it has also triggered massive illegal dumping problems for the city.[2] Multiple studies have explored the influences of CWDCS on the reduction of construction waste in Hong Kong—and a significant reduction of construction waste was achieved at the first three years (2006–08) of CWDCS implementation. However, the reduction could not be sustained. Implementation of the CWDCS did not motivate sub-contractors to change their methods of construction and waste handling.[3]

Build confidence in recycled products for quicker uptake: There are practically no legal hurdles in using recycled C&D waste products now. All major standards have been amended and premium buildings (such as the Supreme Court Extension) have been constructed using it. NITI Aayog so far has recommended green labelling of recycled C&D waste products. But this is not sufficient to stimulate uptake of recycled products. Field surveys have highlighted the major reason for low uptake is the higher cost of the recycled product owning to high GST rate (18 per cent) imposed on it and poor quality of the products manufactured at existing recycling facilities. To improve the uptake of recycled products GST on them and their design quality need to be made at par with conventional building products.

Further, recycling facility operators are manufacturing value added products like concrete blocks and pavers, which may not require expertise to market. They

should be encouraged and allowed to sell the recycled aggregate to professional building product manufacturers. Getting construction agencies of government to mandatorily procure these products is a good strategy to support the product in initial stages. But overt reliance on this impedes innovation and development of the product itself. This approach would ensure that there is no actual economically sustainable circular economy of waste.

Integrate informal sector in C&D waste management and disposal: The Rules and NITI Aayog's strategy have ignored the informal sector. There exists a robust market for salvaged building materials with highly developed expertise and network to manage C&D waste. Many cities like Gurugram are insisting on generators depositing all the waste estimated (by the TIFAC rule of thumb) at their disposal points at the time of building permits. This basically removes the access of the informal sector to the waste. There are reports from Ahmedabad of waste disappearing en route to recycling facilities from intermediate collection points. There is a need to acknowledge livelihoods attached with this waste and that it has potential to complement the C&D waste management system of the city. Formal integration can improve performance.

Mandate adoption of demolition management strategies: Demolition contractors are not part of the formal construction industry. They are also the base actors feeding the informal market of salvaged building material. They can be leveraged to improve resource recovery from the waste. Formal recognition should be provided to demolition contractors and a register of them developed. A separate and independent demolition permit should be developed. Deconstruction instead of quick demolition should be encouraged. In order to discourage quick demolition, cities can impose a minimum wait time between the start of demolition and commencement of construction.

Inform design and construction practices: There is no known C&D waste designing document catering to Indian construction industry. Globally, several construction waste management tools, methods and technologies are used in the construction industry to forecast and design out waste during the preconstruction stage; manage on-site waste during the construction stage; and recycle and recover end-of-life materials and products during the demolition stage.

Forecasting and designing out waste during preconstruction stage: ULBs are asking for a C&D waste management plan as part of building permit but these are merely a listing of the estimated quantum of waste that may be generated by the project and how it would be disposed of. Architects and builders are falling back on the TIFAC rule of thumb to provide this. This requires actual waste management plan that would ensure reduction in waste generation.

There are insufficient design decisions and supporting tools to integrate designing-out-waste strategies in construction projects. Gobally, however, the last few years have witnessed an increase in design waste-related research. The increased C&D waste awareness and ever-increasing waste legislation and availability of fiscal resources has led to the development of an ever-increasing number of templates, guides, manuals and standards to support designers to embed waste minimization in their projects. India needs a similar approach to develop protocols and tools.

Mandate on-site construction waste management during construction phase: Real estate developers and large-scale builders have to fulfil environmental criteria as part of the environment impact assessment (EIA) requirements. C&D waste management requirements come bundled together with the environmental clearance. Increasingly, construction companies under influence of green building rating have adopted better C&D waste management practices. However, despite the endeavour of some large construction companies to reduce and better manage C&D waste, the vast majority of small and medium enterprises in the construction industry engage significantly less in the process and their approach is predominantly reactive to legislative requirements. On-site waste management tools have been developed to handle and better manage segregation of on-site construction waste; quantify waste generation; estimate waste generation rates; waste data analysis; audit construction waste; reuse on-site waste and collate and analyse on-site waste streams. Wider adoption is needed to improve on-site management.

Ensure implementation of end-of-life waste recovery, recycling and circularity: In the last few years, location-based tools, which are usually GIS enabled, have been developed to provide the location of C&D waste management services. Globally, the UK's BREMap developed a searchable map to find the nearest facility for C&D waste recycling facilities. The quality of C&D waste is directly influenced by the performance carried out in the construction and/or demolition site. For instance, one of the main difficulties for waste recovery is the collection of mixed waste (instead of on-site sorting) and the inefficient mechanical sorting of mixed waste. Therefore the workers' training in C&D waste management is essential for enhancing C&D waste sorting. Also, more efficient waste sorting technologies are needed to generate cleaner C&D waste for recovery from mixed waste. By and large, technologies used for waste recovery, recycling and circularity encompass three interrelated methods—source collection and separation, processing, and recovery and treatment. Quicker uptake is critical.

Address waste management in infrastructure projects: Infrastructure projects will require special care and handling. Agencies will have to develop their own recycling facilities. Roadwork projects require additional technological development for recycling of bituminous material.

Link C&D waste management with dust control in construction projects: This is a critical intervention from the perspective of implementation of clean air action plan in cities. The planning stage of the project requires identification of dust-control impacts; careful programming of works to reduce dust impacts; identification of dust-mitigation measures; training of workers and supervisors on-site; water supply and storage for dust suppression; site planning to reduce dust impacts; construction-dust-mitigation techniques like physical barriers etc; use of sprinkler system for dust suppression; management of open areas and stock piles; and addressing concrete production among other measures.

Part 1

INSIDE THE WALL: ASSESSMENT OF CHALLENGE OF C&D WASTE MANAGEMENT

VIKAS CHOUDHARY/CSE

CHAPTER 1

Nature and scale of the problem

Construction boom and material bane

The construction sector has been one of the most stable components of India's growth engine, with consistent increase in the inflow of investment. It is one of the top contributors to the Gross Domestic Production (GDP) of India. The real estate industry is expected to grow at an annual average of 6.6 per cent[4] between 2019 and 2028 and is expected to account for 13 per cent of India's GDP by 2025.[5]

With new buildings and infrastructure projects, the requirement for building materials for construction—never before this high—will continue to rise in the foreseeable future. The building material sector is an enormous economy in itself. The National Skill Development Corporation (NSDC) estimates that the share of cost of construction minerals in a project is in the range of 40–60 per cent.[6] According to a Government of India estimate, for every crore rupees of investment

Table 1: Criticality of availability and use of building materials

Parameter / Resources	Scarcity	Cost	Environmental impact	Embodied energy	Supply risk	Lack of recyclability	Conflict of use
Soil	**	*	***	***	**	***	***
Iron	*	***	***	***	*	*	*
Limestone	*	**	***	***	*	***	**
Sand	***	**	***	**	***	***	*
Stone (aggregate)	**	**	***	***	**	***	**
Copper	*	**	***	***	*	*	*
Bauxite (aluminium)	*	**	***	***	*	*	*
Petroleum (PVC)	*	**	***	***	*	*	*
Silica (glass)	*	**	***	**	*	*	*
Wood	**	***	***	**	**	*	*

(Legend: * is Low, ** is Medium, *** is High)

Note: · Cost refers to cost of extraction and transit/carriage within India, associated with the resource under the framework.

· Environmental impact refers to the environmental impact of a resource due to extraction and processing.

· Embodied energy refers to energy consumed during extraction, production and transport of the resource.

· Supply risk refers to accessibility of the resource, associated legal restrictions on extraction and transport of the resource, and political risks linked to the resource.

· Lack of recyclability refers to secondary uses of a resource based on current practices followed by the construction sector.

· Conflict of use refers to competing uses of a resource by sectors other than construction. For example, soil has two competing uses, brick manufacturing for construction and agriculture.

Source: Achu R. Sekhar et al. 2015. *Resource Efficiency in the Indian Construction Sector: Market Evaluation of the Use of Secondary Raw Materials from Construction and Demolition Waste*, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, New Delhi.

in housing, nearly 290 industries in the building material sector are engaged, besides the core manufacturing industries comprising cement, steel and bricks. This economy supports employment of nearly 750 human-years.[7]

A serious crisis seems to be now looming up in this business: primary construction minerals are no longer easily available (see *Table 1: Criticality of availability and use of building materials*). In a written statement to the Rajya Sabha in 2010, the then Union Ministry of Housing and Poverty Alleviation (MHUPA) had acknowledged the growing shortage of building material, particularly sand.[8] The shortage has been so severe that several civic projects in India faced delays. No improvement has been noted since then. In fact, India for first time started importing river sand from Malaysia and Cambodia in 2017 to meet the demand for construction in the country. The first consignment of 55,000 tonnes or 1,850 truck-loads of sand from Malaysia's Sungai Pahang riverbed reached Port V.O. Chidambaranar, formerly known as Tuticorin Port, in Tamil Nadu, on 14 October 2017.[9] This is telling of the present state of the material crisis in India.

This has a bearing on the housing crisis in the country. Cost overruns in the construction industry have a direct connection with the availability of construction minerals. A study by Venkatesh M. Paranthaman, a construction industry expert, found that resources like human power and materials make the highest contribution—about 24 per cent—to delays in construction projects.[10]

The shortage of aggregates has caused real estate prices to soar. Construction materials such as cement, steel, bricks, tiles, aggregates, fixtures, fittings, paints and chemicals, petrol and other petro-products, timber, aluminium, glass and

plastics account for nearly two-thirds of the construction cost.[11] With the constant rise in the cost of basic building materials and with the poor affordability of large segments of our population, the cost of a house is increasingly going beyond the affordable limits of more than 30–35 per cent of our population in the lower income segments.[12]

All these also bring out the vulnerability of this high-growth sector.

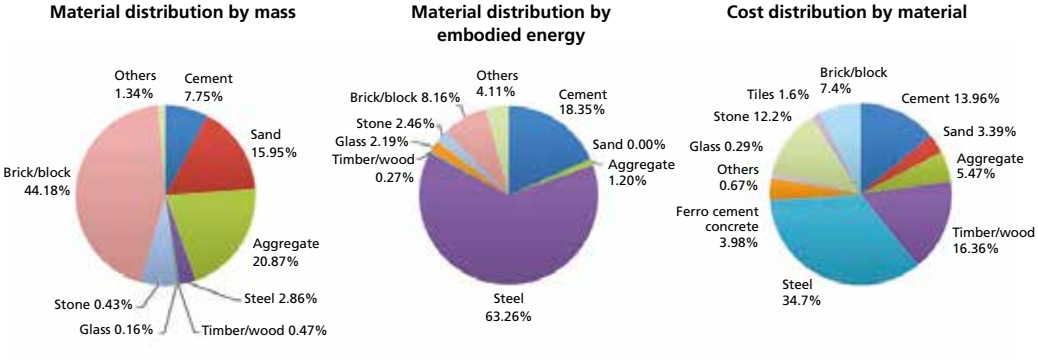
Environmental cost of construction and material

According to the report of the Planning Commission, the construction sector accounts for 30 per cent of India's electricity consumption and 23.6 per cent of its greenhouse gas (GHG) emissions.[13] The construction sector has strong linkages with other industries, such as cement, steel, chemicals, paints, tiles, and fixtures manufacture. It is estimated that 40–45 per cent of India's steel, 85 per cent of paint production, 65–70 per cent of glass, and significant portions of the output from automotive, mining and excavation equipment industries are used in the construction industry.[14]

Any generic building construction requires bricks, cement, sand, aggregates, steel, timber and glass. By volume, their requirements can vary, based on building typology and technology. An analysis of a low-rise office building made with a combination of traditional and modern building technologies—where every possible intervention is made to optimize resources— found that bricks top the list at 44 per cent of all material used in buildings (see *Graph 1: Material—Volume and energy mismatch*). This is followed by aggregates at 20.8 per cent, cement at 7.75 per cent and stone at 6.43 per cent. Among these, the volume requirement of steel is the least at 2.86 per cent. But when energy to produce material is considered, steel's embodied energy is the highest at 63.26 per cent followed by cement at 18.35 per cent, and bricks at 8.16 per cent. The share of economic cost of steel is also the highest at 34.71 per cent followed by timber at 16.36 per cent, cement at 13.96 per cent and stone at 12.16 per cent.[15]

Additionally, national GHG emissions from the construction industry is estimated to be about 30 per cent out of which 97 per cent is attributed to indirect emissions resulting from construction material production such as steel, cement, lime, brick etc., and services required for construction operations (off-site).[16] For India, it is estimated that about 80 per cent of construction sector's GHG emissions

Graph 1: Material—Volume and energy mismatch



Source: Ashok B. Lall 2012. Analysis of Development Alternatives Building, presented at Delhi.

comes from materials likes cement, bricks, steel and lime.[17]

If the use of steel and concrete can be minimized, it will be the most significant reduction in energy intensity and environmental footprint of buildings. But such trade-offs and choices are not easy. For instance, in the past, several decisions were taken by government construction agencies such as the Central Public Works Department (CPWD) to substitute the use of timber in construction with metal to arrest deforestation. However, metal use has increased the energy intensity of buildings, and has actually hiked the rate of deforestation due to an increase in mining and power generation. At the same time, the use of steel has remained quite inelastic, as it is not possible to substitute it beyond a limit without compromising structural safety of the building.

Even though steel, metals and petroleum-based products have the highest GHG and embodied energy among the primary building materials, there currently isn't a shortage in their supply. The real crunch is in the availability minor minerals that make the bulk of the building material. Sustainability in this sector thus will depend on the availability, manner of extraction and use of these materials, which include aggregates (sand and gravel) for concrete, earth for bricks, stone and water.

Unsustainable extraction and conservation pressures have led to mining bans and restrictions in several areas. This crisis points to the larger questions of overexploitation and possible exhaustion. Each material has its own sets of challenges. As increasing amounts of basic materials are extracted to feed the construction boom, environmental and societal damages increase.

It is said that the greenest building is one which doesn't require to be built. Implying most sustainable thing to do is to avoid or reducing need for building new and optimize the existing resources. The building community will have to find ways to improve construction techniques and quality, and minimizing and substituting material as much as possible. The profile of each primary material shows that the consumption of virgin material (minerals, stone, sand etc.) sourced from nature will have significant environmental impacts. Sand mining has scarred rivers, removal of boulders and pebbles from riverbanks has made many areas susceptible to floods, and brick earth mining and soil excavation have ruined fertile lands. Inefficient production processes further add to pollution and high energy-use (as in the manufacture of bricks, glass and steel). Long-range transportation of material is yet another cog in the energy wheel.

There is the additional challenge of wastage in the sector. It is estimated that 4–30 per cent of the total weight of building materials delivered to a construction site turns into waste.[18] Not only does this puts additional pressure on natural systems to provide for building material, it also creates its own problems. One can spot this waste stream lying on our streets, pavements, in ecologically sensitive areas like waterbodies, riverbanks etc. Handling and disposal of this waste has emerged as a major area of environmental concern (see *Box: Environmental concerns with C&D waste*).

C&D waste problem

C&D waste is a direct consequence of construction activities. The C&D Waste Management Rules, notified in 2016, defines C&D waste as 'any waste comprising building materials, debris and rubble resulting from construction, remodeling, repair and demolition of any civil structure'. TIFAC in 2001 had estimated that new construction generates about 40–60 kg of C&D waste per sq. m of built-up

Environmental concerns with C&D waste

- **Urban flooding:** The most common disposal practice for C&D waste is to dump it in low-lying areas, storm-water drains, open drains and water channels. This has led to clogging of these channels, which in turn block the drainage system of the city and cause urban flooding during rains. The situation is so bleak in most cities that even lightest of showers can paralyse neighbourhoods. These floods are not just an inconvenience but a public health hazard as they increase the number of accidents on the road and are breeding grounds for many diseases as well.
- **Destruction of waterbodies:** C&D waste is frequently dumped in or used illegally to fill wetlands, ponds, lakes, water channels and riverbeds. This disrupts the hydrology and destroys the aquatic ecosystem. Disappearance of most urban waterbodies can be traced to dumping of C&D waste.
- **Groundwater pollution:** A few minor sub-streams of C&D waste contain in small quantities hazardous components like paints, oil and asbestos sheets. These degrade into leachate and fine chemical particles and lead to soil and groundwater pollution.
- **Clogging landfills:** C&D waste is mostly inert and doesn't require disposal in a sanitary landfill but is regularly ends up there. This waste is voluminous and takes away much of the space in landfills that would have been used for hazardous waste. This unnecessarily increases the need for more landfills or alternative dumpsites.
- **Hindering municipal waste management:** C&D waste invariably gets mixed with other municipal solid waste during the process of transfer or at the collection site. Once mixed, it makes composting or recycling of MSW highly difficult. Hazardous substances such as sharps, broken glass, boulders, broken wooden logs, rusted metal, broken ceramics, etc. makes handling of overall municipal waste dangerous, frequently leading to injuries to waste workers.
- **Degradation of open spaces:** C&D waste being dumped on unfenced open places creates hazardous environment for people. As it traps water, it becomes a breeding ground for many disease-carrying vectors such as dengue mosquitoes.
- **Obstructing mobility:** C&D waste dumped on streets and footpaths impedes traffic flow and pedestrians respectively. It frequently contributes towards traffic congestion and even accidents. It also damages on-road vehicles, reducing their efficiency and indirectly increasing tail-pipe pollution.
- **Dust pollution:** C&D waste is one of the primary sources of fugitive-dust pollution. The waste has considerable quantities of finer particles that get easily airborne if not handled carefully. Uncovered waste piles and open air transportation of C&D waste is the prime culprit for local deterioration of the air quality from non-combustion sources. Dust from C&D waste is also a major source and component of road dust.

SAYANTONI PALCHOUDHURI/CSE

Table 2: C&D waste estimates for India

Year	Authority/Institute	Estimate (million tonnes)
2000	Ministry of Urban Development	10–12
2001	Technology Information, Forecasting and Assessment Council, Department of Science and Technology	12–15
2010	Ministry of Environment and Forest	10–12
2013	Centre for Science and Environment	530
2014	Ministry of Urban Development	No estimates
2015	Ministry of Urban Development	10–12
2015	Development Alternative and GIZ	750
2016	Ministry of Environment, Forest and Climate Change	530
2017	Building Material and Technology Promotion Council	150

Source: Compiled by CSE

area in India.[19] As for demolition the estimate is 300–500 kg per sq. m of built-up area. More recent official data doesn't exist.

Globally, cities generate about 2.01 billion tonnes of solid waste per year. About half of the solid waste generated can be characterized as C&D waste, according to a 2018 report on solid waste by the World Bank.[20] C&D waste generation at the national level is influenced by several factors, namely, gross domestic product (GDP), population, and C&D waste-related regulatory measures. It is estimated that construction and demolition activities generated in excess of 850 million tonnes (MT) of physical waste in the EU[21] and over 530 MT in the United States in 2014.[22] China's estimate is about one billion tonnes (1,000 MT) of C&D waste in 2013.[23]

India, however, has no clear official estimates of the actual magnitude of this waste. The official numbers put out by various ministries and government agencies between 2000 and 2015 were less than 15 MT (see *Table 2: C&D waste estimates for India*). CSE contested the official numbers and guesstimated that the number should have been higher than 530 MT in 2013. In 2015, an independent assessment by Development Alternative and GIZ pegged the number to be 750 MT. The Ministry of Environment, Forest and Climate Change used CSE's guesstimate of 530 MT in the official press release announcing notification of C&D Waste Management Rules 2016. The Building Material and Technology Promotion Council (BMPTC) in 2017 in their technical assessment suggested the number must be around 150 MT but gave no rationale for it.

Composition of C&D waste

In reality, however, it is difficult to give exact figures of C&D waste produced in a typical construction site. But multiple research works globally have estimated that 4–30 per cent of the total weight of building materials delivered to a building site becomes waste due to damage, loss and over-ordering. The streams and composition of on-site wastes are highly variable, depending on the region and the construction techniques used (see *Table 3: Percentage of each waste category from the total generated in different countries*).

Table 3: Percentage of each waste category from the total generated in different countries

Waste sub-stream	Spain	United Kingdom	Italy	Norway	Portugal	United States	India	China
Soil and rocks	–	–	–	–	–	–	35	–
a) Concrete			–	57.24	–	70	25	8–35
b) Ceramic			–	10.0	–	2	30	15–50
Mixed concrete and ceramic waste (a + b)	85	33	84.3	67.24	82.9	72	55	–
Mixed waste	–		–	–	–	–	–	–
Wood	11.2	27	–	14.58	–	7	2	1–5
Paper	–	18	–	–	1.2	–	–	5–20
Plastic	0.2		–	–	0.16	–	–	
Gypsum	–	10	–	–	6.4	3	–	–
Metals	1.8	3	0.08	3.63	4.5	1	5	1–8
Asphalt	–	–	6.9	–	4.2	14	2	–
Other	1.8	11	8.8	14.55	–	–	1	10–20

Source: Adapted from Mohamed Osmani and Paola Villoria-Sa´ez 2019. 'Current and emerging construction waste management status, trends and approaches', *Waste Streams (and Their Treatment)*, Elsevier Inc., UK.

Characterization studies on C&D waste in India are minimal. TIFAC's 2001 waste characterization study highlighted soil, sand and gravel (fines); brick and masonry; and concrete as the three largest fractions accounting for 90 per cent of the waste. Similar studies and surveys carried out by other bodies for Delhi and India found the bulky materials jointly make up over 90 per cent of the C&D waste (see *Table 4: Indian construction and demolition waste percentage composition*). The remaining 10 per cent comprises wood, metal, bitumen, plastics, etc.

Overall, C&D waste can be broadly classified into three categories: waste which is: (1) not easily recycled or which present particular disposal issues, including chemicals (i.e. paint, solvents), asbestos and plaster; (2) not capable of being directly recycled in the construction industry, but may be recycled elsewhere, including timber, glass, paper, plastic, and oils; and (3) potentially valuable and easily reused or recycled, including inert waste such as concrete, stone masonry, bricks, tiles, asphalt and soil. In terms of waste streams and weight, brick masonry and concrete present by far the largest potential for recycling in the building sector. This has been supported by the findings of comprehensive research conducted across the US, the UK, Spain China, Brazil, Korea, and Hong Kong, which compared the streams and volumes of construction waste in these countries.

Waste as resource

TIFAC estimates that demand for construction material in 2021–22 will be 380 MT for cement, 50 MT for steel, 600 billion bricks, 400 million cubic metre (cu.

Table 4: Indian construction and demolition waste percentage composition

Waste sub-streams	As per Technology Information Forecasting and Assessment Council (TIFAC), 2001 (India)	As per MCD survey, 2004 (Delhi)	As per survey by Infrastructure Leasing & Financial Services (IL&FS) Ecosmart, 2005 (Delhi)	As per study by University of Florida, 2009 (India)	As per Coimbatore City Municipal Corporation survey, 2015 (Coimbatore)
Soil/sand, gravel	36	43	31	35	49
Bitumen	2	0	0	2	0
Metals	5	0	0.4	5	4
Masonry/brick	31	15	59	30	19
Concrete	23	35	0	25	23
Wood	2	0	1.5	2	2
Others	1	7	7.6	1	3

Source: Compiled by CSE

m) for aggregates and 40 million cu. m for timber.[24] Without an alternative to these building materials and in the wake of the looming material crisis, much of the demand will have to be borne by virgin materials, with huge environmental costs. Sand, soil, stone and limestone are critical resources used in sectors that are already facing supply disruptions and price spikes due to mining bans and restrictions. This has pushed the policy question towards finding alternative materials and substitutes. Construction research is now looking at a range of options that include industrial waste, natural alternatives and reuse of C&D waste. It has now been established across the world recycling and reusing C&D waste is a viable alternative to naturally sourced building material. Most developed countries have already capitalized on this and are converting it into resource with varying degree of success.

With regard to C&D waste reuse and recycling rates, the EU and USA reached 79 per cent and 70 per cent respectively.[25] Some EU members (individually) and smaller nations like Singapore have reported over 90 per cent recycling and reuse rate.[26] Globally, it has now been established that tweaking the construction process and waste management policies can to a large extant prevent environmental degradation and pressures on land.

Mature technologies are available in India, and are already being used in cities such as Delhi and Ahmedabad. Many initiatives had been taken even before the notification of the C&D Waste Management Rules in 2016. Way back in 1999, a decentralized solution for debris management was promoted by the Youth for Unity and Voluntary Action (YUVA) in Navi Mumbai and was supported by the City and Industrial Development Corporation (CIDCO). The collaboration led to the recycling of over 1,500 tonnes of C&D waste during 2002–06. But the CIDCO YUVA Building Centre (CYBC) was forced to shut down in 2012 as it failed to receive policy or market support. Delhi developed a pilot project to demonstrate

Table 5: C&D waste recycling plants in India

City	Place	Capacity (TPD)	Operation status
Delhi	Burari	2,000	Operational
	Mundka	150	Operational
	Shastri Park	500	Operational
Noida	Sector 80	150	Operational
Gurugram	Basai	300	Operational
Ghaziabad	Ghaziabad	150	Operational
Thane	Daighar	300	Operational
Indore	Devguradia	100	Operational
Hyderabad	Jeetimedla	300	Operational
Bengaluru	Chikkajala*	1,000	Operational
	Kannur	750	Operational
Ahmedawbad	Gyaspur Pirana	1,000	Operational
Tirupati	Tukivakam village	150	Operational
Vijayawada	Vijayawada	200	Operational
Chandigarh	Industrial Area Phase 1	150	Operational
Surat	Surat	300	Operational

Note: * Privately owned and operated
Source: Compiled by CSE

the potential of collecting and recycling C&D waste in Burari in north Delhi. The pilot plant began operation in 2009, with a recycling capacity of 500 TPD which was later increased to 2000 TPD in 2015.

As of January 2020 there were at least 16 operational C&D waste recycling facilities in India of which three are in Delhi (see *Table 5: C&D waste recycling plants in India*).

A recycling facility through a combination of processes can convert the C&D waste into aggregates, sand, silt and clay, all of which can be reabsorbed and reused as construction material. Additionally, many value added products such as kerb stones, paver blocks, concrete blocks made up from recycled C&D waste are excellent substitutes for conventional products.

The major applications of C&D waste being processed at current recycling plants are the following:

- Granular sub-base (GSB)—Crushed C&D waste can be used as GSB layer for road construction, regardless of the type of construction. The granular sub-base layer is formed by piling and compacting C&D aggregates of different sizes one over the other directly below the pavement surface. This acts as the load bearing and strengthening component of the pavement structure. In addition, it provides drainage for the pavement structure and protects the structure from frost.

AVIKAL SOMVANSHI/CSE

Dumping of C&D waste on sidewalks have rendered them unusable

- Recycled concrete aggregates (RCA)—Pure concrete waste can be recycled to make aggregates of different standard sizes to replace natural aggregates in construction processes.
- Recycled aggregates (RA)—Crushed aggregates of standard size made from a mix of C&D waste materials is termed as recycled aggregates (RA). RA can be used for partial replacement of natural aggregates for construction of non-load bearing structures.
- Manufactured Sand (M-Sand)—Manufactured sand is also produced by crushing of C&D waste, and the finer particle fraction can be used to replace natural sand in construction of non-load bearing structures.
- Smelting—Scrap metal recovered from C&D waste is melted through the process of smelting and recycled to make new products.

Challenge of construction dust

Dusty materials or dust particles from construction is a cause of concern. Dust is generated in different phases of construction activities include construction, remodelling, repair, demolition, transportation and handling of debris and construction material. Construction dust from all these phases is an environmental pollutant, which may include cement, earth, pulverized fuel ash, aggregates, silt, stone fines, sand, debris, sawdust and wooden chips. Pollution source inventory and apportionment studies carried out in a few cities have indicated that their share is not negligible and local exposure from construction activities can be substantial.[27] Clean air action plans under NCAP require stringent control of construction dust.

Dust during handling (loading and unloading) releases a wide range of particle sizes and material types that can cause serious health problems ranging from irritation of the eyes, nose and mouth to effects on the respiratory system.

Larger heavier particles settle quickly and are a hazard to plant and equipment (on-site) operators and to those in the immediate vicinity (off-site). Regularly breathing course construction dust can cause diseases like lung cancer, asthma, chronic obstructive pulmonary disease (COPD) and silicosis.[28] Construction workers have a high risk of developing these diseases because many common construction tasks can create high dust levels. These diseases cause permanent disability and early death. Finer particles (usually invisible) are transported further and contribute to larger gamut of respiratory and cardiovascular diseases associated with $PM_{2.5}$ pollution (off-site) (see *Fig. 1: Dust-generating activities*). Other dust-generating activities include block cutting, mixing, road building, drilling and loading and unloading of debris etc.

