GUIDANCE FRAMEWORK FOR BETTER C&D WASTE MANAGEMENT

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Abbreviations

CPWD	Central Public Works Department
DDA	Delhi Development Authority
DIMTS	Delhi Integrated Multimodal Transit System
DJB	Delhi Jal Board
DMRC	Delhi Metro Rail Corporation
DRSDO	Delhi Rural & Slum Development Organization
DSIIDC	Delhi State Industrial and Infrastructure Development Corporation Ltd
DTC	Delhi Transport Corporation
DUSIB	Delhi Urban Shelter Improvement Board
EWS	Economically weaker section
GNCTD	Government of National Capital Territory of Delhi
HIG	High-income group
IPT	Intermediate public transport
LIG	Low-income group
MCD	Municipal Corporations of Delhi
MIG	Mid-income group
NHAI	National Highway Authority of India
NMT	Non-motorized transport
RTO	Road Transport Office

C&D waste management and dust control—strategy for action

Under the National Clean Air Programme (NCAP), Ministry of Environment Forest and Climate Change (MoEF&CC), 132 non-attainment cities (NAC) are in the process of implementing Clean Air Action Plans to reduce particulate pollution by as 20–30 per cent from 2017 levels by 2024. In addition to this, under the recommendations of the 15th Finance Commission, 42 cities with more than a million population each have been identified for direct funding for urban local bodies (ULBs) for air pollution mitigation. This programme aims for 5 per cent reduction in particulate pollution annually over a period of five years.

These developments have led to the framing of multi-sector Clean Air Action Plans to cut emissions from both combustion and dust sources in cities. While combustion sources include vehicles, industry, power plants, waste burning, lack of clean energy access, among others, dust sources primarily include construction and road dust. With implementation of the plans underway, the focus is increasingly shifting towards proper strategy development for effective reduction of emissions from each source.

The current engagement of Centre for Science and Environment (CSE) with several ULBs and other concerned departments in states have shown that there is enormous demand for a deeper understanding of specific action in each sector to inform the implementation process. The need is to identify the processes, infrastructure and technologies, system planning for implementation and enforcement, policy backing and role definition of different departments and sub-departments for coordinated delivery of services.

This system approach is also needed for planning a funding strategy for the sector. In the absence of proper guidance on the scope and nature of action, infrastructure and technology development, the current approach towards spending of the available fund may lock in ineffective solutions.

Moreover, robust sectoral guidance is needed to further inform the Central monitoring and evaluation framework for NCAP implementation. Central Pollution Control Board (CPCB) has already developed detailed indicators to track quarterly progress in cities. This can be further refined for application to strengthen implementation in cities.

As part of its initiative to develop a guidance framework for implementation of clean air solutions, CSE has selected mitigation of pollution from the construction and demolition waste (C&S) sector as the first in the series to highlight the system design needed for implementation. C&D is the direct responsibility of ULBs, funded under the recommendations of the 15thFinance Commission.

All ULBs are required to develop effective strategy for C&D waste streams as cities are continuously building and expanding infrastructure and built spaces. While cities have their respective agenda of expanding road networks and promoting building construction, national development initiatives are also adding to the frenetic pace of construction in cities. Some of these include the Housing for All mission to build 11.2 million houses by 2022; the Smart Cities Mission; and the Atal Rejuvenation Mission for Urban Transformation (AMRUT). In addition, there is the basic service infrastructure, including water supply and sewage network, buses and metro rails, among others, and now the US$1.5 trillion infrastructure under PM Gati Shakti National Master Plan for multi-modal connectivity to economic zones.

It may also be noted that the Ministry of Housing and Urban Affairs has implemented the Swachh Survekshan programme that is evaluating the implementation of C&D Waste Management Rules, 2016. This review performance of cities related the entire management process and the extent of utilization of C&D waste. In the 2021 edition of the Swachh Survekshan programme, the management of C&D waste stream has been given more weightage in scoring related to overall waste management. This has doubled the points from the previous year's edition—from a total of 50 point to 100 points. This current version is more comprehensive in considering different aspects of management. This programme has created conducive conditions in cities to strengthen waste management.

Construction is responsible for substantial local pollution. Each phase of construction—material transfer, demolition, collection and disposal of waste—generates toxic dust that requires well-defined mitigation strategies. Several source assessment studies carried out in cities have shown substantial relative

contribution of the construction sector to pollution concentration and pollution load. For instance, a source apportionment study conducted by TERI-ARAI in Delhi revealed that dust and construction together contribute 38 per cent to $PM_{2.5}$ and 41 per cent to PM_{10} concentration during summers.

Higher generation and illegally dumping of C&D waste cause air, water and land pollution and environmental degradation of ecologically sensitive areas. Low recycling rates of C&D waste increase dependence on naturally sourced virgin material and mining impacts. Improper construction management at sites leads to fugitive dust emissions and increases public health exposure and risk. These challenges require immediate attention as India stands at the cusp of enormous development.

For mitigation of pollution and proper waste management, Central policies and regulations have already taken shape. C&D Waste Management Rules, 2016 and Environment (Protection) Amendment Rules, 2018 have laid down mandatory requisites for addressing some of the adverse effects of C&D waste. CPCB's Guidelines on Dust Mitigation Measures in Handling C&D Material and Waste, 2017 and Building Material and Technology Promotion Council's (BMTPC) Guidelines on Utilization of C&D Waste in Construction of Dwelling Units and Related Infrastructure in Housing Schemes of the Government, 2016 provide overall guidance and mandate.

However, most cities are yet to adopt and implement these rules. The key concern is how to bridge the gap between policies and regulations on the one hand and their implementation on the other hand.

Scientific management of C&D waste and its reuse is central to C&D waste management. This is consistent with the circularity requirements of Sustainable Development Goal Number 12 on Responsible Consumption and Production. India's draft National Resource Efficiency Policy (NREP), 2019 states that resource extraction in India is 1,580 tonnes per acre, much higher than the