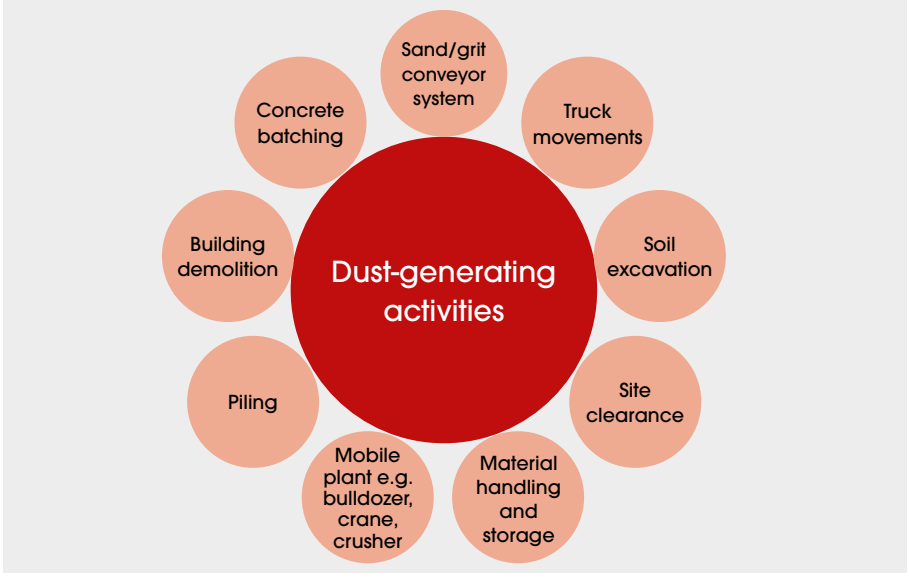
Construction dust can be managed effectively on-site and off-site by identifying and planning for the potential dust-generating activities, measures to be taken to control dust generation and finally the steps to mitigate dust generated.

Preventing dust at source is the most effective method of mitigation. Construction and demolition operations contribute to windblown dust problems—sometimes called fugitive dust—onto nearby areas and roadways which can remain in the air for days or even weeks thereby deteriorating the quality of air.

There is a learning curve in Delhi. In December 2014, the National Green Tribunal (NGT) directed the 'State of U.P., NOIDA and Greater Noida Authority, HUDA, State of Haryana and NCT, Delhi' to stop construction at all sites that were in violation of the NGT order and the Ministry of Environment, Forest and Climate Change's (MoEFCC's) Environment Impact Assessment (EIA) guidelines of 2010.[29] The order stipulated precautions and mitigation measures to control the dust generated from construction activities. A fine of Rs 50,000 was set for not meeting the precautions outlined in the order. A fine of Rs 5,000 was set for carriage of materials and debris in uncovered vehicles. However, the order only covered projects with built-up area greater than 20,000 sq. m, which is a requirement of Environment Impact Assessment (EIA) for clearance from the government.

In response, Delhi government vide orders in October and December 2015 authorized its Revenue Department and municipalities to inspect anyone found

Figure 1: Dust-generating activities



violating the guidelines as stipulated by the NGT for dust-pollution control.[30] A total of Rs 1,18,50,000 was collected from challans, notices and/or inspection issued to violators by May 2016.[31]

The NGT in April 2016 further increased the fines from the previous Rs 50,000 to Rs 5,00,000 for projects with built-up area greater than 20,000 sq. m that were in violation of the precautions outlined in the order and in the 2010 MoEFCC guidelines to prevent dust pollution.[32] Projects with a built-up area of 200–500 sq. m would have pay Rs 30,000 while sites of 500–20,000 sq. m would have pay Rs 50,000 for each violation of the dust-control norms.

In November 2016, the Supreme Court's order in the matter of M.C. Mehta vs Union of India, regarding air quality in the National Capital Region (NCR) of Delhi, directed implementation of Graded Response Action Plan (GRAP) for graded action according to the Air Quality Index (AQI) categories of Moderate and Poor, Very Poor, Severe and a new category of 'Severe+' or Emergency.[33] MoEFCC notified GRAP in January 2017. The Supreme Court made Environment Pollution (Prevention & Control) Authority (EPCA) responsible for GRAP's implementation and monitoring. As part of GRAP, implementation of dust control in all construction sites is necessary. In fact, post implementation of GRAP every winter, construction activities are regularly shut in Delhi and NCR during the days when severe smog episodes continue for contiguous days.

The Delhi Pollution Control Committee (DPCC) has adopted detailed checklist of dust control in construction sites. Based on this checklist, monitoring and inspections is carried out. In fact, some of the key construction agencies like National Buildings Construction Corporation (NBCC) have had to pay penalty multiple times for inadequate dust control. Monitoring and compliance are critical aspects of this intervention.

Challenge of recycling New Age material

Construction technology for infrastructure and buildings is changing rapidly. New fabricated materials are invading the market. It is necessary to understand the waste-generating potential of these materials in the long run. This has not been evaluated comprehensively yet.

Prefabricated building technologies use structural elements or reinforced concrete elements built in a factory setting. They are assembled later at the construction site—e.g. slabs of flyovers and overhead tracks of Metro Rails. These structural elements are designed for dismantling and can be reused in similar projects after the original structure has completed its life. However, since each prefab block is designed to a specific size and load capacity unique to the project, it is difficult to find other projects with similar load profiles to reuse them. Further, if in rare case one is able to find a compatible project, there are no practical guidelines according to which it would be possible to assess and classify if the dismantled prefab blocks are suitable for reuse.[34] But given the fact that most of these prefab blocks are made of concrete they can be easily recycled if found unsuitable for reuse, using the convention C&D waste-recycling facilities.

Another fast-track technology in vogue is monolithic constructions, where walls, floors and slabs form a single unit with concrete poured on-site in formworks. Monolithic constructions are popular in the construction of medium to tall buildings. Other technologies like autoclaved aerated concrete (AAC) and fly ash bricks are also gaining acceptance in the construction industry. These materials

have found support and incentives under the Pradhan Mantri Awas Yojana (PMAY) programme for the affordable housing sector.

Since these materials are still technically concrete in composition, they can easily be recycled after demolition using the conventional C&D waste recycling facilities. Some variation of these technologies (prefab or constructed at site) have expanded polystyrene insulation (EPS), styrofoam, plastic spacers, bituminous material or asbestos embedded within them, recycling of which becomes a problem for most concrete recyclers in India. For instance, the C&D plant at Burari, New Delhi, takes prefab concrete elements to recycle them into aggregates but does not take ones with bituminous material or asbestos.

Recycling of bituminous material is not very popular in India.[35] The process of bituminous recycling involves mixing of the asphalt, fresh bitumen, rejuvenators and new aggregates in suitable proportions. This mixture is used to construct new pavements.

Asbestos waste, as per the guidelines mentioned in IS 11768-1986, should be buried deep enough at waste or landfill sites.[36] Despite its carcinogenic nature, India has not banned use of asbestos in construction. However, methods to recycle asbestos exist. One such method involves transforming asbestos to a mixture of non-hazardous silicate phases through a thermal treatment at 1,000–1,250°C and to a silicate glass at temperature higher than 1,250°C. These products may be recycled to produce traditional ceramics.[37]

Plastics: Plastic wastes are best for recycling if these materials are collected separately and cleaned. Recycling is difficult if plastic wastes are mixed with other plastics or contaminants. Plastic may be recycled and used in products specifically designed for the utilization of recycled plastic, such as street furniture, roof and floor, PVC window noise barrier, cable ducting and panel. Composite plastic materials like thermoplastics are becoming indispensable to the construction industry. Thermoplastics (polycarbonate, polyethylene, polypropylene, PVC etc.) can be recycled, but recycling involves high costs, whereas thermosets (epoxy adhesives) are difficult to recycle. The lack of adequate markets, high recycling cost and lower quality of the recyclates are the major commercialization barriers in recycling of composite materials. PVC-U sourced mostly from window and door fabricators is being recycled into wiring accessories and cable management systems, including skirting and trunking. Composite materials can mostly be down-cycled.

Insulation material: EPS is utilized in many of these new age construction technologies and materials to provide insulation in the buildings. After its useful life, EPS can be densified through machines called densifiers that can convert them into EPS ingots. These ingots find application in frame and furniture industries and can also be granulated and reused to make other plastic products. Mature technologies are available to recycle EPS. In India, with low penetration of EPS in mainstream construction so far, the recycling industry has only begun to warm up to its recycling.

Internationally, recycling of EPS is not popular as it is primarily constrained by transport costs due to its dispersed disposal and short useful lifetime. The material is lightweight and has a lot of air content that makes it bulky and results in high transport cost per unit weight, thus making its recycling economically

unfavourable. This will emerge as a challenge with expansion of its market in the future. Waste management will have to be thought through.

Infrastructure waste

The ongoing expansion of cities is not limited to buildings. Another big dimension of the challenge is the humongous generation of waste from the infrastructure waste. This is expected to increase phenomenally with expansion of urban infrastructure. Mega-urban infrastructures like metro rail, roadwork, drainage etc. are part of this urban growth. The extent and impact of waste generated during the construction of infrastructure projects, such as roadwork, is particularly significant. For example, in Europe during the construction of a road 8–15 tonnes of materials is typically used per metre of a road lane. Since the average volume of construction waste in roadwork is estimated at 17 per cent, this implies a total amount of 130–250 kg of waste per metre of paved road is generated. For other types of infrastructure works, such as drainage, water and sewage works, the average amount of construction waste is estimated to be even higher (19–26 per cent of materials used).[38]

Similar estimates are not available for India. Data available from Delhi Metro Rail Corporation (DMRC) notes that the Delhi metro construction sent approximately 225,000 tonnes of C&D waste to the recycling facility at Burari, Delhi till March 2017.[39] In comparison, Delhi's estimated C&D waste generation is about 3,000–4,000 tonnes per day (TPD).[40]

DMRC, which has been fined multiple times by NGT for unlawful disposal of its C&D waste in the eco-sensitive Yamuna floodplains, has acknowledged management of C&D waste generated during construction of the Metro Rail is one of its most challenging issues.[41] It is of major concern due to the shortage of dumping sites and increase in transportation, disposal and recycling costs. As a solution DMRC has setup an in-house C&D waste recycling plant of capacity 150 TPD to process the waste being generated during construction of Phase-IV metro lines.[42] DMCR on its website claims that its plant may also be used by other agencies for recycling their construction related waste.[43] DMRC is still struggling to sustainably manage its excavation waste.

Other infrastructure projects like highway and roadwork, where bituminous material forms a considerable portion of the waste recycling, is also challenging. Recycling of bituminous material is not very popular in India.[44] No data is available from roadwork agencies on how they are managing their waste.

Globally, it has been noted that the proactive prevention of waste through the modification of existing on-site construction practices, rather than the retroactive management of waste after it has been generated, is more effective and efficient.

VIKAS CHOUDHARY/CSE

CHAPTER 2

Existing regulatory framework

Rules and regulations

C&D waste is probably the oldest stream of solid waste known to humankind but regulation of its management is a recent development. Although waste has always been generated in construction, most countries didn't formally record it as waste and track its generation till the end of the 20th century.

The developed world has made great progress in managing and recycling waste in the last two decades as they formulated policies targeting waste (see *Box: Evolution of C&D waste policy—Global*).

India, however, lags severely in this sector. C&D waste management has remained limited in scope and economically non-viable because of policy muddle. A look at the history of C&D waste management policies up to the notification of the C&D Waste Management Rules 2016 and C&D waste materials finding legal mandate gives us an idea of what was missing and how it was addressed in these policies.

Evolution of C&D waste policy—Global

European Union (EU): Modern utilization of C&D waste for construction goes back to the rebuilding of European cities after World War II. The massive requirement for aggregates was met partly by C&D waste processing. But actual policy to manage this waste only started after 1975. Multiple legislations were put in place that made the formation of waste management plans an administrative requirement and led to the creation of an EU waste catalogue. No binding regulations existed pre-1990. After 1990, waste-related recycling initiatives and targets were introduced.[45]

In 2004, the EU notified new standards for aggregates from 'natural, recycled and manufactured materials', which focused on the fitness of purpose and did not discriminate between natural and unnatural sources.[46] In 2008, the Waste Framework Directive (WFD) 2008/98/EC was issued, which required that 70 per cent of the C&D waste by weight within the EU was to be recycled by 2020.[47] In 2016, the European Commission published the Construction and Demolition Waste Protocol, which aimed to increase confidence in C&D waste management and trust in the quality of recycled building materials by means of improving waste identification, source separation and collection; improving waste logistics; improving waste processing; ensuring quality management; and developing an appropriate policy and framework. The WFD target has been met at the EU level but not individually by all the member states. Sweden, Denmark, Switzerland, Austria and France have managed to recycle as much as 90 per cent of their C&D waste.

Even before the WFD, many countries had taken initiatives to increase recycling. Flanders, a region in Belgium, developed plans in 1995 to achieve 75 per cent recycling during 1995–2000 and to sort waste into recyclable waste, recycling residue and hazardous waste by 2000.[48] The recycling target has been increased to 90 per cent. Similarly, Germany's Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal, 1994, formulated principles to manage C&D waste, among other things, in order to become a closed loop economy.[49]

United States: USA started formalizing management of C&D waste around same time as Europe. The Solid Waste Disposal Act (1965) as amended by the Resource Conservation and Recovery Act (RCRA, 1970) called for utilization of recycled construction materials in federal procurements. This resulted in federally funded projects incorporating requirements for usage of recycled building materials. RCRA was further amended in 1976 and recognized the national importance for recycling waste and called for development of specifications for secondary materials (recycled concrete and asphalt) and their incorporation into building construction standards.[50] But a comprehensive national assessment of this waste stream was not done till the 1990s. USA reported 70 per cent recycling rate in 2019 although the RCRA requirement is still not mandatory.

At the global level: C&D waste management was included in the United Nations Development Programme's (UNDP's) Sustainable Development goals (SDGs).

Rating systems: Many voluntary Green Building Rating Systems (GBRS) that developed over time helped further the management of C&D waste at the construction-project level and build a market for recycled C&D waste products. BREEAM (Building Research Establishment Environmental Assessment Method), launched in the UK in 1990, was the first GBRS to award green rating points for utilizing recycled C&D waste as it reduced the dependence on virgin materials, thereby decreasing the environmental footprint of the building.[51] Since then many rating systems have come up such as Leadership in Energy and Environmental Design or LEED (US), MiljöByggnad (Sweden) and HK Beam (Hong Kong).

The LEED Green Building Rating System recognizes C&D waste management and awards rating points under the credit theme 'Construction and Demolition Waste'. It states: Divert (goes for recycling) at least 50–75 per cent of the total construction and demolition material; diverted materials must include at least four material streams (1–2 points); OR, do not generate more than 12.2 kg of construction waste per square meter of the building's floor area. (2 points).[52] Diversion strategy and where the material will be recycled has to be meticulously maintained for to achieve the points under this credit theme. Other credit themes such as the 'Building Product Disclosure and Optimization—Sourcing of Raw Materials' reward projects which utilize recycled products such as recycled concrete aggregates, recycled aggregates.

Genesis of practice

Reclaiming and reusing building materials from C&D sites have been established practices in traditional construction activities for centuries. Over time a robust informal sector has evolved to support this demand of salvaged and recycled C&D waste. But the first formally organized effort to recycle C&D waste in India was in 1999. A decentralized solution for C&D waste management was developed and promoted by the Youth for Unity and Voluntary Action (YUVA) in Navi Mumbai and was supported by the City and Industrial Development Corporation (CIDCO). The collaboration led to recycling over 1,500 tonnes of waste in 2002–06.[53] But the CIDCO YUVA Building Centre (CYBC) was forced to shut down its recycling plant in 2009 as it failed to receive policy or market support to sustain the operation (see *Box: Death of a pioneer—C&D waste recycling in Mumbai*).

On the policy front, the first comprehensive mention of C&D waste is in the Union Ministry of Urban Development's (MoUD's) *Manual on Municipal Solid Waste Management*, 2000, which includes a chapter on C&D waste. The manual gives basic non-binding guidelines on handling C&D waste.[54]

Death of the pioneer—C&D waste recycling in Mumbai

Youth for Unity and Voluntary Action's (YUVA's) C&D waste recycling venture found few takers.

In 1999, YUVA—a voluntary body in Navi Mumbai supported by the City and Industrial Development Corporation (CIDCO), Maharashtra's urban planning agency—promoted a decentralized solution for C&D waste management. The collaboration, called CIDCO-YUVA Building Centre (CYBC), led to recycling over 1,500 tonnes of waste during 2002–06.

Bejoy Davis, a civil engineer, was responsible for the project. Davis modified an electric-powered machine used in pharmaceutical and chemical industries for the purpose of C&D waste recycling. The decentralized debris recycling plant in Khargar, about 43 km from Mumbai, became operational in 2002. Debris was sourced from various construction sites and broken down into particles, then into fine powder, sieved and eventually mixed with cement and water to create sundried bricks and paver blocks. The plant cost around Rs 2.5 lakh. It could recycle around a tonne of debris in a day. YUVA got its C&D waste free and people who supplied the waste were given discounts on the products. One recycled brick cost Rs 1.35 and pavers were Rs 16 per sq. foot.

CIDCO certified these products and used them to construct footpaths in Khargar, where the plant was located. Two community centres in Rapar, Gujarat, and one centre and a few other buildings in Mumbai used the recycled debris from the CYBC plant.

'As an entrepreneur, I faced a lot of financial difficulties. We had to buy C&D waste because of which the cost of our recycled products was higher than other products available in the market. There were no tax benefits for our eco-friendly products,' Davis said. In spite of all the odds, he tried various permutations and combinations to keep the plant running. He held several meetings with municipal officials, but the Corporation was not keen to recycle Mumbai's C&D waste then.

Most builders in Mumbai claimed they had not heard of this initiative. The Builders Association of India, Mumbai, and other builders said they could not use the recycled C&D waste till BIS certified it.

To sustain the project, CYBC approached private builders and made C&D waste recycling units available to them at their project sites. The entire machinery was moved from Khargar to Borivali East, where a bungalow was being demolished to make way for a four-storey building. Within a space of 300–400 sq. ft, the machinery was set up and C&D waste recycled to make bricks and paver blocks. However, the plant could not be sustained after 2009.

In 2010, CYBC focused on technology transfer as well as organizing training programmes for construction workers. CYBC trained 60 construction workers in masonry in 2010.[58] Lack of policy support and interest from construction industry forced YUVA to shut down CYCB in 2012.[59]

AVIKAL SOMVANSHI/CSE

Demolition is specialized work but mostly carried out by the informal sector in Indian cities

C&D waste management also found a brief mention in Schedule III of the rules for separate collection in the Municipal Solid Waste (Management and Handling) (MSW) Rules, 2000.[55] The rules basically passed on the responsibility of managing C&D waste to local bodies without any details on how to do it. This was extremely inadequate. No city or state, except Mumbai, made any management policy for it.

The Municipal Corporation of Greater Mumbai (MCGM) carried out characterization of its municipal solid waste in 2005 and found that about 2,500 tonnes of the 7,000 tonne of waste generated daily in Mumbai was C&D waste.[56] Since Mumbai had no policy on collection and disposal of C&D waste, it was being dumped in a haphazard manner in low-lying areas, mangroves and creeks. In response, the following year MCGM framed the Construction and Demolition and Desilting Waste (Management and Disposal) Rules 2006.[57] These were never really implemented and could do nothing to support recycling efforts of CYBC's recycling plant that shut its doors in 2009.

Meanwhile, preparation for the Commonwealth Games 2010 in Delhi resulted in the generation of enormous amounts of C&D waste that started to clog the city by 2008. The then undivided Municipal Corporation of Delhi (MCD) in partnership with Infrastructure Leasing & Financial Services Limited's (IL&FS's) Environmental Infrastructure & Services Ltd (IEISL) decided to developed a pilot project to scientifically manage the piles of waste choking the city by collecting and recycling. A few surveys of city's C&D waste character were carried out in 2004 and 2005 by MCD and IEISL respectively. The collection and transportation of C&D waste started on 24 July 2009 and processing at the plant (then 500 tonnes per day capacity) commenced on 29 December 2009. IEISL collected approximately 450,000 tonnes of C&D waste during 2010–12.

Era of advisories

Ths success of Delhi's pilot recycling plant triggered interest in C&D waste management at the national government level. The Working Sub-Group on Construction & Demolition Waste was constituted by the then Union Ministry of Environment and Forest (MoEF) to evolve a roadmap for management of solid waste. It recommended in 2010 that it was necessary to generate data on C&D waste, segregate C&D waste at source, develop institutional mechanisms for waste collection, reuse and reprocess, impose charges on C&D waste generators, formulate standards for C&D waste, and amend the MSW Rules, 2000 to address C&D waste for its collection, utilization and safe disposal.[60] However, these recommendations were ignored in the draft Municipal Solid Waste Management Rules of 2013 by the MoEF.[61]

Meanwhile, in 2012, the then Union Ministry of Urban Development (MoUD), vide its circular dated 28 June 2012, suggested that all states set up environment friendly C&D waste recycling facilities in all cities and towns with population of over 1 million.[62] Nothing was done on the ground though.

'Naturally sourced' problems

By 2013, Delhi's C&D waste recycling plant started facing the same problem that made CYBC shut its plant operation in 2009—no uptake of recycled material. The plant was on the verge of running out of storage space and would have to stop operation when it approached EPCA in May of 2013 to help find buyers for its inventory. ECPA requested CSE to investigate the issue and come up with recommendations to help increase the uptake of recycled C&D waste products in the city.

Investigation by CSE revealed that IS:383-1970, the Indian standard specification related to aggregates for concrete laid down by BIS, stipulates that concrete can be made only with 'naturally accessed material'. Construction agencies have been wary of this requirement of the standard and, fearing illegality, avoided any use of recycled C&D waste.

The report was published in December of 2013 and also noted that technically, scientists and engineers agree that recycled C&D waste can be used as building material, and it was already a set practice in the developed world.[63] Taking cognizance of this, BIS set up a fast-track panel at the start of 2014 to address the issue of recognizing aggregates from materials other than natural sources as part of the Indian standards.

Meanwhile, BIS also clarified that it is a standard-making body and does not forbid use of any new material; any authority can take the initiative to permit recycled material—standards would follow. CSE report also pointed out that there is precedence for construction agencies mainstreaming use of recycled waste (fly ash) before BIS included them in its standard. There was an additional recommendation for the Central Public Works Department (CPWD) to issue guidance and revise its Schedule of Rates (SoR) to allow use of products like paver blocks and flooring tiles made out of recycled C&D waste as it had done for recycled fly ash products.

Making use of the resource

CPWD eventually in its 2014 *Guidelines for Sustainable Habitats* included a set of 'Guidelines on re-use of recycled C&D waste'. The guidelines included ways

and precautions for recycling of C&D waste as well as emphasized the need for a deconstruction plan in order to recover useful products that can be reused without much processing. This allowed the agency to procure 1.8 million recycled C&D waste blocks from the IEISL (IL&FS Environmental Infrastructure Services Ltd) plant for the prestigious Extension of Supreme Court of India complex project.[64]

Also in 2014, another Central government's construction agency National Buildings Construction Corporation (NBCC) piloted in situ recycling of demolition waste for its mega-project to redevelop East Kidwai Nagar in New Delhi. NBCC in partnership with M/S Enzyme India Pvt. Ltd set up a temporary 150 TPD C&D waste recycling plant on the private–public partnership (PPP) model with 100 per cent buyback by NBCC at the project site.[65] The redevelopment project involved demolition of 2,444 existing houses and allied structures. The C&D waste was recycled to produce fine aggregate, course aggregate and manufactured soil that was directly used in construction as a fill material and also in manufacture of downstream products like RMC, bricks, blocks, tiles, pavers, etc. The project established the economic and logistic feasibility of on-site C&D waste recycling.

Following the lead of CPWD, Delhi PWD issued an advisory to all Delhi government departments in 2015, mandating 2–10 per cent use of recycled C&D waste products in all Delhi government building construction and road works.[66] The advisory was reissued by the Delhi PWD in 2018.

Development of codes and standards

In 2015, BIS added an 11th chapter to the National Building Code 2005 titled 'Approach to sustainability'. It recognized recycled C&D waste as building material and suggested possible use of it.[67] It states that:

- Recycled coarse aggregate may be used in concrete for bulk fills, bank protection, base/fill of drainage structures, pavements, sidewalks, kerbs and gutters etc.
- Up to 30 per cent of natural crushed coarse aggregate can be replaced by the recycled concrete aggregate
- This percentage can be increased up to 50 per cent for pavements and other areas under pure compression specific to the standards and practices pertaining to construction of roads.

The then Union Ministry of Housing and Urban Affairs (MoHUA), vide a letter dated 23 March 2016, circulated a notification by CPWD on mandatory use of recycled portions of C&D waste in construction activities if the same is available within 100 km of the construction site.[68] It also specified that coarse and fine varieties of Recycled Concrete Aggregate (RCA) derived from C&D waste are to be used in lean concrete, plain concrete cement (PCC) and reinforced concrete cement (RCC) used in construction.

BMTPC in 2016 released *Guidelines for Utilization of Construction & Demolition Waste in Construction of Dwelling Units and Related Infrastructure in Housing Schemes of the Government* to address the considerable shortage of conventional and traditional building materials in India based on projected high demand of building materials by 2021–22.[69]

Eventually, in 2016, BIS published revised standard IS 383: Coarse and Fine Aggregate for Concrete Specification, which explicitly recognized recycled C&D

Table 6: Extent of utilization of coarse and fine aggregate from C&D waste

Aggregates from C&D waste	Maximum utilization in		
	Plain concrete	Reinforced concrete	Lean concrete (less than M15 Grade)
Coarse aggregates			
Recycled aggregates (RA)	NIL	NIL	100 %
Fine aggregates			
Recycled concrete aggregates (RCA)	25%	20% (only up to M20 grade)	100%

Source: IS 383:2016

waste as a legal substitute for natural aggregate in concrete mix.[70] IS 383:2016 categorizes recycled C&D waste into two types:

- Recycled aggregate (RA): Made from C&D waste, which may comprise concrete, brick, tiles, stone, etc.
- Recycled concrete aggregate (RCA): Derived from concrete after requisite processing.

The revised standard IS 383 permits use of RA and RCA up to a certain percentage in concrete (see Table 6: *Extent of utilization of coarse and fine aggregate from C&D waste*).

The subsequent year, in 2017, the Indian Roads Congress (IRC) issued 'IRC-121:2017 Guidelines for Use of C&D Waste in Road Sector', outlining various products from recycled C&D waste and in the proportions that could be safely used for specific road construction and/or repair applications.[71]

Green certifications

To build confidence in the performance of recycled C&D, waste products quality certifications were rolled out in 2017. Certification is an important way to improve market acceptance when carried out according to established protocol by neutral third parties. ICMQ (Institute for Certification and Quality Mark)-India, a Mumbai-based subsidiary of an Italian certification body that promotes quality, durability and sustainability in the realms of building products and construction, recognized recycled C&D waste as 'recycled content' in its green rating for building material as per ISO 14020 protocol.[72] Concrete paver blocks manufactured using recycled C&D waste at Ahmedabad's recycling facility were certified as 'bronze' under ICMQ-India's Get it Green certification.[73]

Later, the Green Rating for Integrated Habitat Assessment (GRIHA) Product Catalogue added recycled C&D waste products as green and made them eligible for rating points under GRIHA's green-building rating system.[74]

C&D Waste Management Rules, 2016

The Ministry of Environment, Forest and Climate Change (MoEFCC) notified the Construction and Demolition Waste Management Rules in 2016. This was a significant step forward that pieced together and addressed most of the issues around C&D waste management in the country. The notification created the legal framework needed for recycle and reuse of C&D waste in the construction industry.

Stakeholder duties under C&D Waste Management Rules, 2016

Duties of waste generator

- Collection, segregation and storage of C&D waste generated within their premises as notified or directed by the local authority in consonance with the C&D Rules.
- Ensuring that other solid waste is not mixed with C&D waste.
- C&D waste shall be deposited at the collection points or the C&D waste processing facility as designated by the local body.
- C&D waste shall be stored within the premises to avoid any littering or accumulation of waste so as to prevent any obstruction to traffic or public or drains.
- Waste generators who generate more than 20 tonnes per day or 300 tonnes per project in a month shall:
  - Segregate waste into five streams—concrete, soil, metal, wood and plastic, bricks and masonry.
  - Submit a waste management plan to obtain approval from local authority before starting construction, demolition or remodeling work.
  - Pay relevant charges for collection, transportation, processing and disposal as notified by local authority.

Duties of service providers and their contractors

- Service providers shall prepare a comprehensive waste management plan within six months from the Rules notification (that happened in April 2016) to cover segregation, storage, collection, reuse, recycling, transportation and disposal of C&D waste generated within their jurisdiction.
- It shall clean up the C&D waste within a reasonable timeframe, preferably a day, in consultation with the local authority.
- In the absence of logistic support, it shall subcontract authorized agencies for removal of C&D waste and pay relevant charges as notified by the local authority.

Duties of local authority

- Issue detailed directions for C&D waste management as per the provisions of the rule and obtain detailed plan or undertaking from generators.
- Chalk out stages, methodology and equipment used, material involved in the overall activity and final clean up after completion of the construction and demolition.
- Safely dispose of C&D waste contaminated with hazardous waste or toxic material or nuclear waste if any in consultation with concerned authorities.
- Make arrangement for collection of C&D waste and ensuring that clean-up is done at regular intervals.
- Get the waste transported to processing facilities through own resources or private agencies.
- Give appropriate incentives to generator for salvaging, processing and or recycling, preferably in situ.
- Examine and approve waste management plan of generators within one month of submission or within date of approval of

It also brought urgency to find immediate means to recycle and reuse this waste in cities, and linked it with the need to substitute material mined from nature and prevent damage to waterbodies, public spaces and green areas. It officially recognized C&D waste is one of the main contributors to dust pollution in cities such as Delhi.

The Rules are comprehensive. They clearly define the roles of all stakeholders—waste generators or developers, local authorities, Centre and state governments, pollution control boards, standard-making agencies and recyclers (see *Box: Stakeholder duties under C&D Waste Management Rules, 2016*). They also provided a timeframe for establishing and implementation of the rules (see *Table 7: Timeframe for planning and implementation of C&D Waste Management Rules*). The important highlights of the rules are as follows:

- The Rules mandate use of recycled products in construction. Local bodies will have to utilize 10–20 per cent of material from C&D waste in municipal and government contracts for construction.
- The tipping fee for delivery of C&D waste to the recycling plant, and terms

building plan, whichever is earlier.

- Establish the data for C&D waste generation within its jurisdiction and update it once a year.
- Device measures to appropriately manage C&D waste in consultation with expert institution.
- Educate and disseminate information on C&D waste management in consultation with expert institutions and civil society organizations or through their own websites.
- Incentivize usage of C&D products, including those used for non-structural applications.

Duties of State Pollution Control Board or Pollution Control Committee

- Monitor work done by local bodies in implementation of the rules.
- Provide authorization to C&D waste processing facilities after examining the application in the prescribed forms.
- Prepare annual report with special emphasis on the implementation of C&D rules within local bodies and submit it to CPCB before 31 July of each year.

Duties of state government or Union Territory administration

- Prepare a policy document with respect to provisions of C&D waste management within one year of notification of the rules.
- State government/Union territory shall provide suitable for storage, processing and recycling facilities for C&D waste.
- TCAP shall incorporate the site in approved land use plan to prevent any future disturbance to the facility in the long term.
- Usage of materials made from C&D waste materials to be mandatory (10–20 per cent) in municipal and government contracts.

Duties of the Central Pollution Control Board

- Prepare guidelines to manage C&D waste in an environmentally friendly manner.
- Analyse and collate data from SPCB/PCC (Pollution Control Committee functioning in Union Territories) to review the rules from time to time.
- Coordinate with SPCB or PCC for any matter related to environmental standards.
- Forward annual compliance report based on data received from SPCB/PCC to the Central government before 30th August of each year.

Duties of Bureau of Indian Standards and Indian Roads Congress

- Prepare code of practices and standards for use of recycled materials and products of C&D waste in construction and for roads.

Duties of Central government

- Facilitating local bodies in compliance of these Rules by Ministry of Urban Development (MoUD), Ministry of Ministry of Rural Development (MoRD) and Ministry of Panchayati Raj (MoPR).
- Review implementation of the Rules when required by Ministry of Environment, Forest and Climate Change (MoEFCC).

Source: C&D Waste Management Rules, 2016

and conditions of civic body with the concessionaire may be designed to keep the price of C&D waste recycled products about 20 per cent lower than the corresponding conventional products.

- All large developers are accountable for collection and disposal of C&D waste.
- Local authorities are to give appropriate incentives to waste generators for salvaging, processing and recycling, preferably in situ.
- Recycling facilities will have to be created at a safe distance from habitation with adequate buffer zone.
- Local authorities to establish a database and update it once in a year.
- All renovation projects involving demolition, even in the private sector, may be mandated to use at least 20 per cent of recycled C&D waste products.

Under the C&D Waste Management Rules, 2016, Schedule I (14), the following are exempt from the norms of pollution from dust and noise:

- For construction work, where at least 80 per cent construction and demolition waste is recycled or

Table 7: Timeframe for planning and implementation of C&D Waste Management Rules

Compliance criteria	Cities with population of > = 1 million	Cities with population of 0.5–1 million	Cities with population of < 0.5 million
Formulation of policy by state government	12 months	12 months	12 months
Identification of sites for collection and processing facility	18 months	18 months	18 months
Commissioning and implementation of the facility	18 months	24 months	36 months
Monitoring by SPCBs	Thrice a year, i.e. once in four months	Twice a year, i.e. once in six months	Twice a year, i.e. once in six months

Source: C&D Waste Rules 2016.

- Reused in situ and there is sufficient buffer area to protect the surrounding habitation from any adverse impact.

The Rules also provide the environmental compliance criteria and administrative pathways for site selection and setting up of storage and C&D waste processing plants. Additionally, it also defines parameters for application and compliance criteria of materials made from C&D waste in a sanitary landfill.

Policy follow-ups

The Central Pollution Control Board (CPCB) delivered on its mandate and issued 'Guidelines on Environment Management of Construction & Demolition Waste' in March 2017. The guidelines recommend pollution mitigation measures in C&D dump sites and waste-processing facilities.[75] Though guidelines focus on facilities generating 20 tonnes or more in a day or 300 tonnes per project in a month of installed capacity (bulk generators) in cities or towns, the mitigation measures suggested can be scaled after consultation with the concerned department in the state government.

In 2018, the Building Materials and Technology Promotion Council (BMPTC) published *Utilisation of Recycled Produce of Construction & Demolition Waste: A Ready Reckoner* detailing the salient features of all the prevailing C&D waste-related documents and notifications, including duties, monitoring and marketing plan for all the stakeholders.[76]

In December 2018, NITI Aayog published a draft *Strategy for Promoting Processing of Construction and Demolition Waste and Utilisation of Recycled Products*, aimed to address difficult in the implementation of the Rules. It recognized that the biggest challenges to implementation are at the level of urban local bodies (ULBs). It noted that ULBs suffered with land, financial resources and personnel constraints, and their capacities to develop the management and business model as envisaged in the rules are limited. It made some interesting recommendations to fix the problem. The finalized paper was published in 2019 but has not steered any change on ground.[77]

Swachh Bharat Mission and Swachh Survekshan

The Government of India launched its flagship programme Swachh Bharat Mission (SBM) in 2014, which aims to provide basic infrastructural and service delivery with respect to sanitation facilities, including toilets, to every family and adopting the scientific methods to collect, process and dispose of municipal solid waste. In 2016, SBM's report *Technical Aspects of Processing and Treatment of Municipal Solid Waste*, recognized the need for C&D waste management but it was not included in the Swachh Survekshan, which that was launched the same year.[78]

Swachh Survekshan is a pan-India competition held yearly, to encourage cities to improve the condition of urban sanitation. The objective of this exercise is: '*To ensure sustainability of initiatives taken towards garbage free and open defecation free cities, provide credible outcomes which would be validated by third party certification, institutionalize existing systems through online processes and create awareness amongst all sections of society about the importance of working together towards making towns and cities a better place to live in.*'[79]

The ULBs are judged and ranked based on the total number of points earned in four categories—certification, direct observation, and service level progress and citizen feedback.

In 2019, a new indicator for C&D waste management was introduced with the aim of rewarding ULBs that have a mechanism in place to manage C&D waste as per the C&D Waste Management Rules 2016. The C&D indicator carried 50 points of the total 5,000 points available in 2019 (see *Table 8: Ranking scheme as per the Swachh Survekshan 2019*).[80]

To earn points under this category, ULBs were required to submit documents online. The verification process required:

- Average quantity of C&D waste generated daily—ULB to share the data;
- Public notification for C&D waste services.
- Evidence of functional C&D waste helpline/call centre, list of vehicles for managing C&D waste and penalty system in place for open dumping along with details of penalty/fines collected.
- If C&D waste management service provider engaged by the ULB, contract/ agreement copy with payment details to be provided.
- Evidence of ULB approving C&D waste management plan from bulk waste generators generating >300 tonnes C&D waste in a month before sanction is given for construction.

Table 8: Ranking scheme as per Swachh Survekshan 2019

Scheme of ranking	Points
>95% of the waste is managed	50
80–95%	35
60–79%	25
40–59%	15
<40 %	0

Source: Swachh Survekshan Survey Toolkit 2019.

- If bulk waste generator is getting its C&D waste managed by the external agency/contractor, copy of contract/agreement including payments made.
- Notification issued for use of at least 10–20 per cent of C&D waste in government-/municipal-/municipality-approved construction activities in non-structural applications.
- C&D waste should be segregated in following five categories: concrete, soil, steel, wood and plastics, bricks and mortar.
- List of C&D waste collection centres in the city—logbook showing management of C&D waste as per prescribed rules.

Introduction of this category was seen as an encouragement for ULBs to take up C&D waste management in their cities. The criteria chosen for assessment of this category were thorough but highly ambitious and removed from the ground reality. They required reporting on the C&D waste generation data, available infrastructure, public outreach and the implementation of the C&D Waste Management Rules notified in 2016. Finally, the scheme of ranking and allocation is based on the percentage of C&D waste that is managed by the ULB. Though it wasn't explained how this percentage would be calculated based on the information provided by the ULB.

The reality is that cities do not even know how much C&D waste they generate. The estimates are available for a few mega cities but even these are unsupported by any scientific survey. Given this context of the requirements of management as spelled out in the C&D Waste Management Rules 2016, it would have been impossible for any city, except Delhi and Ahmedabad, to get any points in the contest.

This is what seems to have happened. The final report of 2019 Swachh Survekshan shied away from giving any details of C&D waste management in the cities. It used the blanket phrase 'C&D waste management as per C&D Rules 2016' to describe performance of the winners.[81] Only Gujarat was acknowledged to have seven ULBs that are 'processing more than 70 per cent of C&D waste as per 2016 rules', which is an absurd claim given that then only Ahmedabad had a C&D waste-processing facility. It is obvious that extreme concessions were given to cities and a generous definition of processing waste was used while finalizing the results.

Table 9: Ranking scheme as per the Swachh Survekshan 2020

Scheme of marking	Marks
C&D waste helpline in place	10
Dedicated vehicles in place	10
User charges for services and fine being collected for open dumping	10
Dedicated area(s) earmarked to keep C&D waste in the city	10
Land identified and plan in place for processing C&D waste	10
Yes for all above	50

Source: Swachh Survekshan Survey Toolkit 2020.

Table 10: Ranking categories and qualifying criteria for Swachh Survekshan Survey 2021

Ranking categories	Segregation of waste (wet, dry and hazardous*)	Processing capacity against wet waste generated	Processing/ recycling of waste (wet and dry)	C&D waste processing	Percentage of waste going to the landfill	Sanitation status
Platinum (Divya)	>95% wards	>91%	>91%	> 50%	Up to 5%	Water+
Gold (Anupam)	>75% wards	>81%	>81%	>41%	Up to 10%	ODF++
Silver (Ujjwal)	>55% wards	>71%	>71%	>31%	Up to 15%	ODF+
Bronze (Udit)	>35% wards	>61%	>61%	>21%	Up to 20%	ODF+
Aspiring (Aarohi)	>25% wards	>50%	>50%	>10%	>20%	ODF

Note: A city has to meet all the criteria to qualify for a particular category. If it does not meet all the criteria, it will have to settle for the next category where it meets all criteria.

* Mandatory for Platinum

Source: Swachh Survekshan Survey Toolkit 2021.

Understandably, the C&D waste processing marking scheme was changed in the 2020 cycle. Instead of marking cities on the percentage of waste managed in 2020, marks are given for having the bare minimum infrastructure (see *Table 9: Ranking scheme as per the Swachh Survekshan 2020*).[82] This is reflective of how poorly the cities performed on the C&D management criteria in the 2019 cycle that the marking criteria in the survey had to be watered down to such an extent.

Improvement in 2021: The toolkit for Swachh Survekshan 2021 was launched on 3 July 2020. Given the difficulty of assessing cities' C&D waste management in the previous two cycles, the criteria have been revised again. For the 2021 cycle, cities will be graded on two themes worth 50 ranking points each.[83] The first theme focuses on management of infrastructure, and cities are given points based on the city having put in place a C&D waste collection system, notified charges for C&D waste services, and segregation of waste in five streams. The second theme focuses on reuse and processing of the waste collected. Ranking points are awarded based on percentages of collected waste processed and reused. The processing and recycling percentage threshold are kept significantly lower for C&D waste when compared to other solid waste streams even though C&D waste has higher recyclability potential (see *Table 10: Ranking categories and qualifying criteria for Swachh Survekshan Survey 2021*).

Data and reporting requirement fleshed out in Swachh Survekshan 2021 is commendable and would lead to better documentation of the waste and its management in the city (see *Box: Swachh Survekshan 2021 reporting requirements*).

The most significant aspect of the Swachh Survekshan 2021 is that it has moved away from the blanket requirement of recycling plants being set up for C&D waste. It has recognized nonstructural applications of C&D waste that don't require the specialized processing possible only with a recycling plant as legitimate reuse, eligible for gaining ranking points. These applications include lower layers

Swachh Survekshan 2021 reporting requirements

List of supporting documents to be maintained by the ULBs

- Copy of public notification by the ULB for C&D waste management within the ULB;
- Details of vehicles in place for management of C&D waste;
- Summary of user charges and fines collected for C&D waste management;
- List and details regarding the C&D waste collection centres and land for C&D waste processing plants; and
- Sale receipt for C&D waste material used or processed.

Management information system (MIS) data points

- Is on-call collection facility and/or weekly collection schedule available?
- Has the ULB notified and enforced charges for collection and transportation, processing and disposal of C&D waste?
- Are all bulk generators managing and processing their C&D waste on their own as per the Construction and Demolition Waste Management Rules 2016? Segregation to be ensured in the following five categories: concrete, soil, steel, wood and plastics, bricks and mortar.
- Quantity of C&D waste collected from bulk generators (in tonnes) who are sending their waste to other facilities;
- Quantity of C&D waste collected from non-bulk C&D generators (in tonnes);
- Quantity of C&D waste collected or received from ULB operations (in tonnes);
- Total C&D waste collected (in tonnes) (auto sum of above three);
- Quantity of raw C&D waste used in municipal- or government-approved construction activities in nonstructural applications–lower layers of road pavements, inner colony roads, filling of plinth and basement etc. (in tonnes);
- Quantity of material made out of C&D waste in municipal and/or government construction activity (if available) in kerb stones, structural concrete as manufactured aggregate, paving blocks, bricks etc. (tonnes per day [TPD]);
- Quantity of material used or sold out of total C&D waste material made in all facilities in municipal and/or government construction activity (if available) in kerb stones, structural concrete as manufactured aggregate, paving blocks, bricks etc. (TPD);
- Quantity of C&D waste stored, segregated, processed and recycled, by bulk and non-bulk generators (TPD). Segregation should be in the following five categories: concrete, soil, steel, wood and plastics, bricks and mortar.
- Quantity of C&D waste processed in facility (in tonnes).

Methodology for validation (100 per cent direct observation)

- The assessor will visit collections points and all plant(s)/processing facilities updated in the MIS.
- To ascertain the progress, the assessor will also interact with the officials in the plant.
- The assessor will ask for the logbook capturing at least last three months' record and electricity bill to verify the functionality of the facility.
- On the basis of observation and verification of logbook or electricity bills, senior assessors at the back end will arrive at the efficiency level of the plant(s) and sub-indicator-wise marks will be given.

Source: Swachh Survekshan Survey Toolkit 2021.

of road pavements, inner colony roads and filling of plinths and basements etc. The reuse needs to be coupled with recycling that leads to manufacturing of value added products such as kerb stones, structural concrete as manufactured aggregate, paving blocks, bricks etc. This has to be prioritized over unprocessed reuse in cities, but for ULBs with population less than 100,000 the need for recycling plant has been waived off. In fact, only ULBs with population of over a million are mandatorily required to have a recycling plant.

This is the first instance that reuse of unprocessed waste has been acknowledged as acceptable utilization of C&D waste in official documents on C&D waste. This is significant as it opens the door to involving the informal sector in the formal management of C&D waste.

AVIKAL SOMVANSHI/CSE

CHAPTER 3

Barriers to implementation

Roadblocks and gaps

The C&D Waste Management Rules were notified in 2016 and subsequently most amendments to standards and schedule of rates needed to support it have been at the national level. Logically, the management of C&D waste in cities should have been streamlined by now. But Swachh Survekshan's inability to access cities on similar criteria of percentage of waste managed as used for municipal solid waste management is telling of the status of implementation. Mumbai, with the richest ULB in the country, has failed to operationalize a single C&D waste recycling facility

for the city even after multiple High Court orders over and above the mandate by the Rules.

Detailed investigation of the status of implementation of C&D Waste Management Rules among major cities has brought to light a host of challenges and roadblocks faced by both implementation agencies and the construction sector (see *Part 2—Outside the wall: Tracking change in cities*). These range from confusion over estimating the waste generation to the lack of land availability in cities for storage and processing the collected waste.

The problems are, however, not limited to implementation of the Rules. The Rules do a reasonable job of putting in place the policy and structural framework for management of waste generated but they draw a blank when it comes to reducing waste generation itself. These are hindering a wider and quicker creation of C&D waste management environment needed in the country.

It is important to recognize and understand these challenges so that the objective of managing this waste and converting it into a resource can be met.

Inadequacy in practice and infrastructure

Estimation of C&D waste

Multiple methodologies of C&D waste estimation exist globally for building and city levels. But their application in the Indian context is insubstantial due to limitations in availability of data and different waste management practices prevalent in India. For instance, C&D waste is rarely segregated and is not transported in its entirety as a sizeable portion of it is diverted for reselling and for filling activities. Most ULBs track waste disposal, especially at their landfills but they rarely record it in a segregated fashion that could be meaningful for C&D waste estimation.

City officials prefer using a per capita-based index to estimate waste (such as those available for municipal solid waste) but C&D waste has no per capita-based index available for India. Currently, cities and researchers rely on the 2001 Technology Information Forecasting and Assessment Council (TIFAC) study to estimate C&D waste in India. The TIFAC study has given a rule of thumb for C&D waste generated per square metre of construction and/or demolition but these estimates are dated and based on a single study of a very small sample. They don't account for diversity of building typologies or for regional variations in construction techniques and practices. Further, it studied the conventional construction and demolition practices of that time, which have changed considerably in two decades.

It can be argued that the estimates given in the study if used for current building practices would inflate C&D waste generation as lighter building materials and thinner wall assemblies are used in building construction than in 2001. Moreover, it also doesn't account for building material recovery that is promptly undertaken by the informal sector, which reduces significantly the actual waste that requires disposal. Given the reality that there is no other official Indian study on the topic, this study can still give a reasonable understanding of probable C&D waste generation (on the higher side) at a construction site, but it becomes problematic when used to estimate C&D waste generation at the city level.

Assuming that the TIFAC rule of thumb was precise and still applicable to current construction and demolition practices, one would need an accurate database of the city's building stock and its growth and renewal to estimate city-level waste generation. Ideally, data for number of new constructions, demolitions

ANURAG VERMA/CSE

Salvaging doors and windows for reselling from demolition sites is a standard practice among demolition contractors

and renovations needs to be available with details regarding their size, area, materiality and construction-demolition technique employed. Data on the age of building stocks and variations in their renewal rate based on local real-estate trends will also be needed to arrive at reasonable citywide estimates. But these don't exist with cities in a format that can be used for estimation of waste generation.

Further, the sad reality of Indian cities is that a significant chunk of their building stock is unauthorized and therefore not recorded in official databases, and the authorized chunk is poorly documented. The existing building permit system doesn't usually record the quantum of demolition that may be part of the construction activity, and standalone demolitions are rarely registered. Further, repairs and renovations don't usually get reported.

As a result, estimates done using the TIFAC rule of thumb for citywide generation of C&D waste are astonishingly high when compared to what cities record in their waste-disposal logs maintained at landfill sites. Since most cities don't maintain proper logbooks and the general assumption is that most of the C&D waste is disposed of illegally, cities are compelled to accept these high estimates even when they raise eyebrows. But there are cities like Kolkata that have raised objection to this practice of estimation. The city has detailed documentation of C&D waste collected and transported to its landfill site—based on this they have rejected the TIFAC rule of thumb estimates as bloated.

Currently, there isn't a system to credibly check how bloated these estimates are. This is of critical importance as these estimates have become the basis for the cities to set up their C&D waste management and recycling infrastructure as

mandated by the Rules. A high estimate warrants bigger waste-processing facilities, which require more land to set up and financial burden to operate. Given that cities are perennially cash strapped and have land deficits, these bloated estimates force them to build proverbial white elephants.

Further, the TIFAC rule of thumb doesn't apply to infrastructure projects. This estimation of C&D waste generation remains exclusive to cities.

Constraint of land

Land is one of the scarce resources in cities. ULBs are still struggling to find land for traditional municipal infrastructure and amenities (such as municipal solid waste management). The need for C&D waste management compounds the problem of land scarcity for them. Setting up any kind of waste management/recycling facility requires significant amounts of land and cities are frequently left helpless due to outdated zoning requirements and 'not in my backyard' sentiment among citizens. There is additional pressure of real-estate value capture due to which many cities feel diverting available land resource for waste management within cities as a loss of revenue.

Complication with land for recycling facilities: As per the Rules, the responsibility of providing land to set up recycling facilities is on ULBs. The Rules also directed CPCB to ease the environmental regulations for location of recycling facilities so that these can be built within city limits. The Central Pollution Control Board (CPCB) followed through and relaxed the siting requirements with respect to acceptable distance from human habitation. To balance the environmental and health impact of these relaxations, CPCB ratchets up the pollution control requirements at the facilities.[84]

But the paucity and high cost of land within the city limits has forced most cities to divert land from no-development zones within or around the city for setting up these plants. These are generally environmentally sensitive areas where the environmental exceptions given for C&D waste management facilities don't readily apply. For instance, Gurugram's proposal to build its recycling facility in the Aravalli Hills and Kolkata's proposal to build it in wetland were blocked by the respective state environment authorities for falling foul of rules governing environmentally sensitive areas.

Often, the only feasible option for large enough land parcels is outside the administrative borders of ULBs, which requires effective collaboration with other entities, especially state-level departments and/or agencies. For instance, Pune has identified land that belonged to the state government to set up a recycling facility outside the city limits. The land was leased out to the city by the state but the city was not allowed to develop the land under public–private partnership (PPP). There was a legal stipulation that the land could not be subleased to a private entity, but there are no government agencies that build and operate C&D waste recycling facilities.

In rare instances when cities are able to find land within the city limit without environmental or legal complications, there is active resistance from people in neighbouring areas. Assumed noise and air pollution generally associated with waste recycling facilities has made local residents wary of them. Gurugram faced such protests from citizens over its alternative land pick for its C&D waste recycling facility.

Complication with land for intermediate collection: Identifying and demarcating smaller land parcels as intermediate C&D waste collection points throughout cities and town are a challenge for ULBs. These are especially needed to cater to small-scale generation that happens due to household-level repairs and incremental construction. Cities have tried multiple approaches to deliver on the Rules' mandate of decentralized collection, with varying degrees of failure.

Cities have over years developed a network of neighbourhood-level municipal solid waste (MSW)-collection points. The natural instinct has been to dedicate part of that infrastructure to C&D waste but it doesn't work. A major concern with handling of this waste has been its mixing with MSW, which renders both wastes unrecyclable, and storing both at the same location alleviates the risk of cross-contamination. Further, many cities are systematically shifting to door-to-door collection of MSW and converting these collection points into segregation and recyclable sorting facilities, making it logistically difficult to use these crunched spaces for C&D waste collection as well.

Delhi tried to solve this problem by designating ULBs' Junior Engineer Stores for building material located in each ward as C&D waste collection points. These were further complemented by a few parcels of vacant land identified as a collection point by the ULBs. As of March 2020 the city has more than 240 collection points spread across the three municipalities of Delhi. East Delhi Municipal Corporation (DMC) has 54 collection points, North DMC has 87 and South DMC has more than 100 collection points. But these work mostly on paper as most people are not aware of their existence and most Junior Engineer Stores don't have space for the incoming waste (see *Box: Ground reality of Delhi's C&D waste collection points*). As a result most of the waste ends up at MSW collection points or just litters the city.

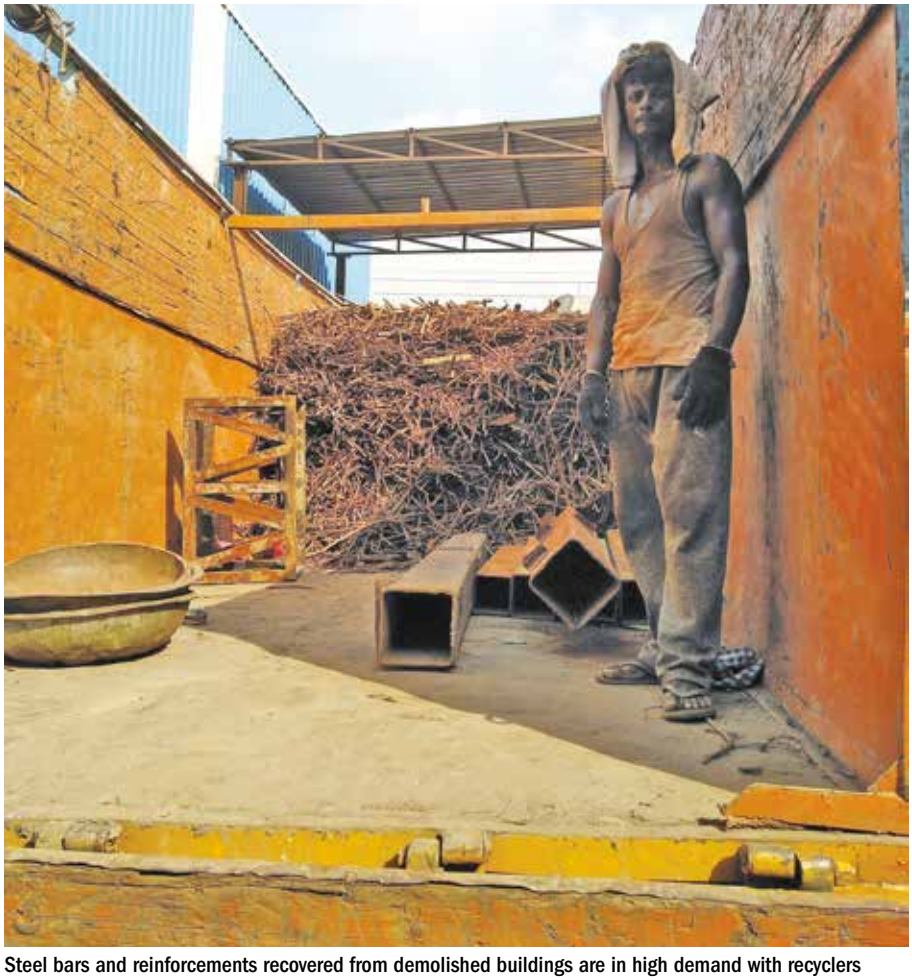
Ahmedabad and Chennai have identified a C&D waste collection points in each municipal zone. These collection points have reasonable space to receive waste but awareness about their location is negligible among the public. Moreover, given the massive size of each municipal zone, it is often expensive to transport waste to these collection points for small generators. There are media reports of informal fees charged for depositing C&D waste at these collection points, which further deters small generators.

Bengaluru has identified abandoned stone quarries outside city limit as collection points. Access roads to these are not in the best condition and long commutes to the quarries makes it infeasible for small generators to use them. Similarly, Gurugram has identified vacant plots in villages outside the city limit.

Pune has been noted to have a more holistic approach. Under its new solid waste management policy, the city has directed all 15 municipal zones to identify space for C&D waste within their solid waste resource centres. To address the problem of long distances within the zones, it has proposed a system of providing portable C&D waste containers to small generators that can be moved around depending upon demand. But it has not been operationalized yet, so its effectiveness in real world remains untested.

Transportation of C&D waste

Trucks or tractors are used to transport C&D waste from sites to disposal sites on payment of a minimal fee to the transporters. The transporters can be private or empanelled with the ULB. There is considerable variation in preferred practice between small and big generators and also among cities.



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Steel bars and reinforcements recovered from demolished buildings are in high demand with recyclers

The responsibility of transporting waste as per the Rules lies with the small waste generators, who are required to deliver the C&D waste at their own expense to a designated collection point owned by the Municipal Corporation. The ULB is expected to transport the collected waste to the disposal site from these points itself or contracts private transporters to do so. Big generators are required to transport the waste directly to the disposal or recycling site on their own expense. This is the system in place in Delhi and Ahmedabad.

The problem with this model, as studied in Delhi, is that many private and informal transporters engaged by small generators are not aware of the collection points in the city. Even when they are aware, getting to the collection point may require a long commute that is an additional cost for transporters. Often they are stopped from dumping waste at these points by their caretakers or asked to informally pay for dumping waste there. Given these transporters work with really tight profit margins, these monetarily taxing additionalities prompt them resort to littering. Further, certain types of C&D waste have value in the informal market, which diverts them from the legally defined management process (see Section '*Informal sector ignored*' later in the chapter). Moreover, the cost of transferring this waste from collection points to the final destination is a costly affair for ULBs and many are unable to find the financial resource to run it at frequency and scale needed (see Section '*Concerns about finances* and *business case*' later in the chapter).

Several cities have adopted a different model. For instance, Kolkata provides an on-call waste-collection service. The small generators are expected to store the waste within their premises and book waste pick-up service by the ULB via calling a helpline number. They are allocated a day and time slot for the pick-up based on location, quantity of waste and availability of pick-up truck. The generator pays the ULB for the service based on notified rates. This model has multiple merits but is plagued by capacity crunch which stops the service from getting extended to the whole city and the suburbs.

Further, given the heavy and bulky nature of C&D waste, employing a transport truck is usually not sufficient to lift the waste and needs to be complemented by hauling machinery. This substantially increases the cost of the operation, and dramatically slows down the delivery of service. As a result, as noticed in Chennai, the service becomes unaffordable and people prefer to not use it. It has been reported that residents find it cheaper to pay a blanket Rs 2,000 penalty for unlawful disposal of C&D waste instead of Rs 1,500 for every tonne of waste removal as charged by the Chennai ULB.

Segregation of C&D waste

The Rules require large generators to 'segregate the waste into four streams such as concrete, soil, steel, wood and plastics, bricks and mortar', but it doesn't specify exactly which four given there are more than four streams of C&D waste.[85] Swachh Survekshan 2021 has sought segregation in five categories—concrete, soil, steel, wood and plastics, and bricks and mortar. This is expected at both generator premises and at designated collection points.

This has led to confusion and non-uniformity among cities. For instance, there are different segregation requirements within NCR cities. Delhi has not spelled them out, while Ghaziabad has notified that every generator needs to segregate waste into four streams (concrete, soil, wood and plastics, and bricks and mortar) at premises. Gurugram has notified segregation on premises in six different streams, namely brick and masonry; concrete and steel; soil, sand and gravel; wood and plastics; other metals; and miscellaneous.

The confusing and shifting clubbing of segregation streams is a problem for the construction industry, which usually has firms operating across multiple ULBs. But an even bigger problem is the space and labour needed to carry out recommended segregation, given the bulky nature of waste and prevalent construction management. Since there is no explicit requirement to reserve space within construction sites for waste storage and sorting, most builders do not plan for it, leading to mixing of waste. The problem is even graver for collection and storage points maintained by ULBs. CSE's field survey of collection points in Delhi and Ahmedabad noted that there were no provisions for segregated collection or storage of the waste at the collection points. Segregated transportation that would be needed to complement segregation at source and collection point has not been noted in formal project management or in any ULB's C&D waste policy.

Informal demolition contractors who recover and sell segregated waste are the best segregated transportation practice noted in the country.

Inadequacy in governance

There has not been even preliminary discussion and planning on C&D waste management in most cities and towns. In the context of overall shortage of

personnel/resources, C&D waste management is seen as a low priority for ULBs. In general, MSW disposal is of greater concern to the public and there have been MSW-related lawsuits in most cities. As a result, C&D waste collection and disposal has been treated as a non-priority.

Among a few cities where the process had been initiated, progress has stalled after preliminary discussions. Most of these cities have been working towards contracting out the collection, transport and processing of C&D waste to private entities, but ULBs are struggling to even establish these private–public partnerships. As ULBs are the principal implementation agency, solely responsible for the overall performance of the management scheme, it is critical to understand the issues plaguing their response.

Lack of monitoring capacity/resources

ULBs typically suffer from chronic shortages in both human and financial resources. Their current resources are already hard pressed to monitor, collect and dispose of MSW as stipulated by law. Therefore, initiating a new C&D waste management system is an additional responsibility that most are sceptical about.

The Rules also require coordination among the town planning department, building department and waste management department of ULBs to manage C&D waste. Interdepartmental coordination has been difficult to achieve for most ULBs. With single-window building-clearance being adopted by most cities, establishing responsibility, accountability and revenue sharing among departments has been even more critical but confusion still prevails within ULBs.

Lack of capacity and experience in C&D waste management

C&D waste management is a new area of work in which most ULB officials have little awareness and experience. Multiple awareness and capacity-development workshops held by CSE with cities in West Bengal, Odisha and Andhra Pradesh have brought to light that ULBs are not equipped with even basic knowledge of C&D waste estimation, feasibility planning, tendering and so on. In many cases, inexperience or prior negative experience with PPPs has been an additional cause of hesitation to proceed with implementation.

Moreover, there is an availability crunch of qualified and experienced C&D waste management consultants and service providers in India. The problem is compounded by the fact that the Rules provide no guidance as to how to conduct feasibility and other studies needed. As a result many cities have wasted money on studies that have not helped them with implementation. There are also funding shortages that impede most cities from hiring quality services for an initial feasibility study and/or a detailed project report (DPR). All these have considerably contributed to impeding implementation of the Rules.

Concerns about finances and business case

The Rules want cities to develop a circular economy around C&D waste. But the learning from Delhi and its struggle to sell recycled products has not instilled confidence among other ULBs. Cities see this as additional financial risk and possible burden. Naturally, cities have been fishing for ways to shield themselves from any financial liability while implementing the Rules instead of nurturing a circular economy. In some cases, ULBs have proposed that the contracted party for collection and transportation of C&D waste actually pays the ULB rather than receives a tipping fee for each tonne of C&D waste that is a practice in place for MSW.

NITI Aayog has also noted that ULBs see the tipping fee to be paid to the contracted party as an unjustified financial burden even when in reality it may not be a net expense given that: a) the ULB saves money by not having to haul bulky C&D waste, and b) the Rules allow the ULB to impose charges on waste generators; tipping fees can be paid from this revenue.[86]

Similarly, many ULBs have proposed that the recycling facility must share profits from selling recycled products with the ULB. These have deterred development of new entrepreneurship in this sector. For instance, Gurugram has as part of their C&D waste processing PPP agreement with Infrastructure Leasing & Financial Services (IL&FS) that the ULB will get 10 per cent share in proceeds from sale of all concrete aggregate products or value added products. In addition, if the ULB purchases a concrete aggregate product, they will get a 5 per cent discount on the price and a 20 per cent discount on value added products.[87] Only a mega corporate entity like IL&FS can afford to give such concessions—small firms or start-ups would be financially crippled by them.

Low involvement of state government agencies/departments; lack of urgency

While ULBs have the pivotal responsibility of planning and implementing C&D waste management, state government agencies and departments often have a final say in their plans. State urban development departments are supposed to frame policies on C&D waste management, supplementing the Rules, to help implementation by taking the local context into account. In most cases, their engagement has been poor. There has been some rekindling of interest from states after C&D waste management appeared as one of the major sectors for air pollution control intervention under the National Clean Air Programme.

Moreover, the active involvement of state urban development departments (sometimes with other related agencies) may be needed for financial assistance and suitable land identification for establishing waste processing facilities as cities struggle to find land under their jurisdiction.

Inertia of construction industry

Lukewarm response and lack of awareness

Being the source of all C&D waste generation (outside of natural disasters), the construction industry is the most important stakeholder in the implementation of the Rules. It is expected to ensure that their generated waste is properly disposed of and that they increase the adoption of recycled products in their construction practices. But it has been slow to move due to inertia and lackadaisical enforcement of the Rules and standards.

NITI Aayog's C&D waste strategy report notes glaring lack of awareness of the C&D Waste Rules in the construction industry across the country.[88] In large projects, where proper handling of C&D waste is mandatory for environmental clearance, there is some sensitivity towards disposal of C&D waste but this has evolved independent of the Rules and are hardly in accordance with them.

Incorrect disposal cost Bengaluru heavily during the mega construction of its Kempegowda International Airport. In its first phase, which concluded in 2013, the then project contractor took advantage of the massive project site and dumped generated C&D waste on the vacant land meant for the second phase of the project.

ANURAG VERMA/CSE

Dumping construction waste on plots adjacent to construction sites is commonly practised by building contractors

Now, the contractors of the second phase are struggling to clean the site of this waste, which is costing them both time and money.

The Rules stipulate that large projects should ideally adopt significant in situ utilization of C&D waste in their projects, wherever feasible.

Even among architects and builders who have knowledge of the Rules, awareness about city-specific details, especially the infrastructure and resources developed by ULBs, is minimal. A *Down to Earth* investigation in 2019 found that faculty at CEPT University, a premium centre for architectural education in Ahmedabad, was not aware of existence of the city's official C&D waste recycling facility that exists within the city.[89] In fact, it has been functional since 2013 but the university was not making use of it to educate student architects and planners about C&D waste management and recycling.

The blame for this ignorance and apathy lies largely with the industry and education system but some part of it lies with ULBs as well. There is little to no information regarding these facilities on their websites and other communication platforms. In Delhi, another *Down to Earth* investigation revealed that officials at the municipal helplines had no information regarding C&D waste collection and disposal points and frequently suggested remedies that have been outlawed under the Rules.[90]

Poor accountability framework

According to the Rules, managing the waste is the waste generator's responsibility. The Rules differentiate between big and small generators and have set responsibilities accordingly. But the way a construction project is structured

makes ascribing the responsibility of managing of C&D waste complicated. The project owner is generally recognized as the generator, but the owner is rarely involved in the actual construction. The standard practice is for the project owner to hire an architect and/or builder who in turn hires a building contractor, who usually subcontracts the disposal of waste to transporters. It has as a result become standard practice by the project owners to forge documents to show compliance with C&D waste disposal requirement as they themselves have no direct control or knowledge of when and how the waste got disposed of. Ideally waste disposal requirements and responsibilities need to be spelled out clearly in contacting and subcontracting agreements for a project and proof of proper disposal mandated.

Lack of confidence in recycled products

The experience in Delhi and Ahmedabad has shown that the market for recycled products made from C&D waste is still quite weak in India. Engagement with the construction industry repeatedly demonstrates that potential buyers are hesitant about such recycled products that they perceive to be inferior in quality. Even when informed about the updated BIS standard (383) that allows recycled aggregates in many applications, potential buyers appear risk averse, pointing to their clients who seem to prefer 'conventional' products. There is also a problem of formal recyclers refusing to sell these products to small- and medium-scale buyers, who are more likely to be experimental with building material choices than established big players.

Moreover, pricing of recycled C&D waste products is problematic. The Ministry of Housing and Urban Affairs has stipulated in many public forums that the cost of recycled products needs to be at par or lower than the corresponding cost of conventional building material. But in reality, recycled C&D waste products are taxed higher than conventional building materials. Currently aggregates are taxed at 5 per cent and manufactured products are taxed at 18 per cent, making the use of recycled products economically unviable for most customers.

The Central Public Works Department (CPWD), in the construction of the Supreme Court Extension, purchased recycled C&D waste blocks from Delhi's Burari C&D waste recycling facility at significantly higher prices per block compared to conventional concrete blocks due to higher GST. Conventional red bricks are taxed at 5 per cent while recycled C&D waste blocks were taxed at 18 per cent. Overall, due to large-scale procurement and design adjustment CPWD broke even to conventional practice but most construction projects don't have these flexibility.

Relaxation of GST for C&D waste recycled products, including manufactured products such as tiles, paver blocks, bricks, sand and aggregates, is a must to help build the market for them.

Low engagement by public construction agencies

State government agencies such as PWD, Housing Development Board/Authority, City Development Authorities and public sector utility companies, are involved in significant volume of construction/demolition work. As per the Rules, these entities are supposed to coordinate with ULBs about proper disposal of their C&D waste, implement in situ utilization of C&D waste in their own projects wherever feasible, and adopt policies to buy recycled products.

However, engagement has remained weak, partly as a result of coordination challenges between state- and local-government-level entities. Delhi PWD was the first state agency to have issued an advisory to all Delhi government departments in 2015, mandating 2–10 per cent use of recycled C&D waste products in building construction and roadwork.[91] Due to the pathetic response, the advisory had to be reissued by them in 2018.[92] But the city still doesn't have much to show on the ground as utilization of recycled C&D waste products in its building projects.

Link between C&D waste reduction and construction dust pollution not understood

Fugitive dust from construction sites are a major source of dust pollution in Indian cities. Construction activities are among the first to be stopped in Delhi as the air quality plunges into smog during winter. Clean Air Action Plans (CAAPs) under the National Clean Air Programme (NCAP) require stringent control of construction dust. The CAAPs have also acknowledged a linkage between C&D waste management and construction-dust control but this connection is not completely understood.

Currently, CAAPs work with the premise that dust from the construction activities can be cut down by erecting wind barriers around the site (green net for superstructure) and spraying water on everything that has an open surface. Fugitive dust from improper storage and disposal of C&D waste is expected to be minimized by implementing C&D Waste Management Rules. Both of these are sound and reasonable means to control dust from construction that can be further enhanced by adopting a waste-reduction approach.

Much of the dust on construction sites is due to poor forecasting and planning of the waste to be generated by the construction itself (see *Section 'Inadequacy in building design and construction management'*). Multiple on-site design changes and alterations to architectural elements that require minor demolitions add to dust creation on-site.

Over-ordering and/or ill-timed ordering of building material is another major cause of increase in construction waste and construction dust. Construction agencies often set up camera-based surveillance systems to prevent pilferage of material from construction sites. This system as well as drone-based approaches can also be used to monitor on-site dust-control measures.

Informal sector ignored

Role of informal sector

A thriving informal economy exists around C&D waste in cities. C&D waste forms an inexpensive material that is easily available in Indian cities and is informally utilized extensively for multiple purposes, many of which are environmentally problematic. One such usage is to reclaim land by filling marshy lands or waterbodies. C&D waste is also sometimes used as a subgrade material for constructing roads. Once the foundation is laid in a construction activity, the intermediate spaces are backfilled with soil or other materials to strengthen and support the foundation of structures.

The Rules have effectively outlawed some of these informal usages of C&D waste (dumping in wetlands) while they have made available legal standards to

improve safety of others (road construction). But the Rules failed to take into account the informal economy and livelihoods attached with it. Now with Swachh Survekshan 2021's recognition of lower layers of road pavements, inner colony roads, filling of plinths and basements etc. as legitimate nonstructural applications of C&D waste, some of the policy roadblocks involving the informal sector in the formal management of C&D waste have been partly lifted. But much needs to be done to integrate wisdom, human resources and efficiency of the informal sector with the formal management structure.

Transporters' income

Disposal of C&D waste that is generated after demolition or during construction work is usually outsourced to transporters hired exclusively for this purpose. Project owners or the construction contractors are only involved in the lifting of the C&D waste from their site—disposal of the waste is left to the discretion of transporters. These transporters in turn sell this waste to projects where there are refilling or reclamation requirements.

This forms a dual source of income for the transporters as they charge for both removal and filling. In Delhi, a dumper with a capacity of about 19–20 cubic metres (cu. m) takes about Rs 3,500 for picking up of debris. A trolley with a capacity of 2–3 cu. m takes about Rs 800–1,000 for picking up of debris. The transporters charge about Rs 500–1,000 for filling at a site.

Transporters usually have clients in waiting for the C&D waste but not always. When they do not have any site available for immediate refilling, the waste is unloaded in abandoned plots, fringes of cities, storm-water drains or waterbodies. This is unavoidable as they don't have any space to store this waste. Dumping of the waste at municipal solid waste (MSW) dhalaos is also a common practice. These dumpings are illegal and usually undertaken at night when vigilance (public and official) in cities is low.

Market of recyclables

Every material in a demolished building has a value and there exists a well-established network of informal traders who are involved in salvaging, recycling and selling these materials. Usually the demolition contractors are the anchor of this informal circular economy. They have over time established a thriving profession that feeds the informal market of salvaged building materials (see *Section 'Demolition management neglected'* later in the chapter).

Materials that are salvaged during deconstruction generally include doors and windows, glass panels, partitions, furniture, bathroom fixtures, pipes, electric equipment and wires. Steel reinforcement and bricks are retrieved during demolition. The debris is the end-of-the-line product and contains soil, concrete, broken bricks and other mixed materials. In commercial and industrial buildings, additional materials are available for salvaging in the form of heating and cooling equipment, ductwork etc.

Most of the C&D waste already has a market but unfortunately the official system being created under the rule has ignored it and is trying to compete with it unknowingly (see *Box: Informal second life of demolition waste*). Cities would have to invest way less in C&D waste management infrastructure if they leveraged the existing informal infrastructure. In fact this would allow for a better and high-value resource recovery and livelihood generation than envisaged in the Rules.

Informal second life of demolition waste

Recovered building material	Process	End product, economics and recycling hotspots
Steel rebars	Hammering during demolition renders some steel bars deformed and twisted, converting them into scrap	**Used for:** Steel scrap is melted down in foundries (furnaces) and cast into blocks of iron and steel **Where:** Foundries in Ghaziabad and Sikandrabad in UP, and Gobindgarh in Punjab **Rate:** Sold at Rs 22–23 per kg by the contractor
	Steel bars that can be retrieved relatively straight and without deformation are rolled into new shapes	**Used for:** In rolling mills, rebars of adequate length are passed between two rolling cylinders to give them a new shape, e.g. iron railings and steel hinges for doors can be made from rebars **Where:** Rolling mills in Ghaziabad, Muzaffarnagar, Badaun, Bareilly and Bijnor **Rate:** Bars of diameters of 10 mm, 12 mm, 16 mm, 20 mm, 25 mm and 32 mm, and lengths greater than 1.2 m or 1.5 m are sold at Rs 25–26 per kg
	Steel bars that can be retrieved relatively straight and without deformation are also utilized in construction	**Used for:** Steel bars with diameters of 8 mm, 10 mm and 12 mm, and lengths of about 1.2 m or 3 m are used in construction by lower-income groups **Where:** In Ghaziabad, the market is in Jassipura. In Delhi, the markets are in Ghazipur and Sonia Vihar **Rate:** Sold at Rs 30 per kg
Doors and windows	Door, windows and frames are taken out before the actual demolition takes place	**Used for:** Doors, windows and frames are bought by merchants, refurbished and sold **Where:** The markets are in Kalindi Kunj (Delhi), Khoda colony (Noida), Shahberi (Ghaziabad), Muradnagar (Ghaziabad) and Hapur **Rate:** Based on the type of wood (or steel), size and quality, doors are sold for Rs 2,000–3,500 per unit. Windows prices are Rs 1,000-2,000 per unit
Red bricks	Approximately 50 per cent of the bricks can be salvaged and reused	**Used for:** Salvaged bricks are utilized in construction by lower-income groups **Where:** These bricks are usually transported directly from a demolition site to a construction site **Rate:** Demolition contractors sell them at Rs 2–2.50 per unit
Bathroom fittings	Bathroom fitting are dismantled before the demolition begins	**Used for:** Bathroom fittings are usually made up of brass (> 70 per cent), an alloy of copper and zinc, and various other metals and alloys. They are melted down in foundries and cast into brass or copper blocks **Where:** Mandoli in Delhi has foundries that melt copper **Rate:** Bulk rate of Rs 200 per kg, copper sells at Rs 300–350 per kg and brass at Rs 380 per kg
Electric fixtures and wirings	Electric fixtures and wirings are dismantled before the demolition begins	**Used for:** Electric fixtures usually contain copper, brass, aluminium and some other metals. Wires are recycled for copper and plastic. Metals are salvaged and sent to foundries **Where:** Merchants dealing with electric fixtures and wires set shop in Chawri Bazar and Jama Masjid areas. Wires are recycled in Yamuna Pushta in Delhi **Rate:** Copper: Rs 300–350 and PVC: Rs 10–15 per kg
Glass	Glass from buildings is salvaged and sold in the second-hand market	**Used for:** Most common types of glass are clear glass and toughened glass. Clear glass can be reshaped and fetches more money. Toughened glass, on the other hand, cannot be resized easily and sells at lower rates **Where:** Merchants in Paharganj, Delhi **Rate:** Clear glass: Rs 12–16 per kg and toughened glass at Rs 4–5 per kg
Debris	Demolition of a building generates a lot of debris, composed of roller-compacted concrete (RCC), bricks, plaster, tiles, glass, etc.	**Used for:** Debris management is generally assigned by demolishers to transporters. There is a lot of demand for debris in backfilling, elevation improvement and road construction. Debris is also dumped illegally on roadsides, and in drains, waterbodies, municipal solid waste dhalaos, etc. **Where:** Across the city as per the demand **Rates:** Transporters charge Rs 600–700 per pickup by a trolley of 2–3 cu. m capacity and Rs 3,500 per pickup by a dumper of 19–20 cu. m. Dumping charges are Rs 500–1,000 per turn
	Pure RCC from demolition is diverted to crushing	**Used for:** Pure RCC waste is obtained free of charge by merchants, crushed and mixed with sand **Where:** Crushers are located in Noida and Gurugram **Rates:** Pickup is free of cost. Some demolition contractors prefer this type of waste as they do not have to spend anything on transportation

Inadequacy in building design and construction management

According to estimates, 33 per cent of wasted materials in any construction project is due to architects' failing to design out waste during the preconstruction stage.[93] However, construction waste minimization through design is complex because buildings embody a large number of materials and processes that are known but not planned for in detail (see *Table 11: Construction waste generated throughout the project*). Review of multiple studies globally shows that architects are hardly taught as part of their education and training to account for waste that would be generated by their building design. C&D waste is accepted as inevitable and poorly defined responsibilities within the profession makes it challenging for architects to design waste reduction measures in integral part of their projects. This is made more complex when further waste is created directly or indirectly by other project stakeholders, namely clients, contractors, subcontractors and suppliers.

Nonetheless, there is a general consensus that design changes during operation activities are one of the key origins of construction waste. The main drivers for design variations during construction are last-minute client requirements (resulting in reworking); inadequate experience of designers in evaluating construction methods and sequence of construction operation (leading to detailing errors that require alteration or demolition of completed works); increasing design complexity (producing off-cuts); lack of design information (leading to assumption offers by contractors and subcontractors, which result in over-ordering of materials); unforeseen ground conditions (uncertain nature of ground conditions is often accepted as a risk that entails waste on modifying the design as required rather than undertaking expensive preliminary investigations to confirm the conditions resulting in soil waste); and long project durations (allowing the design to be modified to suit changes in the market, research or legislation).

Construction procurement systems-related waste sources fall under four main themes: uncoordinated early involvement of project stakeholders, ineffective project communication and coordination, unclear allocation of responsibilities and inconsistent procurement documentation.

Demolition management neglected

Role of demolition management

The Rules classify all building materials, debris and rubble resulting from construction, remodelling, demolition and reparation work as C&D waste. But if one were to factor in resource recovery, not everything needs to go to crushing units for recycling as stipulated in the Rules. In its 2001 assessment of C&D waste, the Technology Information, Forecasting and Assesment Council (TIFAC) noted that of all the materials produced in demolition about 25 per cent from old buildings and 75 per cent from new buildings can be recovered for reuse. Given that demolition is the most prominent waste-generating activity, it is worth accessing it to gauge how can the quantum of C&D waste generated that requires additional processing can be reduced while unavoidable waste is brought back into the economy.

Table 11: Construction waste generated throughout a project

Origin of waste	Cause of waste
Contractual	Waste client-driven/enforced
	Errors in contract documents
	Contract documents incomplete at commencement of construction
Procurement	Lack of early stakeholders' involvement
	Poor communication and coordination among parties and trades
	Lack of allocated responsibility for decision making
	Incomplete or insufficient procurement documentation
Design	Design changes
	Design and detailing complexity
	Design and construction detail errors
	Inadequate/incoherent/incorrect specification
	Poor coordination and communication (late information, last minute client requirements, slow drawing revision and distribution)
On-site management and planning	Lack of on-site waste management plans
	Improper planning for required quantities
	Delays in passing information on types and sizes of materials and components to be used
	Lack of on-site material control
	Lack of supervision
Site operation	Accidents due to negligence
	Unused materials and products
	Equipment malfunction
	Poor craftsmanship
	Use of wrong materials resulting in their disposal
	Time pressure
	Poor work ethics
Transportation	Damage during transportation
	Difficulties for delivery vehicles accessing construction sites
	Insufficient protection during unloading
	Methods of unloading
Material ordering	Ordering errors (i.e. ordering items not in compliance with specifications)
	Over allowances (i.e. because of difficulties in ordering small quantities)
	Shipping and suppliers' errors
Material storage	Inappropriate site storage space leading to damage or deterioration
	Improper storing methods
	Materials stored far away from point of application

Origin of waste	Cause of waste
Material handling	Materials supplied in loose form
	On-site transportation methods from storage to the point of application
	Inadequate material handling
Residual	Waste from application processes (i.e. over-preparation of mortar)
	Off-cuts from cutting materials to length
	Waste from cutting uneconomical shapes
	Packaging
Other	Weather
	Vandalism
	Theft

Source: Adapted from Mohamed Osmani and Paola Villoria-Sa´ez 2019. Chapter 19, 'Current and emerging construction waste management status, trends and approaches', *Waste,* Elsevier Inc., UK.

Demolition services

Demolition is assumed to be part of any brown-field construction project but there is not much recognize of the fact that it is a specialized activity that most architects and builders have very limited understanding. In India, demolition service is overwhelmingly dominated by the unorganized sector with small players that generally don't have professional expertise nor are registered with ULB or other professional body.

There are a handful of specialized companies whose niche is high-tech demolition related to large infrastructure projects but they don't even account for a fraction of demolitions undertaken in the cities. ULBs have neither developed a system to monitor and regulate small demolition contractors nor do the Rules require them to do so.

Legal requirements for demolition

Building construction and demolition activities come under the purview of ULBs. Some kind of official permit or NOC (no objection certificate) is needed for all building demolition but these can vary with each city. For instance, the Chennai Municipal Corporation issues independent demolition permits to construction/demolition contractors. But it is only one of a very few ULBs in the country to do so.

In most ULBs, builders and developers are required to apply for sanction by submitting altered building plans to undertake reconstruction or alterations. ULBs in return issue reconstruction approvals that also account for demolition. For example, in Kolkata, every person who intends to erect a new building on any site, whether previously built upon or not, or re-erect or make addition to or alteration of any building, has to apply for sanction by giving notice in writing to the Municipal Commissioner. In the case of mandatory standalone demolitions, the ULBs issue notices to building owners before demolition.

Due to this clubbing of permits, data on demolition is difficult to segregate and therefore is of very poor quality in cities.

After the notification of the Rules in 2016, multiple ULBs across India made it

Types of demolition methods

The method and sequence of demolition depends on location, availability of time, type of construction and purpose of demolition for a particular project. Time-saving methods are usually expensive and result in generation of higher volume of unrecyclable waste than the slower ones. As a rule, buildings and structures should generally be demolished in reverse order of their construction (top-down) and sequentially.

In general, the following sequence of demolition activities are followed for safe demolitions:

1. Prior to demolition of the main building, all cantilevered structures, canopies, verandahs and features attached to the external wall are demolished.
2. Demolition of the floor slabs shall begin at mid span and work towards the supporting beams.
3. Floor beams shall be demolished in the order as follows:
   a. Cantilever beams
   b. Secondary beams
   c. Main beams
   In cases when structural stability of beams are affected, e.g. due to loss of restraints, the affected beams shall be propped prior to loss of support or restraint.
4. Non-load-bearing walls shall be removed prior to demolition of load-bearing walls.
5. Columns and load-bearing walls shall be demolished after removal of beams on top; and
6. If site conditions permit, the first-floor slab directly above the ground floor may be demolished by a machine sitting on ground level and mounted with demolition accessories.

Deconstruction: This method involves careful dismantlement or deconstruction of a structure to preserve components for reuse, recycling or refurbishment. Dismantling is generally more labour-intensive than demolition. Components that are usually recovered include doors, windows, partitions, glass, plumbing fixtures, electrical equipment, pipes and ducts. In India, demolition is preceded by deconstruction.

Manual demolition: This is a labour-intensive process in which the building structure is hammered manually either with a Jack hammer or a manual hammer. The process is time-intensive as only small portions of buildings can be targeted at a time. This type of demolition is used in both large-scale and small-scale projects and in areas where mechanical equipment cannot reach. In the case of interior demolition, where interior portions are to be taken out while preserving the exterior, manual demolition is preferred.

Demolition of cantilevered structures and balconies: Cantilevered structures that project out of a building, such as a balcony or a canopy, follow a particular sequence of demolition. The exterior walls are demolished first, followed by any structure or dead load that is supported by the cantilever slabs and beams. After that the concrete is broken down, starting from the exteriors edge of the cantilevered floor and working inwards towards the supporting beam.

Demolition of walls, slabs, columns and beams: A bottom-top-bottom sequence of demolition is followed in a frame structure comprising beams, columns and slabs. Slabs and walls on the lowermost floors are broken down through hammering and this process is repeated till the topmost floor. This allows for the debris to fall through the slabs and be removed regularly. Next, the beams are broken down on the topmost floor, followed next by columns and the whole process moves down up till the lowermost floor. RCC slabs, beams and columns are demolished by gradually breaking away the concrete. The rebars (steel reinforcement) that are visible after breaking away the concrete are cut manuallyusing gas cutters manually and separated out.

In a load-bearing structure, the process remains the same, but the walls are not taken down when moving up. The walls are taken down when moving from top to bottom. The building is hammered down to remove the concrete until the rebars are visible. These rebars are cut using a gas cutter and separated out.

Mechanical demolition: This method of demolition uses specialized mechanical equipment and tools, including hydraulic excavators equipped with specialized attachments

Figure 2: Demolition of slabs and beams

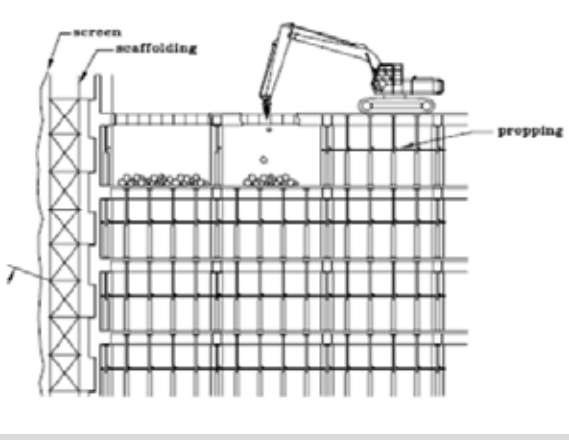
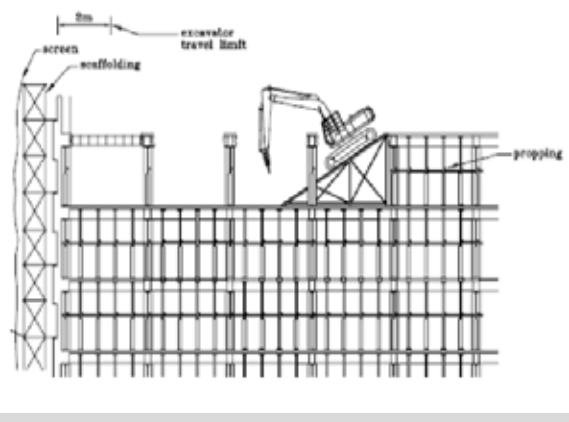
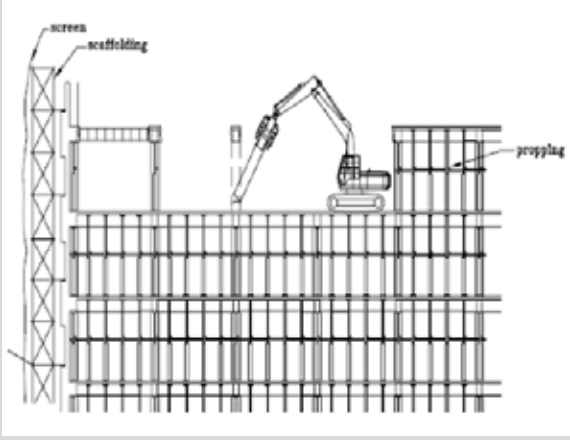


Figure 3: An access ramp to allow machinery to come down to the floor below



that can break concrete and steel, effectively 'chewing' the structure apart. Smaller equipment like skid steers loaders and demolition robots can be used for smaller tasks in the interior and for selective demolition but they still are not generally used in India. Mechanical demolition is preferred when time is a constraint or labour is expensive. Many projects utilize a combination of manual and mechanical demolition as mechanical demolition speeds up the process.

Figure 4: Demolition of interior column



In certain projects, usually high-rises, the demolition begins with the lifting of the mechanical plant on to the building top floor. When a rope or tie wire is used for pulling, workers shall be protected or stay away from the area within reach of the rope or tie wire. The concrete shall be broken away first before the cutting of reinforcement. Alternatively the reinforced concrete slab may be cut by saw cutting (for demolition sequence see *Figure 2: Demolition of slabs and beams*, *Figure 3: An access ramp to allow machinery to come down to the floor below* and *Figure 4: Demolition of interior column*).

Implosion: Implosion is a highly specialized type of demolition that employs the use of explosives to bring down high structures by undermining structural supports so that it collapses within its own footprint or along a predetermined path. The technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight.

A good design will cause the structure to fall towards the centre of the building and/or within the protected area. To minimize dispersion of building debris into adjoining land after implosion, a trench or bund wall shall be installed outside the building to contain the debris unless a basement exists. Implosion is used in very specific projects such as high-rise buildings and industrial buildings and requires high levels of expertise.

a requirement for owners and developers to manage their C&D waste responsibly. Generators are expected to submit a waste management plan to ULBs for approval and can be fined for not adhering to it. For example, East Delhi Municipal Corporation (EDMC) imposes a C&D waste fees per square metre of proposed covered area at the time of sanction of building plans and requires waste generators to deposit their C&D waste at the collection points notified by the municipality. It has made provision for charging a higher C&D waste fee if construction is unauthorized.

In Greater Mumbai, developers/owners are required to submit a waste management plan that will include the amount of C&D waste to be generated and the location and permission to deposit the waste at designated sites. The city has permitted private sites to function as C&D waste storage subject to prior approval.

After obtaining due approvals from the ULB, waste generators prepare tenders for demolition of buildings. Government departments such as the Public Works Department (PWD) prepare tenders and invite bids for demolition. The bids are calculated on the basis of cost of recyclable materials like steel, door and window frames, RCC work, and brickwork in a building. The assignment of demolition is awarded to the highest bidder. In most cases, contractors pay the departments for demolition and removal of waste from the site. Private developers contact

The business of demolition

Demolition is not a formally organized profession in India. An army of demolition contractors work tirelessly in removing the debris of old buildings and clearing the area once the structure is brought down. Demolition contractors assess the scope of work by considering several factors, including age and structural technology used in the building, timespan in which the work needs to be completed and the quantum of recoverables from the demolition work.

'We involve both manual labour as well as machines with breaking and crushing capabilities,' Qasim Ali, a Ghaziabad-based demolition contractor, said. The market value of the recoverables is assessed, which helps to determine whether the contractor is to be paid anything over and above the materials recovered. 'To stay competitive, we keep the profit margins down only to around 8–10 per cent,' Qasim Ali added. In some cases, the owners or developers keep the recoverable, and demolition contractors are only paid a fee.

Bringing the house down: Many methods, depending on the nature and scale of a project, are used in demolition. A frame structure consisting of beams and columns follows a bottom–top–bottom approach. Slabs and walls on the lowermost floor are broken down through hammering first and this process is repeated upwards to the top-most floor. This allows the debris to fall through the slabs to be removed regularly. Once all the walls and slabs have been removed, the beams followed by columns are broken down in a top–down manner.

In load-bearing structures, walls are the last to be torn down, with beams and columns. The rest of the process is the same. Slabs in the building are hammered down to remove the concrete until the rebars are visible. Rebars are cut with a gas cutter and separated out.

In some time-constrained projects or in buildings that are difficult or costly to demolish manually, large rock-breakers mounted on JCBs are utilized. Demolition contractors either own these machines or hire them. 'Our fleet of machines is parked in Faridabad, from where we send them wherever they are required,' Qasim Ali said. Renting a JCB costs about Rs 1,000–1,200 per hour. A more powerful machine called JCB Poclain can cost upto Rs 20,000 a day. Manual labour is still required as a JCB can only cover a height of up to 20–25 feet (approximately two-floors). Moreover, demolition machines, dumpers and trolleys are usually not allowed in residential areas and that complicates the process.

Another method is implosion, which involves controlled explosion of supporting structures of a building, whereupon the building collapses on itself. Several companies across India provide this service. 'We mostly use implosion to demolish industrial structures in areas of low urban density. Implosion can also be a viable option for high-rise buildings. Since construction of high-rises is fairly new in

independent contractors for demolition. In these cases, the developers can have similar arrangements as government department or may pay for availing the services of demolition contractors.

Demolition contractors are responsible for disposal of waste generated.

Standards and guidelines for demolition

The National Building Code 2016 covers safety in demolition of buildings under 'Part 7: Construction management, practices and safety' in 'Section 4: Safety in construction'. It provides detailed guidelines on how to ensure safety while demolishing various kinds of civil structures. Several ministries have issued separate guidelines and standards on demolition of buildings and structures relevant to their jurisdiction. For instance, the Ministry of Steel has developed a standard safety code for the iron and steel sector to provide a safe procedure for demolition of building and structures. The standard notes and lays guidelines for collapse of structure, falling material, flying material, impact/hit by material, collapse of equipment/ machinery, noise, entrapment, fall from height, electrocution, fire, explosion etc.

All the guidelines are centred on safety and don't offer any guidance to optimizing resource recovery and waste reduction. Further, there are no binding legal requirements at the city level to control and monitor demolition to ensure

India, we expect implosion-based demolition to grow rapidly,' Srinivasu Yatham, head of business development at Uttam Blastech, a Hyderabad-based company specializing in demolition and implosion, said. Dense urban areas are unsuitable for implosion-based demolition.

Striking gold in rubble: 'We can obtain about 2 kg of steel per square feet of built-up area,' Kapil Kumar Baswal, co-owner of New Delhi-based Bharat Demolition Pvt. Ltd, said. These estimates are based on experience rather than science and may lead to over- or under-estimation and therefore losses for the contractors. But contractors consider this part and parcel of their business line as another project can fetch them more profits, compensating for their losses.

Demolition contractors try to ensure that valuables are stripped off buildings in a systematic manner. Doors and windows along with their frames, furniture, lighting fixtures, electricity wires, bathroom fixtures, water pipes, carpeting and wall paper are taken out in a process that can also be called deconstruction.

Specialized labour might be employed for his process at the behest of merchants buying the recoverables to reduce damage due to handling. This approach is frequently employed for doors and windows, especially if they are valued as antique. Demolition contractors approach these merchants and the price is set based on the material used, intricacy of design and condition of the recoverable. 'If a merchant picks up the material from the site itself, it is better for us,' said Raesuddin, a demolition contractor based in Ghaziabad and was involved in transportation of recovered material prior to moving into the demolition business himself.

Second life of building scrap: In Delhi-NCR, doors and windows can be sold in Kalindi Kunj, Bhopura, Khoda Colony and Shahberi. Moradnagar, Modinagar and Hapur also have such markets.

Steel bars (rebars) used as reinforcement in columns, beams, slabs and other building elements such as staircases and chajjas (architectural sunshades) in buildings are among the most valuable recoverables. 'Sariya (rebars) fetch us around 70 per cent of the total money from the recoverables,' said Qasim Ali. Recovered steel is segregated into categories—twisted and deformed steel bars are sold off as raw material for foundries which melt them into steel and iron ingots.

Another major recoverable is bricks. As per Qasim Ali, 'A 10 x 15 ft, 9-inch-thick wall contains about 1,100 bricks, of which an average of 500 are salvaged, and the rest become debris.' Whole bricks are separated from the debris manually and mortar stuck to them peeled off using specialized tools. These bricks are then sold off to merchants dealing with second-hand bricks. As they come at half the price of new bricks, they are quite popular with lower-income groups' construction requirements. 'Ghaziabad has high demand for second-hand bricks and even bricks from Delhi end up here,' Raesuddin said.

Similar markets exist for electrical fixtures and wiring, bathroom fittings, galvanized iron pipes, etc.

(Adapted from Anurag Verma and Avikal Somvanshi 2020. 'Demolition drive', *State of India's Environment 2020*, *Down to Earth* magazine, New Delhi)

a safe demolition. Demolition contractors are generally required to get consent from neighbouring property owners but there are no legal rules that inform the demolition activity to be carried out without compromising the structural integrity of adjacent structures. Health and life safety of the personnel involved in demolition is not well addressed as part of by-laws.

Actual practice

Private developers, municipalities, public construction companies and property owners frequently utilize the services of demolition contractors. They are usually responsible for demolishing the structures and also manage the C&D waste thus generated. They have a unique business model that is complex and ingenious (see Box: *The business of demolition*).

Demolition contractors are allotted a fixed duration of time to demolish a building and remove waste from a site as per their tender or contract. The contract generally involves the contractor keeping the materials to be recovered, which is sold off in the informal market. The worth of the contract is generally dependent on the quantum and market value of the recoverable, which determines whether the contractee or the demolition contractor gets paid. They assess the scope of the work by considering several factors, including age and structural technology used in the building, timespan in which the work needs to be completed and quantum of recoverable from the demolition work, which includes steel, metal, bricks, windows and doors, furniture and tiles.

Buildings can be demolished either manually or mechanically after doors and window frames are removed. Regional differences in methods of demolition have been observed. Manual demolition with a hammer and pickaxe is the norm in north India. This investment in terms of time and labour is made primarily due to the higher rates of reuse of building materials, especially good-quality whole bricks. The presence of a profitable secondary market for recycled materials and low labour rates encourages contractors to demolish manually.

Unfortunately, quick-fix mechanical demolition practices where whole structures are bulldozed without diligent resource recovery are becoming the order of the day in cities. The C&D Waste Management Rules need to be revisited to recognize and integrate the role of demolition contractors and the informal sector and to ensure maximum resource recovery and recycling.

ANURAG VERMA/CSE

CHAPTER 4

Recommendations and way forward

Issues hindering effective and inclusive C&D waste management that would enable the adoption of a circular economy have remained a challenge. Despite legal and regulatory reforms carried out during the last decade to enable collection and recycling of C&D waste, on-ground implementation has remained a non-starter in most of the country. Only a few metropolitan cities have initiated action. Further, given the limited scientific research and piecemeal pilots in the country, the solutions to India's C&D waste problem need diverse and nimble approaches.

While the environmental and material challenges associated with C&D waste remain even after notification of C&D Waste Management Rules in 2016—and need urgent nationwide attention—two new policy developments over the last couple of years require immediate interventions for scale and speed of transformation. One is the requirement of the National Clean Air Programme (NCAP), which has set the target of 20–30 per cent reduction in particulate pollution in 122 cities that do not meet the National Ambient Air Quality Standards (NAAQS).[94] These plans include action to control pollution from the construction sector, with special focus on C&D waste. Clean air action plans need detailed indicators based on the regulations to quantify C&D waste generation and accordingly plan infrastructure for collection and recycling.

The other imperative comes from the 15th Finance Commission's direct allocation of Rs 4,000 crore to urban local bodies (ULBs) for air-pollution control.[95] In fact, based on this recommendation the Union Budget for 2020–21 has earmarked funds for the ULBs in Class I cities. C&D waste management is the direct responsibility of ULBs and this funding can catalyse significant changes in cities. But it requires detailed indicators for implementation strategies so that all aspects can be adequately planned and tracked for progress and monitoring. This will also further strengthen the interventions under the Swachh Bharat Abhiyan so that the ranking initiative of the city-based programme can incentivize the right interventions for C&D waste management.

The recommendations have been made keeping in view these needs. They have been framed based on the assessment of the sector as well as city-based granular view of the ground reality. They also take into account NITI Aayog's 2019 *Strategy for Promoting Processing of Construction and Demolition Waste and Utilisation of Recycled Products*, which is the current official guidance for the state governments. It has proposed remedies for many governance and awareness issues. But there are gaps as it has not dived deep into the undercurrents that are dragging the implementation of the Rules, which include inadequacy of the Rules themselves.

This report, therefore, has taken the learning from cities implementing the Rules and international best practices and builds further on NITI Aayog's strategy.

Improve the practice and infrastructure

Need robust methodologies for estimation of C&D waste

A comprehensive assessment of total C&D waste generation, utilization and disposal in cities is required. ULBs to some extent have comprehensive documentation of quantum of C&D waste that is hauled to the landfills or dumped in locations under their direct jurisdiction. However, a significant portion of the waste is diverted to the informal market and for illegal filling before construction and/or disposed of in places beyond the municipal jurisdiction.

NITI Aayog has recommended arriving at rough estimates using the Technology Information, Forecasting and Assessment Council (TIFAC) rule of thumb for cities and using it to design C&D waste infrastructure and management centred around setting up a recycling facility. As explained in the last chapter, this is not the best approach. Cities should invest in conducting detailed survey and mapping existing C&D waste generation and flow, and base their C&D waste management plan on that instead of rushing towards setting up a recycling facility. It would be worth investing in this rather than in propping up expensive oversized infrastructure.

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The informal sector has developed sorting and storage facilities for material recovered from building demolitions

Globally, the methods developed to estimate C&D waste generation vary depending on the scope of C&D waste estimation—whether they are regional-level or construction projects. Studies at the regional or city level estimate C&D waste generation within an area by multiplying the construction activity by the rate of waste generation determined at a project level (see *Section 'Forecasting and designing out waste at pre-construction stage' later in this chapter*). Most of these studies have sourced data from government statistics to estimate the construction activity of a region. Therefore data sources play a significant role in these studies as they are directly related with the accuracy of the estimations. Furthermore, case studies are usually adopted to gain knowledge on C&D waste generation and composition. Researchers have used different techniques for data collection such as field observations, sorting and weighing on-site, truckload records and surveys. Several studies analysed C&D waste generation rate according to several factors, including building use, structural typologies, size of dwellings, or a combination of these. Other studies analysed the rate of accumulation of construction waste for the entire duration of the project.

To improve future action, cities must create easily accessible databases of buildings and their physical and legal attributes. Construction and/or demolition permits need to be inventorized with associated waste management plans attached. In addition to inventorization of the amount, characterization of C&D waste is necessary because the composition of C&D waste varies from city to city. It is important to know the composition of C&D waste in a particular city since the composition affects: a) the management plan, including collection, transportation and storage, b) the processing techniques and technologies to be used, and c) the products to be manufactured out of recycled waste.

Lack of precise estimates of the quantum of C&D waste need not hold up plans for setting up a management plan. Proper waste accounting, collection, transportation and storage system can be put in place even in absence of citywide estimates. Large construction projects should be nudged to invest in on-site reuse and recycling, while others can be asked to reduce waste generation. All cities can leverage the existing informal market for C&D waste to further reduce their need for recycling facilities.

For metropolitan cities, where generation of C&D waste can be assumed to be substantial irrespective of quality of C&D waste estimates, planning for recycling facility can be undertaken. But the size of the facilities should be based on C&D waste officially collected in the city, with the option of future expansion. This would ensure that the city has enough waste to keep the operation and maintenance of the facility economically viable.

Land identification for collection and recycling

NITI Aayog's strategy has simply repeated the requirement of the Rules of cities finding land for recycling facilities and collection points without addressing problems faced by the cities. It notes that state governments need to help cities in this but is evasive about how that can be done. Cities would need to find land with or without assistance from state governments but to make this manageable they need to innovate their management strategies to actually reduce the requirement of land.

Cities need to prioritize locating land for intermediate collection points and storage of C&D waste instead of for recycling facilities. It is important that the waste being generated daily is not littered away while city tries to set up recycling facilities.

It has been noted that the travel distance to collection/disposal points is critical for small generators as it has significant costs attached to it. Therefore, to stop littering or illegal dumping, a dense network of C&D waste collection points is needed in cities. Given the paucity of land availability within cities, innovative approaches such as providing waste containers to construction sites as part of the building permit as proposed in Pune can be explored. This would allow for temporary storage of waste being generated, which the city or the generator can periodically haul and transfer to the final disposal site. The city can charge a fee for this as part of building permit itself.

Door-to-door collection can also be adopted to reduce the requirement of land. Kolkata's on-call collection service is also a possible option for cities that can afford it. This system reduces the need for land for collection as the onus of storage is transferred to the generator. But it needs to be efficient and affordable for the public so that they actually use it.

The requirement for land can be further minimized if cities are able to get builders to reuse and recycle on-site and leverage the informal market for salvaged building material.

With regard to land for setting up recycling facilities, effort should be made to identify land within cities to reduce transportation distances. In case there is paucity of large land parcels to set up single large recycling facilities, the option to set up multiple facilities on smaller plots of land should be explored. The recycling technology is flexible and available for diverse scales of capacity (see *Box: C&D waste-processing technology*). Having a decentralized recycling infrastructure is always preferred over a centralized one.

Given the complicated nature of land ownership, the option to allow private land to be used as collection, storage or recycling facilities can be explored. Mumbai

C&D waste-processing technology

Stationary processing unit: An assembly of crushing, sieving and washing machinery interconnected by conveyer belts for material movement. The machinery is housed on steel or concrete platforms on a permanent basis. The crushing units also have dust-control and noise-control systems, magnetic separator devices and additional devices based on requirements. The systems are either semi- or completely automated units. The capacity of stationary processing units can be 100–2,000 TPD or even more.

Mobile crushing units for C&D waste recycling: Currently rare in India but likely to become more common in the future in light of the new Rules. The technology is similar to the stationary processing unit but all the equipment is mounted on top of a customized mobile unit or truck. The concept involves integrating all the equipment on one truck, which has a customized chassis and body compared to conventional trucks. This kind of design provides the flexibility of ensuring that the crushing station can be easily transported to construction or demolition sites. This would enable on-site crushing without transfer of materials from one place to another, saving significant transportation costs if the quantity of waste to be processed is large enough. The feasibility of the technology also depends on the use of finished products, distance to be transported, availability of labour and nature of waste (segregated waste). Mobile crushers come in all sizes and processing capacities starting from bobcat machine-sized crushers, with a processing capacity of around 5 TPH and higher. Since the entire assembly line needs to be mounted on mobile units, the processing capacity of these units will be comparatively limited to around 1,000 TPD.

Mini mobile crusher: A practical solution for ULBs generating less than one or two truckloads of C&D waste per day. Those with processing capacities of around 5 TPD can be maintained by ULBs for processing waste into finer secondary raw material. Alternatively, they can be maintained by designated pre-cast concrete building-material manufacturers, to whom the C&D waste can be delivered as a business model.

AVIKAL SOMVANSHI/CSE

has tried this with reasonable success but strict safeguards needs to be in place to stop illegal diversions.

In instances where the land found suitable for recycling facilities falls outside the jurisdiction of ULBs, the intervention of the state government may be required. This is essential when a cluster of small urban local bodies want to set up a combined recycling facility.

Set up transportation system for collection and transfer of C&D waste

NITI Aayog's strategy focuses on monitoring and tracking the movement of trucks involved in transportation of C&D waste and recommends a gamut of fees and penalties that ULBs can impose on generators to pay for the tipping fee for transportation. Given the experience from the ground, high fees and penalties actually encourage illegal dumping by transporters. To stop illegal dumping, therefore, fiscal measures should complement infrastructure design that would make depositing waste to collection points easier than illegally dumping it.

The most effective way of doing this is to reduce the distances that the waste needs to travel at the expense of the generators. Developing a dense network of collection points would be best way to go about this. Transportation of the waste from these collection points to its final destination can be managed by the city or by a private party at the city's behest. This system is in place in North Delhi Municipal Corporation, where the recycling facility operator is responsible for picking up waste from collection points. The cost of the final transportation is paid from the waste-handling fee charged as part of the building permit. This matter will have to be evaluated separately for cities with land and those who have an acute problem of land availability.

It must be noted, however, that there aren't many C&D waste management firms in India that can afford to undertake the consolidated operation of collection, transportation and recycling in a city. Repeated failure of tenders seeking such an arrangement in cities such as Bengaluru and Mumbai has highlighted the need for cities to have a different approach. Based on the experience in Bengaluru, breaking up the operation of collection, transportation and recycling would be more lucrative. It would attract start-ups and new entrepreneurs into the business of waste and develop healthy competition that might bring down costs for the city.

A network of informal transporters exists in every city for transportation of C&D waste. Cities need to figure out a way to leverage it to cut their cost and new infrastructure creation.

Segregation and storage of C&D waste

The best place to segregate waste is at the source—as with municipal solid waste. Likewise, storage of segregated waste is plagued by non-availability of space. Cities need to mandate earmarking of a certain percentage of project sites for C&D waste storage as part of building design approval requirements.

Construction site level: Compared to MSW, C&D waste has an inherent advantage in storage requirements. Given the nature of construction activity, each of the C&D waste streams is naturally segregated by its time of generation across the span of construction. Waste generation during demolition is also segregated, as there is a well-defined sequence for demolition of any structure. But due to relatively short time-gaps between each stage of demolition, the generated waste tends to get

mixed up. Therefore, the requirement of space for storage of waste at generator premises can be drastically curtailed if the temporal segregation in their generation is capitalized on. This would require diligence from the generator and ability of the city to collect and/or receive the segregated waste with swiftness so that the limited storage capacity on sites can be freed up for next stream of waste.

Informal demolition contractors have perfected the art of tapping into temporally segregated waste to collect, transport and sell off each waste stream—something that both the construction industry and ULBs need to learn and utilize.

City level: The ability of ULBs to receive segregated waste is a bigger challenge. The Rules are not explicit about segregation at collection and storage points, but Swachh Survekshan 2021 has sought segregation in five categories—concrete, soil, steel, wood and plastics, and bricks and mortar. Given the paucity of land within cities, finding land parcels large enough to allow for segregated collection into five categories is bound to be a damper in the whole process. Further, segregation categories need to be standardized and a uniform minimum should be mandated across cities.

No city so far has invested or even proposed to develop facility to recycle steel, wood, and plastics that it is to be collected. Only immediately feasible way to handle this would be to rope in the informal sector and build-up their infrastructure for recycling and storage of these wastes. This infrastructure planning is critical and need to be developed incrementally.

Strengthen governance framework

NITI Aayog's strategy seeks handholding assistance to cities and increased involvement of state government and agencies (see *Box: NITI Aayog's mapping of state-level facilitation*). It also acknowledges existence of fraudulent consultants that have duped many cities with 'guidance' that was not appropriate to their circumstances, resulting in stalled progress and dwindled enthusiasm. It has thus

NITI Aayog's mapping of areas for handholding of cities

a) Geographic mapping of waste generation hotspots, possible locations for intermediate collections and final processing facilities, transportation distances, etc.;
b) Framing of by-laws on C&D waste management incorporating appropriate levels of fees and penalties for generators;
c) Development/augmentation of construction/demolition permits consolidated into an easily accessible inventory and linking them with project approvals;
d) Development of a financial model for cities with little or no net cost for C&D waste management, where the revenues generated from upfront fees collected from generators are used to pay tipping fees to the contracted party for collection and processing;
e) Development of tendering documents;
f) Development of reporting and monitoring framework and procedures;
g) Development of public procurement policy for recycled products; and
h) Identification of financial assistance from central/state bodies/schemes for planning and implementing C&D waste management.

NITI Aayog's mapping of state-level facilitation

a) State agencies, particularly Urban Development Departments (UDD), may be able to provide funds for initial planning to cities;
b) State agencies including UDDs and Pollution Control Boards (PCB) may be able to provide technical expertise to cities who need them, especially smaller towns;
c) Sometimes suitable land for a processing facility may only be available outside the jurisdiction of a municipal body, so coordination with state level agencies is essential;
d) State agencies such as PWD, Housing Boards, etc. are significant generators of C&D waste and need to adopt policies for C&D waste management in coordination with municipal bodies. These agencies are also ideal entities to adopt Public Procurement Policies for recycled products since they are significant bulk consumers.
e) A sustained 'push' by state-level agencies, accompanied by facilitation, can convey a sense of urgency to municipal bodies who may otherwise accord lower priority to C&D waste management. Sustained state-level engagement is imperative for adoption of C&D waste management throughout the state in a time-bound manner; otherwise progress may be restricted to one or two 'resourceful' cities only.

suggested that MoHUA may empanel suitable expert agencies/consultants who can provide handholding assistance to cities. It says experts/consultants would be needed to engage with the city over an extended period of time, providing guidance on issues ranging from waste mapping, by-law drafting, and public procurement policy for recycled products to identifying financial assistance (see *Box: NITI Aayog's mapping of areas for cities' handholding*).

NITI Aayog's recommendations are comprehensive for developing the governance system as envisaged in the Rules. Especially recommendation to link C&D waste management facilitation to fiscal support to states is in line with the NDA government's approach of using Central funding to get states to improve urban infrastructure. But most of the emphasis has been on developing hard infrastructure and very little on soft infrastructure needed to help cities sustain the hard infrastructure.

For instance, creation of a massive pool of credible experts/consultants in the country to handhold cities is needed but no strategy has been formulated to that end. Given C&D waste management draws a complete vacuum in the current education system and professional skill-pool, this ought to be a herculean task.

The reality of R&D in C&D waste management is that no comprehensive scientific study has come out since TIFAC's 2001 paper. German development agency GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) has supported a few assessments of pilots in Delhi and Ahmedabad that have been undertaken by civil society organizations. These have put forth some standardized solutions but these are grossly inadequate given the diversity among Indian cities. Guidelines and toolkits produced by various government agencies over the last few years are mere repacking of the Rules and GIZ's standardized solutions. There is a need to invest in developing knowledge, templates, guides, manuals and standards for a range of waste applicable to the Indian context (see Section '*Inform design and construction management*' later in the chapter). These would need further incorporating in the education system.

Further, most efforts are centred on propping up a system that will be greatly dependent on the ability of governments and cities to pay for it. It is fairly linear in its money flow. There are some legitimate concerns that this may get reduced to a vehicle to mint money for a small but specialized group of consultants and service providers feeding on ever-increasing waste estimation and associated infrastructure creation. The goal needs to be focused on minimization of waste and not monetization of it. Fixing this may require revisiting the Rules themselves.

Mobilize the construction industry

NITI Aayog's strategy is the weakest when it comes to engaging the construction industry. It has invested all its brainpower in tried and proven ineffective models of organizing awareness seminars and workshops for professional and industry associations such as CII, FICCI, Builders Association of India (BAI), Indian Institute of Architects (IIA), CREDAI, etc. It is also pushing for private green building ratings to incorporate waste management as an incentive for the construction industry. The efficacy of this approach can be gauged by the scale of adoption of Energy Conservation Building Code (ECBC) by the industry. In fact it has been noted globally that the construction industry has been slow to reform its practices despite evidence to support the economic and business benefits of waste reduction and management.

There are a variety of constraining factors that impede the construction industry from adopting the waste minimization and recycling approach. These are largely due to the conservative aspect of the industry. It is widely agreed that the major constraints to adoption of sustainable construction waste management are related to perceptions and attitudes toward waste management.

The main challenges to adopting effective waste reduction and recycling strategies that face stakeholders in their projects are:

- Lack of managerial commitment;
- Lack of industry construction waste minimization norms;
- Difficulties in changing existing practices;
- Lack of operatives experience in waste management;
- Perception that waste management systems are not cost effective;
- Waste accepted as inevitable by-product of construction;
- Unwillingness to reuse or recycle materials with little economic value;
- Extra costs to implement C&D waste-related strategies and initiatives;
- Any savings made are unequally distributed, therefore giving little incentive for workers to participate in waste management;
- Poorly defined individual responsibilities for waste management;
- Limited waste minimization guidance;
- Time devoted to sorting out and handling on-site waste, thus extending the work plan schedule; and
- An increase of red tape due to extra paperwork for filling control forms, inspection reports, and so on.

Provide a financial pull for the construction industry

Push and pull is needed to get the construction industry to improve its waste management. The Rules have created a push by creating a legal requirement for waste management but the much needed financial drivers at the project level that

can pull the industry are missing. Waste management financial benefits are related to the direct costs of both waste disposal and raw material purchase.

In some European countries, high waste tax has achieved significant levels of reduction in C&D waste. High levels of landfill taxes in Denmark and the Netherlands have demonstrated a low dependency on landfill and a high level of waste recovery.[96] The EU has also supported waste minimization with on-site recovery and reuse by developing extensive waste management tools and guides (see *Section 'Inform design and construction practices*' later in the chapter). This also has been made possible by extremely strict enforcement in these countries.

There is a danger, however, in overtly relying on fiscal penalties as a pull mechanism. Similar to EUs, high waste-taxation policy in Hong Kong has given mixed results. Hong Kong has one of the most aggressive C&D waste fee regimes in the world, adopted as means to reduce waste generation in the city. The Construction Waste Disposal Charging Scheme (CWDCS) was implemented in 2006, and regulated that all construction waste must be disposed of at government waste facilities if not otherwise properly reused or recycled. While the CWDCS has significantly improved construction waste management in Hong Kong, it has also triggered massive illegal dumping problems for the city.[97] Multiple studies have explored the influence of CWDCS on the reduction of construction waste in Hong Kong and a significant reduction of construction waste was achieved in the first three years (2006–08) of CWDCS implementation. The reduction, however, could be sustained. Implementation of the CWDCS has not motivated sub-contractors to change their methods of construction.[98]

To avoid a spurt in illegal dumping as means to escape high disposal fee, fiscal incentives would be required. Pune had proposed a waste fee refund scheme as an incentive for reducing waste generation. The scheme had proposed to charge a hefty C&D waste fee as part of the building permit fee. The fee had two components—estimated quantity of waste generation based on volume of construction and travel distance between construction site and proposed waste disposal site (to be provide by the city). To incentivize waste reduction, the city had proposed to refund part of the fee if the final waste generated by the project was deemed to be substantially lower than the estimate at the building permit stage. But to get the refund, the generator had to produce proof of on-site waste reduction, reuse and recycling. This is a good system on paper that other cities can explore to pull the industry to adopt better waste management. But for it to work, cities would also require extensive monitoring and tracking. Fortunately, cities are already expected to develop and employ these systems under various official urban development programmes.

The current system, including the recommendation of NITI Aayog, is geared to pass on the whole financial burden of creating and operating C&D waste management infrastructure on to the construction industry. It provides no incentive to them to managing it on their own via waste reduction and on-site reuse and recycling. In fact, it can be argued that if the industry starts managing its own waste the envisaged C&D waste management model would go bankrupt. Therefore, ULBs need to develop a banquet of non-penalties and fee-based incentives and revenue model to ensure long term sustainability of the system.

Build confidence in recycled products for quicker uptake

There are practically no legal hurdles in using recycled C&D waste products now. All major standards have been amended and premium buildings (such as the Supreme Court Extension) have been constructed using it. NITI Aayog does a commendable

job of documenting all these development. But in its strategy, the recommendation is fixated on getting green labelling for recycled C&D waste products, which may be a noble cause but it is not the reason why uptake of recycled products is low.

Field surveys have highlighted the major reason for low uptake is the higher cost of the recycled product owning to high GST rate (18 per cent) imposed on it and poor quality of the products manufactured at existing recycling facilities. Further, there is an issue with recycling facility operators who are also manufacturers and salesperson for these products refusing to sell them to small-scale buyers who are more likely to experiment with their building material options.

To improve uptake of recycled products, the GST on them need to be made at par with conventional building products.

Recycling facility operators are currently asked to manufacture value added products such as concrete blocks and pavers, which are an additional responsibility for them, and they may not have the required expertise to manufacture these and/or market them to the public. This is one of the reasons they have been lobbying for governments to buy back their recycled products. Getting construction agencies of the government to mandatorily procure these products is a good strategy to support the product in the initial stages but over-reliance on this impedes innovation and development of the product itself.

This approach needs to change to ensure that there is an actual economically sustainable circular economy of this waste. Recycling plants should be encouraged and allowed to sell the recycled aggregate to professional building product manufacturers that have technical ability to design better products and market it as well.

Integrate informal sector in C&D waste management and disposal

The Rules and NITI Aayog's strategy have completely ignored the informal sector, which is a very important stakeholder in the whole system. There exists a robust market for salvaged building materials with highly developed expertise and a network of traders to manage C&D waste, including its collection, segregation, transportation, storage and reselling.

Many cities like Gurugram are insisting that generators deposit all waste generated at the city's disposal points as per the waste estimation (using the TIFAC rule of thumb) reported in the building permit. This basically removes access of the informal sector to the C&D waste, which would otherwise be partly (if not completely) salvaged by it. There are already reports from Ahmedabad of waste disappearing en route to the recycling facility from the intermediate collection points. There is a need to acknowledge that livelihoods are attached with this waste and that it has potential to complement the system of C&D waste management of the city. While informal C&D waste management is currently plagued by many undesirable practices, involving these informal players would actually help to better curtail them.

With Swachh Survekshan 2021's recognition of lower layers of road pavements, inner colony roads, filling of plinth and basement etc. as legitimate non-structural applications of C&D waste, some of the policy roadblocks to involving the informal sector into formal management of C&D waste have been partly lifted.[99] It is up to cities now to engage with the informal community and figure out how a symbiotic relation can be fostered. This has potential not only to substantially improve

city's waste management and reduce financial burden but also generate jobs and livelihood.

Just as MSW Rules have incorporated informal waste pickers and recyclers to improve the efficiency and cost of the MSW management operation in the city, the same needs to be done for C&D waste management.

Mandatory adoption of demolition management strategies

Most demolitions in cities are carried out by demolition contractors. They are not part of the formal construction industry. They are also the base actors feeding the informal market of salvaged-building material. Their immense street smarts can be leveraged to improve resource recovery from the waste.

The following steps are suggested:

- Provide formal recognition to demolition contractors and develop a register of them;
- Develop a separate and independent demolition permit;
- Encourage deconstruction instead of quick demolition; and
- In order to discourage quick demolitions, cities can impose a minimum wait time between start of demolition and commencement of construction.

Inform design and construction practices

There is no known C&D waste designing document catering to the Indian construction industry. Globally several construction waste management tools, methods and technologies are being used in the construction industry to forecast and design out waste during preconstruction stage, manage on-site waste during

ANURAG VERMA/CSE

Paucity of time is usually the main reason cited by the construction industry for not segregating waste during demolition

British standards on reducing waste during building projects

Reducing and managing waste is high on the UK's Sustainability agenda, particularly from the construction sector, which is the largest contributor of waste. Reduction of construction, demolition and excavation waste is, therefore, a high priority for the industry. One of the ways this is being achieved is through more efficient building design and specifications.

In 2013, UK's standard-making body started developing BS 8895, a suite of codes of practice that address specific and interrelated issues and processes related to material efficiency in building projects. BS 8895 is in line with the Royal Institute of British Architects' (RIBA) Plan of Work.[103] Its designing for material efficiency in building projects will include the following:

- Part 1: Code of practice for strategic definition and preparation and brief
- Part 2: Code of practice for concept and developed design
- Part 3: Code of practice for technical design
- Part 4: Code of practice for operation, refurbishment and end of life

BS 8895 Part 1 was published in 2013 and covered 'Stage 0 Strategic Definition' and 'Stage 1 Preparation and Brief'. Part 2 was published in 2015—it sets out the process for the integration of designing for material efficiency and how it fits into the 'Stage 2 Concept Design' and 'Stage 3 Developed Design'. Part 3 was published in 2019 and provides technical design information for material efficiency. Part 4 is still to be published.

These documents give recommendations for designing for material efficiency that are accepted as good practice by industry leaders and practitioners, and bring together the results of practical experience and acquired knowledge for ease of access and use of the information. It is intended for use by the design team when preparing concept and developed designs to include proposals for material efficiency. These then inform the final project brief and other strategies such as the sustainability strategy and project execution plan.

construction stage, and recycle and recover end-of-life materials and products during demolition stage.

Forecasting and designing out waste at pre-construction stage

ULBs are asking for a C&D waste management plan now as part of the building permit but these are merely a listing of the estimated quantum of waste that may be generated by a project and how it would be disposed of. Architects and builders are falling back on the TIFAC rule of thumb to provide this. There is no asking for an actual waste management plan that would ensure reduction in waste generation.

The reality is that even at the global level, there are currently insufficient design decisions supporting tools to integrate designing-out-waste strategies in construction projects. The last few years have, however, witnessed an increasing in design waste-related research. Increased awareness of C&D waste and ever-increasing waste legislation and availability of fiscal resources have led to the development of an increasing number of templates, guides, manuals and standards to support designers to embed waste minimization in their projects (see *Box: British standard on reducing waste during building projects*).

Guides and templates: The EU's Waste Management Plan templates provide automated templates to facilitate the development of waste management plans and thus calculate variables of interest such as waste output and costs. Furthermore,

VIKAS CHOUDHARY/CSE

Construction dust is a major source of air pollution

the UK-based Waste and Resources Action Programme (WRAP) introduced in 2010 a guide containing broad guidance for architects to adopt a fivefold waste minimization strategy in their projects. The guide comprises the following five principles: design for reuse and recovery, design for off-site construction, design for material optimization, design for waste-efficient procurement, and design for deconstruction and flexibility.[100] Although the content of WRAP designing-out-waste guide has been seen as a step forward to engage architects in designing-out-waste, it has been criticized for not associating the proposed principles with all parameters of the design process environment, including stakeholders' coordination, communication and roles. More importantly, the guide failed to conduct a waste diagnosis across all design stages to map out the direct and indirect origins of design waste, and causes and sources that are critical in informing and implementing designing out waste principles and strategies. Nevertheless, these can be leveraged to develop guides and templates for the Indian construction industry.

Prediction tools: In Europe and USA waste prediction tools are popular for estimating potential C&D waste generation in building projects. In general, these tools are based on aggregating waste indices or ratios, which are obtained by dividing the amount of C&D waste generated (in volume or weight) by either the amount of materials purchased or per the gross floor area of the project (in square metres). For this, reliable ratios for C&D waste estimation are essential in order to plan an efficient waste management system for a construction site or a region. For example, performance indicators for individual C&D waste products have been produced from completed projects on the EU's SMART-Waste Plan. These performance indicators have been applied to construction output to provide an estimate of waste arising from new build construction and refurbishment and determine on-site waste management methods and actions for each waste type.[101] Similarly, WRAP developed Net Waste Tool to help generate waste forecasts during

site operations and prioritize waste reduction and recovery actions to input into a Site Waste Management Plan.[102]

A number of recent studies, however, used a multiple linear regression analysis and proposed a statistical model to determine the amount of waste generated by assessing the influence of design process and production system. These culminated in the generation to a set of design variables related to compactness of the building, the practice of waste recycling in construction sites, floor plan area and adopted construction system. That said, the latter was restricted to a limited number of broad design variables that are specific to high-rise buildings. As such, it did not offer a comprehensive model to assess the impact of all design processes on on-site waste production for any type of building projects.

In the last few years, development in Building Information Modelling (BIM) has shown the potential to drive out construction waste in building. It has been argued that BIM techniques can be used by architects as a platform to minimize design waste in their projects; structural engineers to reduce construction generation for structural reinforcement and demolition contractors to optimize reuse, recycling, and recovery during demolition and renovation activities.

However, methods and tools that integrate informed designing-out-waste strategies across all project stages are absent in the literature but in India even these disintegrated products have not been developed nor appropriated. There is a need to invest in these construction and regional level studies to flesh out required indices to improve C&D waste designing.

Mandate on-site construction waste management during construction phase

Real estate developers and large-scale builders are considerate of C&D waste disposal requirements of any large construction project due to EIA requirement. C&D waste management requirement come bundled with the environmental clearance, not being limited to the current legislation, for the project. Increasingly, construction companies under influence of green building rating have adopted better C&D waste management. For instance, globally many mega construction firms have introduced several C&D waste management practices, including development of an on-site waste management plan for each project, on-site waste management training packages for their workers and subcontractors, and innovative processes aimed at minimizing waste and selecting recycled and recyclable materials. But these are except to the prevalent practice. The vast majority of big developers and almost all small and medium enterprises in the construction industry engage significantly less in the process waste management and their approach is predominantly reactive to legislative requirements.

Globally, several construction waste management tools, such as site waste management plans, toolbox talks and material bar-code systems are being used during the construction stage. On-site waste management tools have been developed to handle and better manage on-site construction waste segregation; quantify waste generation; estimate waste generation rates; waste data analysis; audit construction waste; reuse on-site waste and collate and analyse on-site waste streams.

In particular, C&D waste estimation and quantification tools are used to calculate the quantity of waste generated from building projects. Data collection and audit tools record the amount, type and sources of waste generated in a building project. For example, CALIBRE and Construct Clear are tools which allow project

management teams to refine on-site processes by recording real-time data on-site to measure on-site efficiency and quantifying C&D waste. Smart Start in the United Kingdom and Waste Spec in the US are tools to facilitate on-site auditing and thus evaluate the waste management performed across all the construction sites of a company.

Furthermore, an increased number of studies were conducted to assess the potential impact of off-site construction techniques on on-site waste reduction. Emerging information technologies, bar coding systems, GPS, GIS and wide area networks (WANs) are being progressively introduced to effectively manage on-site waste.

These tools and practices need to get mainstreamed in Indian construction industry as well.

Ensure implementation of end-of-life waste recovery, recycling and circularity

In the last few years, location-based tools which are usually GIS enabled have been developed to provide the location of C&D waste management services. For example, UK's BREMap developed a searchable map to find the nearest facility for C&D waste recycling facilities.

By and large, technologies used for waste recovery, recycling, and circularity encompasses three interrelated methods: source collection and separation, processing, and recovery and treatment.

The quality of C&D waste is directly influenced by the performance carried out in the construction and/or demolition site. For instance, one of the main difficulties for waste recovery is the collection of mixed waste (instead of on-site sorting) and inefficient mechanical sorting of mixed waste. Training of workers with regard to C&D waste management is, therefore, essential for enhancing C&D waste sorting. More efficient waste sorting technologies are also needed to generate cleaner C&D waste for recovery.

Waste management in infrastructure projects

All the measures documented for construction management for waste reduction and recycling in buildings are applicable for infrastructure projects as well. Nevertheless, infrastructure projects will require special care and handling. Agencies responsible for infrastructure development will have to develop their own recycling facilities instead of relying on and burdening the city's C&D waste management infrastructure. Roadwork requires additional technological development for recycling of bituminous material.

Address dust control in construction projects

This is a critical intervention from the perspective of implementation of clean air action plan in cities. The planning stage of the project requires identification of dust-control impacts; careful programming of works to reduce dust impacts; identification of dust-mitigation measures; training of workers and supervisors on-site; water supply and storage for dust suppression; site planning to reduce dust impacts; construction-dust mitigation techniques such as physical barriers; use of sprinkler system for dust suppression; management of open areas and stock piles; addressing concrete production among others (see *Annexure 1: Dust-control checklist for construction projects* and *Annexure 2: Dust-control checklist for C&D waste collection and transportation*).

AVIKAL SOMVANSHI/CSE

CHAPTER 5

Implementation strategy for C&D waste management at the local level

Implementation of C&D waste management at the ground level requires a detailed template and indicators to define the scope and nature of action. Adoption of appropriate indicators for quantification of waste, on-site management, segregation, collection and transport of segregated waste, planning recycling facilities accordingly, on-site dust control and material handling, managing reuse, changing rules and by-laws for holistic governance, deterrence, among others, is necessary. To this is urgently neede to frame adequate strategies as well as monitor and report progress on each indicator to make a real difference. All clean-air and waste-management plans need to adopt these indicators. Indicators are needed for both buildings and infrastructures.

C&D waste management implementation indicators		
S. no.	**Action points**	**Indicators of the action for implementation and reporting**
Quantification and planning		
1	Document and quantify existing C&D waste handling practice	Collate records of C&D waste collected by ULB; Map designated disposal point in the city; Map illegal dumping hotspots in and around city; Collate building and demolition permits issued in the last one to five years by type and size; Establish number of active building and demolition permits; and Make a directory of demolition contractors in the city; and Map informal market of salvaged C&D waste.
2	Improve waste generation and disposal quantification	Introduce separate permit for demolition and mandate a minimum waiting period between demolition and construction to discourage quick and wasteful demolition practices; Mandate reporting waste-generation estimate, segregated by sub-streams, for all building and demolition permits; Mandate waste management plan for bulk generators; Notify the requirement for a comprehensive waste management plan (WMP) from bulk waste generators; and Notify minimum percentage of C&D waste generated to be utilized on-site.
Governance		
3	C&D waste unit	Set up a separate C&D waste cell or unit with staff from both buildings and solid waste departments of ULB
4	By-laws and rules	Amend city by-laws to include C&D waste management rules; Notify sub-streams of waste that buildings and ULBs would segregate the generated waste in; Notify sub-streams of waste that infrastructure projects would segregate the generated waste in; Notification of charges (including inbuilt charges at the time of permission for construction) for collection, transportation, processing and disposal of C&D waste; Link building occupancy certificate, connection to utility services (electricity, water, gas and sewerage) with evidence of debris on-site recycling and/or disposal at designated sites; Notify fines and penalties for unlawful disposal; and Notify incentives for waste reduction and on-site waste reuse and recycling, link incentives to evidence of debris on-site recycling and/or reduced amount disposed at designated sites.

C&D waste management implementation indicators		
S. no.	**Action points**	**Indicators of the action for implementation and reporting**
On-site waste design and management		
5	Design on-site waste storage	Forecast waste generation segregated by sub-streams; Optimize design and project management to reduce waste generation; Plan for probable on-site reuse and recycling of forecasted waste. All efforts to be made to minimize overall amount of C&D waste to be disposed off-site; and Plan storage on-site for C&D waste pending reuse, recycling or collection for management off-site.
6	Segregation and storage of demolition waste	Deconstruct instead of demolition. Undertake a pre-demolition visual assessment of recyclable content to decide on suitable demolition techniques to recover as much material as reasonably practical; Provision space for segregated storage of demolition waste within construction site work area; Use signs to identify stockpiled material; Stockpiling of contaminated materials on an impermeable surface in a bunded area; Cover/damp down stockpiles in dry weather to prevent fugitive dust; Minimize excessive stockpiling by phasing works and schedule recycling or transfer accordingly; Stockpile height should be less than the height of the site boundary hoarding to reduce exposure to wind; and Locate stockpiles away from watercourses, ditches and drains and on level ground.
7	Segregation and storage of construction waste	Provision of space for the segregated storage of C&D waste within construction site work area. The space required will be determined from the waste forecast taking into account the planned reuse, recycling or disposal; Waste storage containers with appropriate signage used to store waste. Segregated waste containers will be based on sub-streams notified by the city; Bulk generators to monitor the storage area via CCTV; and Minimize build-up of waste by scheduling frequent on-site reuse, recycling or transfer.
8	On-site reuse and recycling	20 per cent (or as notified by city) by value of construction materials from a reused or recycled demolition waste source incorporated in the works; 25 per cent (or as notified by city) by weight of recycled aggregate for permanent works; 90 per cent (or as notified by city) of waste (by weight) arising from demolition works to be reused or recycled;

C&D waste management implementation indicators		
S. no.	**Action points**	**Indicators of the action for implementation and reporting**
	Off-site reuse and recycling (infrastructure and mega developers)	Mandate setting up of recycling facility for major sub-streams on project site and 100 per cent utilization of recycled waste in the project; and Encourage setting up shared recycling facility for minor sub-streams.
9	Monitoring and vigilance	Appoint a C&D waste manager for the construction project responsible implementing of WMP; Maintain log for on-site waste generated, reused, recycled, and transferred for management off-site; and Bulk generator to have facility for digital monitoring and surveillance of waste storage, on-site application and transfer to off-site.
Segregated collection and transportation		
10	Develop a system for collection and storage points	Identify bulk segregated storage points (these can be potential sites for setting up recycling facility in future); Designated collection points of segregated storage available within reasonable distance for small generators to bring and deposit; Cities or areas within cities with land shortage can be provided with door-to-door collection facility; Mandate bulk generators to directly send the waste to bulk storage or recycling facility; and Allow private land to be used as collection/storage point subject to environmental clearance from pollution control board for the same.
11	Develop a system for transportation	Set up a mobile collection unit for transportation of collected waste from collection points to bulk storage, processing and disposal points; Develop a schedule for segregated collection (on call basis facility and weekly schedule); and Set up a helpline to book collection service for bulk generators, establish charges based on quantity of waste and travel distance to disposal site.
12	Monitoring and vigilance	Make a directory of transporters authorized to transport C&D waste; and Mandate GPS tracking of trucks involved in transportation of C&D waste.
Processing and recycling facility		
13	Land	Locate land for recycling facility within or close to the city.

C&D waste management implementation indicators		
S. no.	**Action points**	**Indicators of the action for implementation and reporting**
14	Setting up recycling facilities	Establish C&D waste management facility—permanent recycling plants for metropolitan cities, temporary/mobile recycling equipment for smaller cities; Recycling facilities to be developed for all sub-streams (concrete, bricks and mortar, metals, plastics, etc.) as identified by the city for segregation; Capacity of each sub-stream recycling facility to be determined as per segregated waste generation estimate of the city accounting for targeted waste reduction, on-site reuse and recycling, and off-site reuse. Set up decentralized multiple units of recycling facility for major sub-streams (concrete and bricks) at the city level; and Centralized recycling facility to be set for minor sub-streams (plastics, metals) at the regional level.
15	Operation of recycling facility	Maintain logbook of waste received, processed and sold; Mandate setting up of CCTV camera to monitor and record operation of the plants; and Mandate annual audit of to verify the functionality of the facility.
16	On-site recycling	Provide facility to hire mobile recycling equipment by either developing an inventory at the ULB or empanelling entrepreneurs that provide this service.
Regulating reuse		
17	Ensure environmentally safe reuse	Notify acceptable reuses of C&D waste based on environmental impact of these; Outlaw sale of C&D waste to non-construction projects; Publish rates for sale of C&D waste for various reuses; C&D waste suitable for recycling should not be diverted for reuse such as refilling and backfilling; and Mandate prior approval for purchase of C&D waste for reclamation, refill, and backfill. Link the approval with environmental clearance for the project.
	Integrate informal sector	In absence of recycling facility for all sub-streams of waste, leverage the informal market for salvaged material.
Landfill		
18	Disposal	Ban disposal of C&D waste at sanitary landfill sites.

C&D waste management implementation indicators		
S. no.	**Action points**	**Indicators of the action for implementation and reporting**
19	Reuse in landfill covering	Mandate procurement of processed C&D waste to be used for covering layer in landfill from recycling facility; and Ban use of unprocessed C&D waste as landfill cover.
Supporting market for recycled material		
20	Taxation	Reduce GST on products made from recycled C&D waste; Don't seek discount on purchase of recycled products for self-consumption if taking cut in the profit from the sale of recycled products; and Don't impose royalty or any other type of fee on recycling.
21	Ensure uptake	Mandate certain percentage of the material for all new construction by government agencies to be recycled construction waste; Mandate 100 per cent buyback for bulk generators if they send their waste to the recycling facility; Mandate recycling facility to sell recycled aggregates to independent building product manufacturers; and Mandate recycling facility to accept small purchase orders.

Part 2

OUTSIDE THE WALL: TRACKING CHANGE IN CITIES

AVIKAL SOMVANSHI/CSE

CITY CASE STUDIES

Major metropolitan cities across India have initiated construction and demolition waste (C&D) waste management after the notification of the Construction and Demolition Waste Rules and Regulations, 2016. More cities have joined the initiative after inclusion of C&D waste in Swachh Survekshan 2019. Swachh Survekshan has now been modified and made more granular in the updated version put out by the Ministry of Housing and Urban Affairs in July 2020.

Information regarding the actual performance of these initial efforts in cities is sketchy and most of it is not publicly available. To understand issues cities face in adopting and implementing C&D Waste Management Rules 2016, CSE conducted detailed investigation of the status of the process of implementation in select cities.

AVIKAL SOMVANSHI/CSE

An old bungalow being demolished in a South Delhi neighbourhood

This investigation included review of the literature available in public domain; field inspection of C&D waste collection and processing facilities; and interviews with government officials, local stakeholders, academicians and civil society actors working in the area of waste management. CSE also visited illegal dumping sites in these cities as part of investigation and efforts were made to understand city's informal sector as well. All the field visits were conducted in 2019.

This assessment of ground realities was carried out in Delhi, Ahmedabad, Mumbai, Thane, Pune, Bengaluru, Kolkata, Jaipur, Gurugram, Noida, Ghaziabad, Tirupati and Vijayawada. Field investigations in these cities have been critical to ideation of this report and crafting recommendations to improve C&D waste management in cities. Policies and practices in Chandigarh, Indore and Hyderabad were also analysed but CSE did not conduct field investigation in these cities.

1. DELHI

The National Capital Territory of Delhi has five ULBs governing its urban areas. They include North Delhi Municipal Corporation (North DMC), East Delhi Municipal Corporation (EDMC), South Delhi Municipal Corporation (SDMC), New Delhi Municipal Council (NDMC) and the Cantonment Board. A 2005 survey of then unified Delhi Municipal Corporation estimated 4,600 tonnes per day (TPD) of C&D waste generation in the city.

The Delhi government notified the Solid Waste Management by-laws, 2017—which partly incorporated the provisions of C&D Waste Management Rules, 2016—in 2018. They have been adopted by all city ULBs. The provisions of the new by-laws do not go into the specifics of the C&D waste management process and are rather weak in details as the reader is referred to the national C&D Waste Management Rules, 2016.

C&D waste management

The city ULBs do not issue separate permissions for demolition of a building. As any demolition work is generally associated with a new construction, owners and/or developers need to get their building plans—which automatically includes demolition work—approved. No separate waste management plan needs to be submitted.

Builders are not required to pay any waste generation fees except for projects under the jurisdiction of EDMC and SDMC. A waste generation fees of Rs 60 is charged by EDMC per sq. m of the proposed built up area at the time of sanction of building. The fee is 1.5 times higher for unauthorized construction. SDMC has imposed a processing fee of Rs 205 per tonne at the time of sanctioning a building plan and Rs 225 per tonne for lifting waste. Transportation charges would be increased by 10 per cent every two year.

In North DMC, the general public can arrange for pickup of their waste by approaching the Junior Engineer (JE) of the ward or by submitting a complaint through the 311 App developed for the municipality. Small trucks with capacity up to 3 cu. m pick up this waste, along with C&D waste littered across the ward, and bring it to the collection points. The service is free of cost and provided by the municipality. According to North DMC, the generators upon dumping the waste shall get a receipt which can later be collected by the JE from the contractor/occupier/owner of the property. Delhi also has a Rs 5,000 fine for unlawful disposal of C&D waste.

C&D waste-processing plants

Currently, the city has three recycling plants (at Burari, Shastri Park and Mundka) with combined capacity of 2,650 tonnes a day (see *Table 12: C&D waste recycling plants in Delhi*). The first plant was commissioned by the then Municipal Corporation of Delhi in 2009, with a capacity of 500 TPD, which was later increased to 2,000 TPD. Three more plants are in pipeline that will add 2,000 tonnes to existing capacity. SDMC is adding two more plants; one with a capacity of 500 TPD by the end of 2020 in Bakkarwala in North Delhi, and another one of 1,000 TPD in Maidan Garhi in south Delhi. All plants are operated by IEISL (IL&FS Environmental Infrastructure Services Ltd).

Table 12: C&D waste recycling plants in Delhi

S. no.	Name	Jurisdiction—run by	Capacity
1.	Burari (started in February 2009)	Jurisdiction: North DMC Run by IEISL	2,000 TPD
2.	Mundka (started in August 2017)	Jurisdiction: DMRC projects Run by IEISL	150 TPD
3.	Shastri Park (started in February 2015)	Jurisdiction: EDMC Run by IEISL	500 TPD
4.	Rani Khera	Jurisdiction: North DMC Run by IEISL	1,000 TPD
5.	Bakkarwala	Jurisdiction: SDMC Run by IEISL	500 TPD
6.	Maidan Garhi	Jurisdiction: SDMC Run by IEISL	1,000 TPD
7.	Libaspur	Jurisdiction: PWD projects Run by IEISL	500 TPD

Source: National Green Tribunal (NGT).

For redevelopment of East Kidwai Nagar, the National Buildings and Construction Corporation (NBCC) set up in 2014 a temporary C&D waste-recycling facility with a capacity of 150 TPD. M/s Enzyme India Pvt. Ltd, a private operator, has set up on a PPP model, with 100 per cent buy back by NBCC. All the waste generated by demolition of original buildings in East Kidwai Nagar was recycled on-site to manufacture concrete blocks that were utilized in the construction of the new buildings by NBCC.

These plants utilize both dry and wet processes to recycle C&D waste and turn them into aggregates, manufactured sand and other value added products such as concrete blocks, paver blocks, tiles and kerb stones. The plant in Shastri Park owned EDMC does not produce any value added products due to space and storage constraints. Collectively, these plants can manage about 40 per cent of the C&D waste generated every day in the city.

Collection points

There are more than 240 collection points spread across ULBs of Delhi, which receive C&D waste in small quantities every day from small scale generators. These collection points are mainly municipal Junior Engineer (JE) stores or vacant land, which belongs to the North-DMC. Their sizes also vary significantly. For instance, the point near Lok Nayak Jai Prakash Hospital is spread across a vast area. The point receives large quantities of waste since it caters to the most of the Walled City, which is very congested and it is challenging to find designated multiple collection points. While it is suggested to designate collection points no further than 3 km from generation sites, identification of collection points can be challenging in mega cities such as Delhi. North-DMC has designated 104 collection points across the jurisdiction area.

CSE's survey of these collection points revealed that many are not accessible to the general public, and none have provision to store waste in a segregated manner.

Table 13: Truck capacity

Mode of transport	Capacity
Tractor trolleys	2–3 cu. m or 1.5–2 tonnes
Dumpers	19–20 cu. m or up to 15 tonnes
Tata Ace (MCD)	1.5–2 cu. m

Source: CSE compilation.

Transportation

Small generators (generating less than 20 TPD or less than 300 tonnes per month) are required to bring their waste to the multiple collection points that have been provided by the municipalities. Disposal of the C&D waste is usually contracted to transporters by the demolition contractors. The debris is transported in tractor trolleys or dumper trucks within the city. For smaller projects, animals and cycle trolleys are also a common means of transportation (see *Table 13: Truck capacity*)

Bulk generators (greater than 300 tonnes per month or 20 TPD) are required to directly bring their waste to the C&D waste recycling facilities currently active in the city.

The waste from the collection points is either picked up by the trucks owned by the recycling plant or is sent by the municipality on their own means. Two slips are generated at the collection points with the details of the transporting entity and the amount of waste picked up. One slip is retained by the municipality while the other is collected at the recycling facility where the amount of waste received is verified.

Capacity of one truck is around 15 tonnes. Waste is lifted from these points when it reaches this weight. Under the design–build–operate–transfer (DBFOT) model, the plant management lifts waste from a collection point when it reaches 15 tonnes of weight. North DMC pays the plant a tipping fee of Rs 226 per tonne, which increases at a rate of 5 per cent every year (it was Rs 148 in 2009 when the plant was commissioned). Around 20–25 trucks per day are circulating around the corporation area for collection of C&D waste. The plant owns six trucks; the rest are contracted with private agencies.[104]

Bulk waste generators are mainly authorities like DMRC, PWD, DDA, etc. They mainly transport the C&D waste directly from construction sites and pay a processing fee of Rs 205 per tonne to the plant. According to the data shared, the maximum waste is received from the Public Works Department (PWD) Delhi at 44 per cent of the total, followed by North DMC at 37 per cent (North DMC largely represents the waste transported from collection points to the plant), Central Public Works Department (CPWD) transported 5 per cent, Delhi Metro Rail Corporation (DMRC) 6 per cent, Delhi State Industrial and Infrastructure Development (DSIIDC) 3 per cent, Delhi Development Authority (DDA) 1 per cent and National Buildings Construction Company (NBCC) brought less than 1 per cent of C&D waste to the plant.

Segregation and processing

All the waste received at the plant first passes a weigh-bridge and then is manually segregated to take out rejects such as rags, metal, plastic, etc. The waste is then divided into two streams to be processed separately—one with only concrete and

the other with mixed waste comprising bricks, mortar, mixed concrete, etc. The only-concrete stream undergoes a dry process and mixed waste undergoes a wet process. About 90 per cent of the waste received at the Burari plant has been mixed waste which has undergone wet processing.

Uptake of recycled products

The level of awareness is extremely poor among the construction agencies and efforts made by government agencies to change this is negligible at the start. This is reflected in uptake of recycled waste products that the C&D waste recycling plants are manufacturing. The Delhi government issued an advisory in 2015 asking all public agencies to mandate 5 per cent use of such products for non-structural applications while examining and approving building plans.[105] But they have nothing to show for it. In fact Delhi plants storages, as recently as 2018, were overflowing with unsold recycled products.

The Central Public Works Department (CPWD) eventually in its *2014 Guidelines for Sustainable Habitats* included a set of '*Guidelines on re-use of recycled C&D waste*'. The guidelines included ways and precautions for recycling of C&D waste as well as emphasized the need for a deconstruction plan to recover useful products that can be reused without much processing. This allowed the agency to procure 1.8 million recycled C&D waste block from the Burari plant for the prestigious extension of Supreme Court of India complex project.[106]

The Delhi government reissued the advisory in 2018, coupled with improved levels of awareness. The city's recycling plants have cleared most of their unsold itinerary of recycled C&D waste products by start of 2020. ULBs themselves purchased most of the itinerary.

Informal sector

Demolition work in the city is dominated by the informal sector. After approval of the building plans, tenders are floated for the demolition jobs. A demolisher salvages the buildings for valuables like doors, windows, iron, bathroom fittings, and electrical equipment and then continues to demolish the buildings. Machinery such as excavators with demolishing hammers alongside manual labour is utilized for demolishing. Thereafter, transporters are hired that are responsible for disposing of the C&D waste in a timely manner.

The transporters have established a neat business opportunity out of this. They charge the demolition contractors for picking up the C&D waste. This C&D waste finds many uses and is in high demand across the city. It is used for backfilling, elevation improvement or in road construction. The C&D waste is sold to the potential buyers for one of these uses. For picking up the C&D waste from the site, the transporters charge as much as Rs 700 for a trolley of C&D waste; for a dumper, they charge as much as Rs 3,500. The dumping charge at sites that have a requirement for C&D waste is as much as Rs 1,500 per dump.

But in many cases when there is not enough demand, the debris is dumped illegally across the cities in waterbodies, drains, municipal solid waste dhalaos, isolated stretches, or by the roadside. It is mostly done during night time when vigilance is low.

2. AHMEDABAD

Ahmedabad is one of the fastest-growing cities in India with mega-infrastructure developments, including a metro rail project. The city is governed by the Amdavad Municipal Corporation (AMC) and divided into 64 wards within six zones. About 2,700 permits were issued by AMC for construction of buildings in 2014–15. Approximately 50 per cent of this was for reconstruction, and 40–45 per cent permits were issued for renovation. The city generates about 700 TPD of C&D waste.[107]

C&D waste-processing plant

Ahmedabad was the second city in India to implement C&D waste processing by adopting a similar public–private partnership (PPP) model to Delhi's. In 2012, Amdavad Enviro Projects Pvt. Ltd (AEPPL) was given the contract of collecting, transportation, processing of C&D waste generated in the city. AEPPL had set up a 300-TPD capacity C&D waste recycling plant at Gyaspur Pirana under a 30-year PPP. The processing facility was operationalized in 2014, the capacity of which was increased to 600 TPD in 2016 and to 1,000 TPD in 2018.

The plant manufactures a variety of value added products, including:

- Precast RCC
- Precast concrete box culverts and manholes
- RCC fencing pole, door frame, grill
- Kerb stones and ferro covers, road edge stones, paving stones, granite
- Interlocking paving blocks
- Bitumen-bound materials
- Concrete
- Pipe bedding
- Hydraulically bound mixtures (HBM) for sub-base and base
- Unbound mixtures for sub-base
- Capping
- Embankments and fill

Collection points

According to AMC, in 2017 there were 16 collection points where citizen could dump their C&D waste. When CSE visited the city it found that majority had been discontinued and only four were functional. This was confirmed by the then deputy municipal commissioner of AMC who was in-charge of the city's solid waste management.

Transportation

The transportation service for C&D waste is provided by AEPPL, the C&D waste processing plant operator. AMC pays Rs 178 per tonne as tipping fee for transportation of waste from the collection points to the recycling plant.[108] The city also provides doorstep pickup service to people who can avail of the service by paying a fee based on approved rates. People can avail this service by registering a complaint for collection of C&D waste by phone call on the AMC operated

Table 14: Transportation and processing fees charged by AMC

Weight	Per tonne	Per trip (minimum trip)
Less than 1 tonne waste		Rs 200
For 1–5 tonnes waste (minimum quantity)	Rs 225	Rs 675
More than 5 tonnes waste (large quantity)	Rs 212.5	Rs 1,700

Source: Integrated Solid Waste Management System of Ahmedabad City. Available at *https://smartnet.niua.org/sites/default/files/resources/solid_waste_management_amc_ppt.pdf*. Accessed on 13 May 2020.

Comprehensive Complaint Redressal System (CCRS).[109]

This door-to-door service is also contracted out to AEPPL. To make collection of small quantities (less than one tonne) economically viable, such requests are mapped and scheduled so that four to five spots can be covered in a single trip.[110] People are expected to report successful resolution of the complaint through CCRS (see *Table 14: Transportation and processing fees charged by AMC*).

Reutilization and recycling

AMC has adopted a preferential procurement policy under which 50 per cent of requirement of paver blocks and curbing stone and 25 per cent of requirement of manhole covers (without frame) (which can be increased or decreased as per requirement) should be done by the respective departments/projects from AEPPL and the rates should be as per the existing rates of AMC approved tender and/or rates as per the schedules of rates (SOR), whichever is less. AMC has also approved a policy of procuring precast/pre-stress walls from AEPPL to build compound walls for AMC's various properties. At the time of CSE's visit, the plant was mostly producing paver blocks for the ongoing Metrorail construction.

3. MUMBAI

The Municipal Corporation of Greater Mumbai (MCGM), the ULB responsible for local government in the city, estimated that around 1,200 TPD of C&D waste is generated in Mumbai across 24 wards. This estimate includes unclaimed C&D waste and the waste collected from a dedicated C&D waste on-call service launched by the municipality in 2015. This estimate does not consider the C&D waste dumped in and outside Mumbai illegally or on ULB-approved unloading sites.[111] This estimate is considerably less than the 2,500 TPD estimated by CPCB in *Guidelines on Environmental Management of C&D Wastes*.[112] Currently the city has no official recycling facility.

C&D waste management

MCGM allows private and public landowners to provide their property as 'approved designated unloading site' for C&D waste. After obtaining necessary approval from the solid waste department of the ULB, these sites are available for the developers or owners for dumping their waste. The sites are to be located outside the Municipal Corporation of Greater Mumbai (MCGM's) municipal boundaries. A developer or builder will have to submit a C&D waste management plan (WMP) online in order to obtain a no objection certificate (NOC) for starting any project that will involve generation of C&D waste.

The WMP includes:

- A brief description of the project along with a proposed plan for development by the architect;
- Excavation permission from the collector, Mumbai;
- The amount of C&D waste expected to be generated;
- The amount of C&D waste expected to be reused on-site and the amount to be transported to the C&D processing facility;
- A consent letter along with notarized documents from the landowner of the designated site mentioning the quantity of C&D waste that can be accommodated at the site;
- Transportation:
  - » Appointment letter of transport contractors along with the acceptance letter;
  - » Details of the transporting entity along with the list of vehicles equipped with GPS to be used for transportation;
  - » The planned route for transporting the waste;
  - » A declaration to transport the waste during daytime and to abide by C&D waste management rules;
  - » A declaration to maintain a register of time of entry and exit of all vehicles, along with the approximate quantity of waste transported from the site;
  - » Each vehicle deployed shall carry a challan issued by the project site mentioning all details like the challan number, name of the project site, transporter firm, disposal site and time of leaving the project site. A failure to produces the challan will mean that the transportation will be considered illegal;
- Declaration to follow dust pollution control measures, including:
  - » Provide barricading and enclosure at the construction site;

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Illegal dumping of C&D waste in Thane Creek

  - » Vehicles used for transportation shall not spill waste or slurry during transportation. Each vehicle must be properly covered with tarpaulin while transporting;
  - » The body, wheels and chassis shall, therefore, be washed and cleaned thoroughly to avoid spreading of waste on the road.
- A bank guarantee.

After payment of an online fee, the application is sent to the executive engineer of the solid waste management department of the ULB for approval. Builders or developers who generate small quantities of C&D waste (less than 300 tonnes per project) are exempt from this rule and are required to contact the ULB to get the C&D waste removed.

Demolition management

A demolition contractor is hired by the developer or government organization that undertakes demolition. The value of the demolition contract is generally based on the value of the salvageable material, labour and other factors. Salvageable material can include wood, metal, bricks, tiles and ceramics. Once the valuables are removed, the building is demolished through a combination of manual and mechanized methods. To speed up the process, machines like excavators with demolition equipment are used.

Segregation

C&D waste is segregated into wood, steel, glass, tiles, ceramics and debris by contractors. Whole bricks are removed only when buildings are demolished manually.

Transportation and collection

Generally, transporters are hired by demolition contractors. As per the requirement of the waste management plan to be submitted by the developer or builder, the details of the transporting entity need to be furnished to obtain a no objection certificate to start construction.

In 2015, the ULB started a waste-collection service called Debris on Call, where generators accruing less than 20 TPD C&D waste can call up a helpline number provided for each ward to get their waste or an unclaimed C&D waste pile picked up. For residents and societies that need their debris to be picked up, the civic body charges Rs 400 per tonne and an additional 15 per cent supervision charges.

Fines: MCGM also levies a fine of up to Rs 20,000 for illegal dumping of C&D waste within its wards. For not delivering C&D waste in a segregated manner, there is a fine of Rs 1,000.[113]

C&D waste processing and disposal

Waste salvaged during demolition is sold by contractors while the debris is usually dumped in unidentified areas illegally or at designated unloading sites approved by the ULB. There are two landfill sites in Mumbai—Deonar and Mulund—where C&D waste used to be dumped before the High Court ban in 2018. Despite the ban, the waste collected in the 24 wards of MCGM continues to be dumped at Deonar and Tardeo dump sites.

MCGM has plans to set up a 1,200 TPD C&D recycling plants in Mumbai.[114] Two hectares of land will be provided to operate and maintain the processing and recycling plant for a period of 15 years. The Corporation also plans to take help from contractors in identifying and penalizing illegal dumping activities. MCGM has added a clause to the latest tender allowing citizens to set up a plant if they have a large open space. This will require taking environmental clearance from the Maharashtra Pollution Control Board (MPCB) and a no objection certificate from the traffic police. The tender has attracted no takers.

Godrej Constructions has been operating a small-scale private C&D recycling facility on its facility in Vikhroli, Mumbai. The facility caters almost exclusively to C&D waste generated at projects of Godrej Constructions.

C&D waste reutilization

Once the recycling facility is operational, MCGM also plans to buy 20 per cent of recycled C&D waste in the form of concrete, sand and bricks at a 20 per cent discount.

4. THANE

Thane city is governed by the Thane Municipal Corporation (TMC) and divided into 116 wards. There are no official figures for the amount of C&D waste generated in the city available from the ULB. CPCB in *Guidelines on Environmental Management of C&D Wastes* has estimated 600 TPD as city's C&D waste generation.

C&D waste management

TMC notified the TMC C&D Waste Management Guidelines, along with the schedule of tipping fees and penalties in February 2019.[115] The guidelines make it mandatory for all C&D waste generators within the jurisdiction of TMC to follow rules pertaining to C&D waste management through collection, transportation and processing mechanisms provided by the municipality.

The guidelines identify the different categories of waste generators and provide a list of procedures to be followed to manage their C&D waste. The list includes:

- Duties and responsibilities of different categories of waste generators;
- Registration procedure: Every waste generator is required to be registered with TMC;
- Procedure for collection and transportation of C&D waste;
- Penalties and regulations in place for unauthorized or illegal disposal of C&D waste; and
- Procedure for waste management plan to be provided by bulk waste generators;

Five categories of waste generators have been identified (see *Table 15: Different categories of C&D of waste generators in Thane*).

Table 15: Different categories of C&D of waste generators in Thane

Category	Type of waste generator
A	**Small generators** (household or minor repairs) generating less than 1 tonne and all those carrying out work that does not require any prior permission or approval from TMC
B	**Large generators** (major repair, renovation or remodelling) generating 1–20 tonnes and all agencies—private or public—that carry out work that requires approval of TMC
C	**Bulk generators** (developers, demolition or infrastructure agencies and contractors) generating more than 20 tonnes in a day or 300 tonnes per project in a month or all agencies—private or public—that carry out work that requires approval of TMC C1: All private agencies and developers C2: Government agencies C3: Thane Municipal Corporation
D	**TMC works** (non-bulk generation) undertaken by the Corporation itself and all contactors that are engaged by TMC for carrying out demolition, construction or public works
E	**Service providers** (non-bulk generation) authorities (other than TMC) who provide services like water, sewerage, electricity, telephone, roads and drainage

Source: Notification for implementation of C&D Waste Management Rules, 2016.

Storage and segregation

All waste generators (Categories A–E) will be required to store the waste to ensure that there is no littering or deposition of construction and demolition waste, no obstruction to traffic or public easement or drains and shall ensure C&D waste is not mixed with MSW and hazardous waste.

Service providers (Category E) shall try to remove waste in a day, if possible, or work out a timeframe with TMC or set up in situ salvaging, processing and recycling facilities. If logistics support is not available, it shall tie up with authorized agencies for collection, transportation and processing of C&D waste and pay relevant charges as notified by the TMC.

Bulk waste generators (Category C) are required to segregate waste into fours streams: (i) concrete (ii) soil (iii) steel, wood and plastics, and (iv) bricks and mortar, and shall submit waste management plans and get appropriate approvals from the TMC before starting construction, demolition or remodelling work.

Collection and transportation

All waste generators have to register with TMC and submit a request for on the website, with the ward office or on a helpline for acceptance and collection of C&D waste. This will include the details of the waste generator, quantity of C&D waste to be generated and the expected date of pickup or delivery of the C&D waste (see *Table 16: Available C&D waste services and rates*).

C&D waste management plan

All bulk generators (category C) are required to submit a waste management plan (WMP) at the building plan approval stage or before starting construction, demolition or remodelling work. The Solid Waste Management (SWM) project department of TMC will approve the WMP within one month from submission and issue the necessary NOC. Failing to register disapproval within a month will be treated as deemed approval.

Table 16: Available C&D waste services and rates

Category of C&D waste generator	A Small	B Large	C Bulk*	D TMC works Non-bulk	E Utility services Non-bulk	F Unauthorized
Type of services	T,P&D	C&T P&D	P&D	P&D	P&D	C&T P&D
Quantity in tonnes	Less than 1	1–20	More than 20	Up to 20	Up to 20	Not applicable
Rate (Rs per tonne)	Free	1,089	545	525	545	1,050

C: Collection; D: Disposal; P: Processing; T: Transportation

* All bulk generators need to provide a Waste Management Plan

Source: Notification for implementation of C&D Waste Management Rules, 2016.

The WMP needs to contain information related to:

- A brief description of the project along with a proposed plan for development by the architect;
- Excavation permission from the Collector, Thane;
- The amount of C&D waste expected to be generated;
- The amount of C&D waste expected to be reused on-site and the amount to be transported to C&D processing facilities;
- Transportation: An appointment letter from the transport contractor along with an acceptance letter; details of the transporting entity along with the list of vehicles equipped with GPS to be used for transportation; the planned route for transporting waste; a declaration to transport waste during daytime and abide by C&D Waste Management Rules of 2016; and a declaration to maintain a register of time of entry and exit of all vehicles, along with the approximate quantity of waste transported from the site. Each vehicle deployed shall carry a challan issued by the project site mentioning details like challan number, name of the project site, transporter firm, disposal site and time of leaving the project site.
- A declaration to follow dust-pollution-control measures: Provide barricading and enclosure at the construction site; vehicles used for transportation shall not spill waste or slurry during transportation. Each vehicle must be properly covered with tarpaulin during transportation. The body, wheels and chassis of the vehicles shall be washed and cleaned thoroughly to avoid spreading of waste on the road.

C&D waste-processing plant

Waste collected and received directly from category C, D and E generators is transported to a C&D processing plant located in Deoghar for recycling. The plant has a capacity to recycle 300 tonnes of C&D waste daily. Categories A, B, C, E and F generators are required to pay Rs 1,089 per tonne of C&D waste as transportation and processing charges to the TMC and category D generators are required to pay Rs 1,050 per tonne. If transportation is done by the generator, 50 per cent of the tipping fee is waived off.

Illegal or unauthorized dumping and penalties

Citizen and RWAs can lodge complaints against unauthorized or illegal dumping of C&D waste through a toll-free helpline number. Authorized agency staff has to ensure that C&D waste is not dumped indiscriminately on roadsides or public spaces, remove such C&D waste, and pursue TMC to get complaints registered against defaulters. Citizens or RWAs can provide evidence of illegal dumping via photos with registration number of vehicles doing the dumping. These are used by TMC to initiate action against such defaulters and vehicle owners. TMC charges between Rs 5,000–20,000 for various lapses observed in compliance with the C&D Waste Management Rules (see *Table 17: Schedule of penalties for violation of C&D waste management rules in Thane*).

Table 17: Schedule of penalties for violation of C&D Waste Management Rules in Thane

Particular	Penalty for every violation (in Rs)
Failure to store C&D waste as per the C&D Waste Management Rules	5,000
Failure to deliver C&D waste in a segregated manner or mixing C&D waste with other wastes	10,000
Illegal dumping of C&D waste in front of houses, roads, parks or at any other public space	20,000
Illegal dumping of C&D waste in forests, mangroves zones, riverbeds, canals and quarries or in a non-designated area	20,000
Failure to dispose of C&D waste within a stipulated time (as specified in the waste management plan)	10,000
Violating norms while transporting C&D waste or spilling waste on roads during transit	10,000
Non-performance of any other obligation under the Rules for a continuous period of seven days	10,000

Source: Notification for implementation of C&D Waste Management Rules, 2016.

C&D waste reutilization

In line with the Swachh Bharat Mission's garbage-free toolkit, the guidelines mandate:

- Use of a minimum of 40 per cent C&D waste in any TMC or other government approved construction activity in non-structural application, lower layers of road pavements, inner colony roads, filling of plinths and basement, landscaping and levelling of ground
- Use of a minimum of 20 per cent recycled C&D waste products such as bricks, tiles, paver blocks, drainage covers, kerb stones, structural concrete as manufactures aggregates in TMC or other government construction activity at 80 per cent of the schedule rate.

5. BENGALURU

The city of Bengaluru is governed by Bruhat Bengaluru Mahanagara Palike (BBMP) and comprises 198 wards. CPCB in *Guidelines on Environmental Management of C&D Wastes* estimates that city's C&D waste generation is about 1,000–3,000 TPD.[116]

C&D waste management

BBMP notified the *Guidelines for C&D Waste Management* in March 2016. It provides guidelines for estimation, storage and transportation of C&D waste within the ULB's jurisdiction.[117] All waste generators (developers, owners, renters) wishing to construct, renovate, repair or dismantle any premises shall have to obtain a plan sanction from the building plan approval authority.
The generator shall have to furnish:

- A C&D waste management plan; and
- Existing building plan/proposed building plan.

The C&D waste management plan shall include:

- Contact details of the applicant with a reference to the building plan;
- Details of the type of construction (new construction, demolition, repair) with the square footage of the project site;
- Details of the location of the site, with information about the BBMP zone and ward the project falls in;
- An estimate of the C&D waste to be generated during the project duration;
- Information about the disposal site. BBMP has designated one disposal site for each of its seven zones;
- Allocation of storage space as per the guidelines; and
- An affidavit that the generator shall follow the C&D waste management guidelines as notified by the BBMP.

During the construction or demolition activity, the waste generator shall maintain a log in a waste monitoring format—as per the guidelines—of the nature and the quantity of C&D waste to be generated during the duration of the project. The logbook shall be made available to the authorities during inspection. A commencement certificate shall be issued to the generator after the approval and clearance of the C&D waste management plan. A completion certificate/occupancy certificate shall be issued only after inspection and approval of up-to-date waste monitoring format and after receipt of all proof for disposal at the designated site.

Small-scale generators are required to keep the C&D waste within their premises and get it picked up through BBMP-authorized waste transporters or empanelled vendors whose information would be made available on the BBMP website.

The guidelines provide no criteria to distinguish between small and large waste generators nor steps to control dust pollution occurring due to C&D activities. But it provides guidelines to manage hazardous waste generated during construction and demolition which requires the generator to prevent any mixing of this waste with C&D waste and disposal through Karnataka State Pollution Control Board (KSPCB)-authorized recyclers or to hazardous waste disposal sites.

Penalties: Non-compliance to the C&D Waste Management Rules 2016 shall invite penal action against the violators under the Environment Protection Act (EPA) 1986, Karnataka Municipal Corporation Act 1976 and other applicable laws.

C&D waste-processing plant

BBMP has a C&D waste processing facility with a capacity of 750 TPD in Kannur Village that became operational in early 2020. The facility is operated by Rock Crystal Ltd for BBMP and is responsible for collection and transportation of waste as well. BBMP has fixed C&D waste service charges at Rs 134 per tonne of waste.[118]

Rock Crystal Ltd has been successfully operating for many years a much larger recycling plant (1,000 TPD) in Chikkajala, close to Bengaluru's Kempagwoda International Airport. They process only concrete waste in their Chikkajala facility and provide free waste-pickup service for sites within 10 km of their plant. They don't manufacture value added products like pavers and blocks but directly sell the recycled concrete aggregates to interested buyers. CSE visited the facility at Chikkajala and found its recycled aggregate to be of superior quality compared to ones at Delhi and Ahmedabad.

Collection points

BBPM has made generators responsible for storage, collection and transportation of the C&D waste to its recycling facility at Kannur Village.[119] City has no designated collection points but had identified seven sites for disposal/recycling in its C&D waste guidelines that were notified in 2016.[120] According to media reports in 2018, these sites were not functional.[121] CSE was also not able to access these sites during its visit to the city.

C&D waste reutilization

BBMP through a public notification in November 2019 made it mandatory for all infrastructure service providers and government organizations undertaking construction work within the jurisdiction of BBMP to replace a minimum of 20 per cent by weight of aggregates, sands, pavers, masonry blocks, granular sub-base (GSB) and soil with similar products available from processing of C&D waste for their works as permitted by the Bureau of Indian Standards, Indian Road Congress, Central Public Works Department (CPWD) and Public Works Departmen (PWD).

6. JAIPUR

The Jaipur Municipal Corporation (JMC) or Jaipur Nagar Nigam is the ULB responsible for local administration within 91 wards of Jaipur. According to CPCB estimates in *Guidelines on Environmental Management of C&D Wastes,* the city's C&D waste generation is about 150 TPD.[122]

C&D waste management

JMC notified the C&D waste management by-laws in 2018,[123] which covers the duties of waste generators, service providers and their contractors and the Municipal Corporation.

Preparatory process: According to the by-laws, any building permission shall be granted only all the components of the C&D waste management by-laws 2018 are incorporated. The various components of the by-laws are described in the proceeding paragraphs.

Fines: The Corporation shall penalize the generator with spot fines if any littering or deposition of C&D waste outside the premises comes to light. These fines would also be applicable for material suppliers of sand, cement, aggregate, bricks etc. If they are found to be littering or depositing material in such a way that they are an obstruction to the traffic or the public or drains. Additionally, unsegregated C&D waste at project sites shall also attract fines as per the directorate of local bodies or as per the decision given by the council/JMC commissioner from time to time.

Storage and segregation

The by-laws make it mandatory for the generator to segregate and store the waste in an environmentally sound manner. According to the by-laws, all waste generators prima facie are responsible for segregating the waste into five streams—concrete; soil; steel; wood and plastics; bricks and mortar; and others. Additionally they must ensure that the waste is not mixed with other waste such as municipal solid waste (MSW), e-waste and biomedical waste and that is stored within the project premises.

Bulk waste generators will be required to submit a waste management plan (WMP) and get appropriate approvals from JMC and keep the Corporation informed about the activities from the planning to implementation stage on a project-to-project basis. The WMP shall be examined and sanctioned within a period of one month. The by-laws require JMC to prepare a comprehensive WMP, covering segregation, storage, reuse collection, transportation, recycling and disposal. No such requirements or rules, however, have been framed yet.

Collection and transportation

All waste generators are required to pay relevant charges for collection, transportation and disposal of C&D waste as notified by the JMC, for which a dedicated helpline number shall be created. The waste shall be moved to collection centres or the processing centre as notified by the Corporation from time to

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A construction site in Old Jaipur

time. The collection of C&D waste throughout the city will be taken care by the Corporation and to prevent illegal dumping and sure the waste is removed in a reasonable timeframe.

C&D waste reutilization

The Corporation will give incentives to generators for salvaging, processing and/or recycling within their premises, preferably in situ. JMC shall use at least 40 per cent of recycled C&D waste in municipality-approved construction activities for non-structural application such as lower layers of road pavements, inner colony roads, filling of plinth and basements etc. It shall also use 10 per cent of value added products made from C&D waste such as kerb stones, paver blocks, concrete bricks etc.

C&D waste-processing plant

JMC has not put forth any public proposal for setting up a C&D waste processing facility for the city. CPCB notes in *Guidelines on Environmental Management of C&D Wastes* that the state government proposes to set up C&D waste processing plants in 29 cities, including Jaipur. It further notes that in Jaipur a private company proposes to set up a recycling facility with a capacity of 300 TPD on 6 acres (2.42 hectares) of land near the existing dumping stations.[124]

7. KOLKATA

The Kolkata Municipal Corporation (KMC) governs waste management in the city of Kolkata. According to CPCB, citing a survey done by GIZ and Development Alternatives in *Guidelines on Environmental Management of C&D Wastes*, Kolkata generates 1,600 TPD of C&D waste. CPCB does not provide its own estimation in the guidelines though. KMC has contested the figure given in the guidelines and stated that the quantity is only around 40–45 TPD.

C&D waste-management system

According to the building by-laws of Kolkata, any person who intends to demolish a building or a part thereof must provide information in writing to the municipal commissioner and ensure that it is done under the supervision of an empanelled structural engineer.[125] However, it must be noted that no specific permits are issued solely for demolition. Any person who intends to erect a new building, whether previously built upon or not, re-erect or make additions to or alterations of any building has to apply for a sanction by notifying the municipal commissioner in writing after which the permissions are given.

Disposal: Currently the C&D waste collected is used as a landfill cover and used as a sub-base material for roads being constructed in and around the landfill site. According to officials from KMC, this collected C&D waste is also used for filling purposes in low-lying areas.

Penalties: Information regarding penalties is not available for KMC but neighbouring New Town Kolkata Development Authority (NKDA) charges Rs 2,000 per tonne to remove waste and imposes a heavy fine of Rs 50,000 for unlawful disposal. An offender has to pay an additional penalty of Rs 10,000 per day if payment is delayed.

Collection and transportation

Small waste generators can utilize an expansive network of 660 collection points spread across Kolkata city free of cost to dump small quantities of C&D waste. One can also dump the waste directly to the dump yard, in which case Rs 550 per tonne per trip is to be paid to KMC. Citizens can also get their C&D waste picked up and transported to the disposal site for a fee of Rs 1,650 per tonne per trip. Bulk generators are required to directly bring their waste to the landfill site or avail KMC's pickup service for a fee of Rs 1650 per tonne per trip by contacting the assistant director in each borough.[126]

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Kolkata Municipal Corporation has an on-call C&D waste pickup service

C&D waste-processing plant

The city does not have any recycling facility (as of June 2020). KMC has invited bids for setting up a C&D waste processing plant with a capacity of about 400–600 TPD spread across 5 acres (2.02 hectares) of land, which shall be provided by the municipality.[127] The authorities had originally proposed to locate the plant at a landfill site in Dhapa, but the Wetland Committee has imposed a restriction for development in the said region and thus denied permission to the proposed plant. KMC has since chosen a new location at Batanagar, an industrial locality outside KMC's jurisdiction but covered under the Kolkata Metropolitan Development Authority.[128]

8. PUNE

The city of Pune is governed by the Pune Municipal Corporation (PMC). Pune's C&D waste generated was estimated by CPCB in *Guidelines on Environmental Management of C&D Wastes* as 250–300 TPD.[129]

C&D waste management policy

In January 2018, PMC notified the Public Health and Sanitation Bye-laws 2017, which distinguishes waste generators in three categories, with detailed information about the duties and responsibilities of the PMC and the generators in handling the C&D waste.[130] The by-laws make it mandatory for generators to submit a waste management plan to the authorities and to transfer the waste to collection points by their own means or through the PMC.

Duties and responsibilities of the PMC

The corporation shall:

a. Make submission of a waste management plan (WMP) mandatory at the approval stage or prior to issuing a work order for waste generators.
b. Examine and sanction the WMP within one month of submission or along with the building approval plan, whichever is earlier.
c. Provide and publish the list of C&D collection/transfer points.
d. Allow private agencies who are willing to provide their land to become a designated disposal sites for the city.
e. Provide the necessary infrastructure for safe C&D disposal, including containers, skippers, transport vehicles, transfer stations, disposal sites etc.
f. Notify charges for containers, gunny bags, tags, collection, transportation, disposal fees etc. for C&D waste.
g. Prevent unauthorized dumping in the city.
h. Encourage reduce, reuse and recycling of waste as close to the source at possible.
i. Provide an authorized reuse/exchange mechanism where the C&D waste generated in one part of the city can be utilized at another location.
j. Keep a log of the C&D waste generated produced, processed and disposed in the city.
k. Submit periodic report to the Maharashtra Pollution Control Board.

Duties and responsibilities of the C&D waste generators

Category I: All agencies, private or public, that require the approval of the corporation.

Category II: All contractors engaged by the corporation to carry out public works, and work undertaken by corporation itself.

1. The generator may ask the Corporation to provide containers or gunny bags to store C&D waste.
2. The generator shall segregate the waste into concrete, soil, steel, wood and plastic, bricks and mortars in containers or gunny bags provided by the Corporation. They shall be stored in a manner that does not cause inconvenience

AVIKAL SOMVANSHI/CSE

Pune has identified a low-lying area in Wagholi to set up its C&D waste-recycling facility

to the public, passers-by or residents of nearby premises and/or may not cause obstruction to traffic or public or drains.

3. Those materials that can be reused at the site for construction, land filling, paving shall be kept separately from C&D waste on-site.
4. The generator is responsible for transferring the C&D waste to the designated disposal sites or transfer stations by itself (within the time prescribed by the corporation) or avail the services of the corporation for pick up and transfer.
5. Service providers shall store waste on-site that does not cause inconvenience to the public and transfer the waste to the designated disposal sites.
6. A waste management plan (WMP) will be submitted and include:
   a) Quantum of waste expected to be generated;
   b) Manner of disposal of the waste;
   c) Payment of C&D waste handling, transportation, disposal and other charges as per the rates notified by the corporation; and
   d) Security deposit for containers.

   These will be based on the requirements set by the Corporation. Failing to follow the WMP will attract fines. Category I generators shall submit the WMP as part of the approval process. Category II generators shall submit the WMP before commencement of any work and adhere to the terms and conditions mentioned it.
7. In case the waste generators decide to transfer the waste themselves, they shall have to pay a security deposit and provide transportation authorization as well.
8. Process flow for the generators (when pickup through authorized agency):

a) Submit WMP, pay waste generation fees, collection service coupon (CSC) and container manifest.
b) Call an authorized agency for placements of container—attach container manifest and provide CSC to authorized agency.
c) Call an authorized agency for pickup and container manifest shall be updated accordingly.
d) The authorized agency places the container and collects the CSC, pickups up the container and updates the manifest, transports it to the disposal site and pays tipping fees and collects receipt and finally submit the manifest and the delivery receipt to the corporation.

9. Process flow in case of the generators transports the waste itself, it shall:
   a) Collect container manifest, deposit a security along with transport authorization, deliver waste to the designated disposal sites, pay tipping fees and collect delivery receipt and updated container manifest.
   b) Submit the container manifest, delivery receipt to the corporation for refund of security deposit.

Category III: All those carrying out work that does not require prior permission or approval from the Corporation.

The generator is responsible for transferring the C&D waste to the designated disposal sites or transfer stations by itself (within the time prescribed by the Corporation) or avail the services of the Corporation for pickup and transfer.

C&D waste practice on ground

Dumping of C&D waste illegally within the city jurisdiction is banned and can attract a fine of Rs 25,000 per violation. The solid waste department of the city has started a helpline number that can be used by citizens to get their C&D waste lifted. It charges Rs 19 per tonne per km for the service. There is no provision of recycling the waste currently but a C&D waste processing plant is being set up at Wagholi with a capacity to treat 200 tonnes per day. Identification of lands to serve as collection points was underway when CSE visited the city in 2019.

9. GURUGRAM

The city is part governed by the Municipal Corporation of Gurugram (MCG) and partly by the Haryana Urban Development Authority (HUDA). The ULBs estimate 300 TPD of C&D waste generation in the city.[131]

C&D waste management

MCG issued its first order on C&D waste in 2015 that designated disposal points and introduced penalty for illegal dumping in the city. The first violation attracts a penalty of Rs 5,000, with a 20 per cent increase with every subsequent violation.

According to an order by MCG, waste generators will pay a charge of Rs 360 per tonne for each kind of waste (brick and masonry; concrete and steel; soil, sand and gravel, wood and plastics; other metals; and miscellaneous). Waste shall have to be segregated on-site and Rs 720 per tonne will be charged for disposal of unsegregated waste.[132]

Within the same order, all developers are required to submit plans for the clean-up. Violation of the conditions will be punishable under Sub-section (1) of Section 15 of the Environment (Protection) Act, 1986. Each failure is punishable with imprisonment for a term which may extend to five years or fine up to Rs 1 lakh or both and with repeated violation additional fine will be imposed at Rs 5,000 for every day and for as long as the contravention continues.

All large generators of waste will have to pay charges for transportation, collection, processing and disposal. They will be responsible for segregating C&D waste before disposal.

Segregation and collection points

MCG has notified segregation on premises in six different streams, namely brick and masonry; concrete and steel; soil, sand and gravel; wood and plastics; other metals; and miscellaneous. All waste generators are mandated to store their waste on-site as per the segregation scheme.

The ULB has designated 15 C&D collection points in the city. While two

VIKAS CHOUDHARY/CSE

The constuction boom in Gurugram has made C&D waste one of its most pressing environmental issues

designated dumping sites are in Sector 39, one each is in Sector 18, Sector 22A, Sector 21, Sector 14, Sector 42, Sector 53, Sector 52, Sector 44, Sector 57, Sector 50, Jail Road, Auto Chowk and Sector 11.

MCG adopted a new enforcement strategy starting 2020 and outsourced enforcement of C&D waste management to a private entity. Enforcement agency Pragati AL Natural Resources had issued challans worth Rs 50 lakh and recovered around Rs 28 lakh till July. The agency had submitted recovery assessment of over Rs 80 lakh since January.[133]

C&D waste-processing plant

Currently, the city has one recycling plant operated by Infrastructure Leasing & Financial Services (IL&FS) with a capacity to treat 300 TPD of C&D waste. The plant is in Basai, 5 km away from the main city. The plant reported collecting 300–500 tonnes of C&D waste daily in its first three months of operation. Talks of increasing the processing capacity of the plant have therefore started.[134]

The plant at present only produces products such as gravel, sand, stones and concrete. But plans to manufacture value added products such as kerb stones, paver blocks etc. starting May 2020 were underway. Additionally, the city has two mobile plants with a capacity of 400 TPD near the auto market in Basai.

As per their agreement with IL&FS, the civic body will get a 10 per cent share of proceeds from the sale of all concrete aggregate products or value-added products. In addition, if MCG purchases a concrete aggregate product they will get a 5 per cent discount on the price and 20 per cent discount on value-added products.

Recent development:* MCG has adopted a methodology (based on the TIFAC rule of thumb) to estimate the amount of C&D waste generated in a project. All projects are mandated to conduct estimations, disclose them to the MCG and pay C&D waste generation fee accordingly. Non-payment of the C&D waste-generation fee leads to sealing of construction sites. Non-disclosure of the estimation also attracts penalty, which has recently increased fivefold.

MCG has empanelled agencies for door-to-door C&D waste collection. MCG's C&D waste digital portal can be used to call up these agencies to pick up people's C&D waste. The service charges have been set at Rs 360 per tonne of C&D waste to be picked up. Since the service is currently not available throughout Gurugram, MCG has established multiple collection points in the city where people can send their C&D waste. MCG is empanelling the informal sector to provide transportation facilities to people unavailable to avail official service.

To ensure compliance, MCG has adopted new monitoring and enforcement practices, including night patrolling to identify illegal dumping activities, CCTV cameras at select locations, identification of C&D waste dumping hotspots, impounding of vehicles found illegally dumping C&D waste, and issuing e-Challans for violations.

MCG has made changes in contracting guidelines for all municipal construction projects. Now, their contractors are obligated to replace 10 per cent of their building material with processed C&D waste products. Recycled C&D waste products are being cross-subsidized so that they are cheaper than conventional building material. MCG has also decided that beginning October 2020 it will start manufacturing paver blocks and similar products from the recycled aggregates produced at its recycling plant. It will use these pavers in developing bicycle tracks and walking tracks within the city.

* Based on information shared by Vinay Pratap Singh, Municipal Commissioner of Gurugram, with CSE on 25 August 2020. It has not been verified by CSE as part of its field investigation.

10. GHAZIABAD

Ghaziabad is governed partly by the Ghaziabad Nagar Nigam (GNN) and partly by Ghaziabad Development Authority (GDA). The city is estimated to generate about 130 TPD of C&D waste.

C&D waste management

In 2019, GNN notified C&D waste management policy for the city. It defined the responsibility of every waste generator and stipulated that generators must:

1. Ensure that the collection, segregation and storage of C&D waste generated by it is made timely.
2. Ensure C&D waste is segregated at premises, into four streams, including:
   a. Concrete
   b. Soil
   c. Woods and plastics
   d. Bricks and mortar
3. Ensure that segregated waste is not mixed with MSW or each other and shall be stored separately at project premises.
4. Ensure the segregated waste is transported by the generator to the collection points (as notified by the GNN from time to time).
5. Pay Rs 445 per tonne for each kind of segregated waste to the agency authorized by GNN for the purpose of storage, processing and disposal of C&D waste.
6. Ensure that residents within the GNN municipal limits are facilitated by GNN against the payment of Rs 440 per tonne payable in advance to GNN. A separate escrow account shall be created to facilitate the GNN residents. Residents can submit requests or intimate the agency for removal of C&D waste.

ANURAG VERMA/CSE

C&D waste littering in Ghaziabad has severely affected mobility in the city

7. All bulk generators must submit a plan indicating the provisions made for the collection and segregation of C&D waste along with the project time period, prior to the commencement of project.
8. The plan must also include the actions planned by the bulk waste generators/ service providers, for the final cleanup of the premises after completion of the project. Bulk waste generators/service providers having already ongoing projects shall submit the plan within 30 days from the date of order.

Failure to comply with or contravention of these directions will be punishable under sub-section of Section 15 of the Environment (Protection) Act 1986, i.e. in respect of each failure or contravention after the conviction for the first such failure or contravention

Under Section 15 of the Environment (Protection) Act 1986, the Penalty for contravention of the provisions of the act and the rules, orders, and notification:

1. Imprisonment for a term which may extend up to five years with fine which may extend up to Rs 1 lakh, or with both, and in case the failure or contravention continues, with additional fine which may extend up to Rs 5,000 for every day during such failure or contravention continues after the conviction for the first such failure or contravention.
2. If failure or contravention continues, the offender shall be punishable with imprisonment for a term which may extend to seven years.

C&D waste-processing plant

In 2018, GDA proposed to set up a C&D waste processing facility spread over 5 acres (2.02 hectares) of land. In 2019, a recycling plant of 150 TPD capacity started functioning in the city. The plant is operated by eCube India (P) Limited under a PPP agreement with GNN. The urban local body (ULB) is levying Rs 260 per tonne as fees for collection and transportation of C&D waste from private waste generators.

11. NOIDA

ANURAG VERMA/CSE

Noida is a hotspot for construction activities but city authorities have not made C&D waste management a priority

The city is governed by the New Okhla Industrial Development Authority (NOIDA). There are no official estimates for the quantity of C&D waste generated by the city. The city has a C&D waste-recycling plant operational in Sector 80 which has the capacity to treat 150 TPD. It is planned to increase the capacity of the plant to 300 TPD. Residents can call a helpline number to register complaints regarding dumping of C&D waste. Unidentified C&D waste is also collected from across the city and taken to the C&D waste-processing facility.

12. INDORE

Indore is governed by the Indore Municipal Corporation (IMC). CPCB in G*uidelines on Environmental Management of C&D Wastes* estimated 100 TPD as the city's C&D waste generation. [135]

C&D waste-processing plant

IMC set up a C&D waste-processing plant near Devguradia Trenching Ground. The plant has a capacity of 100 TPD and covers 4 acres (1.61 hectares). It has a life expectancy of 15 years. It was set up by M/S DNP Pvt. Ltd, Ahmedabad. The project design and management consultant was Eco Pro Environmental Services, who is also the consultant for Indore Municipal Corporation. The operation and maintenance (O&M) work for the plant is allotted to Sita Daily Company. Construction work at the site began on 12 December 2017 and it was completed on 20 February 2018.

Collection and segregation

IMC has four collection and segregation centres for C&D waste. For the collection of waste there are three procedures:

a) Any C&D waste generator can bring their waste on their own expense and dump it at the collection centre.
b) The C&D waste generator can call on a toll-free number for collection of their C&D waste on a payment basis.
c) The C&D waste generator can also use the Mayor helpline app, i.e. Indore 311 app, for collection of their C&D waste on a payment basis.

The payment basis is as follows:

- If the material is transferred in small loading vehicle, charges are Rs 1,200 per trip.
- If the material is transferred in a large loading vehicle, its charges are Rs 2,000 per trip.

The four collections and segregation centres are as follows:

a) IT Park Square, Indore: The collection centre at the IT Park square covers an area of 4,600 sq. m (23 m x 200 m). The approach road is a flexible bitumen pavement.
b) Gandhinagar Centre: The collection centre at Gandhinagar Centre covers an area of 3,600 sq. m (40 m x 90 m). The approach road is a flexible bitumen pavement.
c) Kabitkhedi Centre: The collection center at Kabitkhedi Centre covers an area of 3,600 sq. m (40 m x 90 m). The approach road is a flexible bitumen pavement.
d) Ahirkhedi Centre: The process of land acquisition is under process for setting up the collection centre.

The waste from the collection and segregation centre is then transported to the processing plant. The cost for transportation of C&D waste from the collection centre to the processing plant will be levied by the O&M company.

13. HYDERABAD

Hyderabad is composed of 150 wards managed by the Greater Hyderabad Municipal Corporation (GHMC). CPCB in *Guidelines on Environmental Management of C&D Wastes* has estimated 5,000 TPD as the city's C&D waste generation. No official estimate is available from GHMC but it has been reported that it collected over 217,000 tonnes of C&D waste in 2019 at its Jeedimetla plant, the only operational C&D dump site in the city.[136]

C&D waste management

The authorities are also planning to collect C&D waste-generation fees from developers/owners, which will be charged at 20 per cent of the building permit fees. The fees will have to be paid in advance along with details of the amount of C&D waste expected to be generated.[137]

Citizens can reach the GHMC helpline or lodge a request through the ULBs mobile application to get their C&D waste lifted for which the authorities charge Rs 360 per tonne, which includes transportation from the site to the recycling facility.[138] All the vehicles used for transportation are equipped with a GPS to better monitor their movement and prevent illegal dumping.[139] Unauthorized dumping of C&D waste attracts heavy penalties in Hyderabad. The first offence is fined at Rs 25,000, with an additional Rs 25,000 for the second consecutive offence. The third offence attracts Rs 1 lakh. The entity on whose behalf the C&D waste is dumped in an unauthorized way is fined Rs 50,000.

C&D waste-processing plant

CPCB has noted in *Guidelines on Environmental Management of C&D Wastes* that GHMC has proposed setting up decentralized C&D waste recycling plants at four locations (Fathullaguda, Jeedimetla, Kothwalguda and Mallapur). A 500-TDP-capacity plant was set up at Jeedimetla in 2019 under a public–private partnership (PPP) between GHMC and the Ramky Group. A recycling plant at Fathullaguda will also be set up by the Ramky Group.[140]

14. CHANDIGARH

The Municipal Corporation Chandigarh (MCC) is the local body responsible for the city's waste management. According to the MCC, the city generates 90 TPD of C&D waste.[141] But CPCB in *Guidelines on Environmental Management of C&D Wastes* estimated just 3.5 TPD as the city's C&D waste generation.

C&D waste management

MCC's C&D waste policy mandates that anyone reconstructing their house/building has to send the generated C&D waste to the plant in Chandigarh Industrial Area, Phase 1. The ULB has levied C&D waste processing charges at the rate of Rs 160 per sq. m per storey for reconstruction and renovation, and Rs 40 per sq. m per storey for new construction. These are to be paid at the time of the approval of the building plan. The fee will be increased by 10 per cent annually from 1 April every year.[142]

Generators are be allowed to take the processed material from C&D waste worth the fee paid to the plant at their own transportation cost within one year of the approval of their building plans to use it as construction material.

In case of violation, a challan is charged at the rate of Rs 5,000 per vehicle for dumping unprocessed waste outside designated collection and processing points. Charges for the challan will be increased by 10 per cent every year.

C&D waste-processing plant

MCC has set up the C&D waste-processing plant in Chandigarh Industrial Area, Phase 1. The plant became operational on 15 May 2019. It has a capacity of about 150 TPD for crushing construction waste—the capacity can be increase further up to 180 TPD.[143] The plant produces material that can be utilized for cement concrete works such as washed sand, crushed aggregates of 10 mm, 20 mm and 40 mm. The plant also manufactures road material, i.e. kerbs, channels, tiles and paver blocks.

MCC has been dragged to the National Green Tribunal (NGT) for not seeking environmental clearance from the pollution control authority for setting up the plant.

15. TIRUPATI

DINESH RAJ / CSE

Tirupati segregates its solid waste

The Municipal Corporation of Tirupati (MCT) is the local body responsible for the city's waste management. Tirupati is divided into 50 municipal wards. There are no official estimates available for C&D waste generated in the city.

MCT notified some key provisions of the C&D Waste Rules in October 2018.[144] In February 2019, MCT commissioned a C&D waste handling facility through a 20-year build, own, operate and transfer agreement with Pro Enviro C&D Waste Management Private Limited. The facility is being developed under the Smart Cities Project. A 2-hectare site has been granted to the concessionaire at the Tukivakam village, adjacent to the city's composting site. Operations have started with mobile equipment and the facility is expected to be fully functional by the end of 2020. The concessionaire charges Rs 450 per tonne from bulk generators. The service is also available for one-time generators of C&D waste at the same rate.[145]

16. VIJAYAWADA

Vijayawada is divided into 59 municipal wards and waste management is the responsibility of the Vijayawada Municipal Corporation (VMC). According to VMC, the city generates about 150 TPD of C&D waste.[146] But CPCB in *Guidelines on Environmental Management of C&D Wastes* estimates just 70 TPD as city's C&D waste generation.[147]

C&D waste-processing plant

In November 2018, VMC awarded a contract to PRO Environs C&D Waste Management Pvt. Ltd to recycle the city's C&D waste. The 200 TPD processing facility was established on a build, operate and transfer model. The company was given land on a 20-year lease. The plant has been receiving and processing 80–100 tonnes of C&D waste per day and generating 25 tonnes of recycled sand and aggregates. Bulk generators have to either transport the C&D waste to the processing facility or pay transportation charges.[148]

Transportation

The collection and transportation of C&D waste from generators and collection points is contracted out to the plant operator.

To ensure quality of service, VMC has defined penalties that will be levied on the agency in the following cases:

- Failure in lifting C&D waste (at least one truckload) from designated location—fine Rs 2,000;
- Failure in transporting C&D waste to the processing facility—fine Rs 2,000 per instance;
- Failure to lift claimed C&D waste from the generator within 48 hours—fine Rs 2,000 per instance;
- Failure to lift C&D waste dumped on roadside within 24 hours—fine Rs 1,000 per instance;
- Non-performance of any other obligation under the Agreement for a continuous period of seven days fine Rs 10,000.[149]

C&D waste reutilization

According to media reports, the plant was manufacturing around 25 tonnes of sand each day by recycling C&D waste and the entire quantity was supplied to realtors. Each tonne of recycled sand was sold for Rs 450; 5 tonnes was sold for Rs 1,800. The same quantity was sold for Rs 8,000–10,000 in the local market.[150] The plant was receiving bulk orders from realtors in and around the city due to shortage of sand in the region.

ANNEXURES

Annexure 1: Dust-control checklist for construction projects

On-site dust control[151]	
S. no.	**Activity**
Material handling	
1	Watering is undertaken whenever necessary for the following:
	Unpaved areas (e.g. unpaved main haul road)
	Access roads
	Construction areas
	Any dusty materials before loading and unloading
	Stockpile of dusty materials
2	Water sprays are either fixed or mobile to allow individual areas to be wetted as and when required.
3	Application of suitable wetting agents (e.g. dust suppression chemicals) is used in addition to water if necessary.
4	Debris is covered entirely by impervious sheeting or stored in a debris collection area sheltered on the top and the three sides.
5	Every debris chute shall be enclosed by impervious sheeting or similar materials.
6	Conveyor belts are fitted within wind boards.
7	Conveyor transfer points and hopper discharges are enclosed.
8	Drop heights are minimized from all conveyors.
9	Materials that have the potential to create dust are enclosed.
10	Storage time of materials on-site is minimized.
11	Bulk crushing and/or material storage takes place inside sheds.
12	Skip hoist is enclosed by impervious sheeting.
13	Debris chute is enclosed by impervious sheeting.
14	Debris collection area is sheltered on the top and on three sides.
Hoarding/dust screen	
15	Hoarding of not less than 2.4 m high from ground level is provided along the building site boundary.
16	Effective dust screens, sheeting or netting is provided to enclose any scaffolding built around the perimeter of the building under construction.
17	Screening of dust generating activities through the use of wind breaks.
Excavation	
18	Working area of any excavation or earth moving operation is sprayed with water immediately before, during and immediately after the operation.
19	Exposed earth is properly treated by compaction, turfing, hydroseeding, vegetation planting or sealing with suitable surface stabilizer within 6 months after the last construction activity on the site.
20	Any spoil, debris or material and silt are removed and the affected land and areas are restored to the natural state.

Vehicle dust/emission	
21	Heights from which excavated materials are dropped during loading/unloading are minimized.
22	Three-sided roofed enclosure with a flexible curtain across the entry is provided when dusty materials are discharged to vehicles from a conveying system at a fixed transfer point.
23	Surface of the areas within the site where there is regular movement of vehicles are paved and any loose surface material is removed.
24	Vehicles within the site are restricted to a maximum speed of 8 kmph and speed limit signage is put up at appropriate locations.
25	Haulage and delivery vehicles are confined to designated roadways inside the site.
26	Materials transported off-site by vehicles are covered by tarpaulin, with the cover properly secured and extended over the edges of the side and tailboards.
27	Dusty materials are dampened before transportation.
28	Vehicle washing facility(ies) is/are provided at all site exist(s) to wash away any dusty materials from vehicle body and wheels before they leave the site.
29	A hard-surfaced road between any washing facility and the public road is provided.
30	Wheel washing facilities are inspected, maintained and cleaned on a regular basis.
31	Vehicles are inspected regularly and well maintained to ensure that they are operating efficiently and that exhaust emissions are not causing nuisance.
32	Vehicle engines are turned off when they are not in use.
33	Settling silt/sediment in wheel washing bays is removed regularly.
34	Any earth, mud and debris at the site exit is removed.
Demolition works	
35	Any area in which demolition work takes place is sprayed with water immediately prior to, during and immediately after the demolition activities to maintain the entire surface wet.
36	Impervious dust screens or sheeting is used to enclose the whole wall to a height of a least 1 m higher than the highest level of the structure being demolished.
37	Any dusty materials remaining after a stockpile is removed are wetted with water and cleared from road surfaces.
38	Use of enclosed chutes for dropping demolition materials to ground level and the chutes are dampened regularly.
39	If asbestos is found in the buildings or structure, special procedures as detailed in the Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste must be followed.
Drilling and blasting	
40	Spray water during breaking of rock or concrete.
41	Areas within 30 m from the blasting area shall be wetted with water prior to blasting.
42	Blasting operations are well arranged and appropriate precautions are taken (e.g. use of blast nets, canvas covers and watering).

Annexure 2: Dust-control checklist for C&D waste collection and transportation

Collection and transportation dust control[152]	
S. no.	**Activity**
Debris handling	
1	Debris is covered entirely by impervious sheeting or the collection point is sheltered on the top and three sides.
2	Watering is undertaken whenever necessary for the following:
	Unpaved areas (e.g. unpaved main haul road)
	Access roads
	Construction areas
	Any dusty materials before loading and unloading
	Stockpile of dusty materials
3	Water sprays are either fixed or mobile to allow individual areas to be wetted as and when required.
4	Application of suitable wetting agents (e.g. dust suppression chemicals) is used in addition to water if necessary.
Vehicle dust/emission	
5	Heights from which C&D waste are dropped during loading/unloading are minimized.
6	Three-sided roofed enclosure with a flexible curtain across the entry is provided when dusty materials are discharged to vehicles from a conveying system at a fixed transfer point.
7	Materials transported off-site by vehicles are covered by tarpaulin, with the cover properly secured and extended over the edges of the side and tailboards.
8	Dusty materials are dampened before transportation.
9	Vehicle washing facility(ies) is/are provided at all collection/disposal point exist(s) to wash away any dusty materials from vehicle body and wheels before they leave the site.
10	A hard-surfaced road between any washing facility and the public road is provided.
11	Wheel washing facilities are inspected, maintained and cleaned on a regular basis.
12	Vehicles are inspected regularly and well maintained to ensure that they are operating efficiently and that exhaust emissions are not causing nuisance.
13	Vehicle engines are turned off when they are not in use.
14	Settling silt/sediment in wheel washing bays is removed regularly.
15	Any earth, mud and debris at the collection/disposal site exit is removed.

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Centre for Science and Environment

Centre for Science and Environment (CSE) is a non-governmental, independent policy research institution based in Delhi that was started in 1980 by the late Anil Agarwal, a leading figure in India's environment movement.

For more than three decades now, CSE has helped shape policies and build public awareness to bring change in areas of pollution mitigation and public health security, low carbon development, natural resource management and livelihood security to make growth sustainable and inclusive.

CSE's public advocacy and research efforts have delivered path-breaking results—from championing equity in **climate change** negotiations, to supporting public transport and **sustainable mobility** practices in cities (CNG in Delhi), and mobilizing the country through a water literacy programme that catalyzed important policy changes on decentralized **water and wastewater management.** CSE programmes have achieved important public health outcomes by strengthening regulatory oversight in the use of **pesticides and heavy metals,** while its innovative **industry ratings** programme that certifies environment performance, serves as an alternative model of civil society governance to control industrial pollution and resource efficiency in India.

Today, CSE is well recognized for its path-breaking role in **capacitating public institutions** and regulatory agencies, while its **environmental education** efforts across a vast network of schools helps build a cadre of knowledgeable, committed environmental actors.

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Such is our footprint.

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Construction and demolition (C&D) waste poses a serious threat to our environment. Heaps of concrete, bricks and metal waste from building construction and infrastructure choke our waterbodies, green areas and public spaces in cities and outside. Huge amounts of toxic dust particles from the debris pollute the air. Rules to manage this waste were notified in 2016, but their implementation on the ground has remained a challenge. Recent critical policy developments are now expected to have a strong bearing on acceleration of C&D waste management in cities.

The National Clean Air Programme aims to reduce particulate pollution by 20–30 per cent by 2024 in about 122 cities that do not meet the National Ambient Air Quality Standards. Clean-air action plans in these cities have included C&D management as part of their clean-air strategies. The other big development is the 15th Finance Commission's direct allocation of Rs 4,400 crore to urban local bodies (ULBs) for air pollution control. C&D management is the direct responsibility of ULBs, and this funding can catalyse transformation in cities and strongly support Swachh Bharat Abhiyan.

This report assesses the current preparedness of cities with regard to C&D waste management and presents an action plan with detailed indicators for strategy development and implementation.

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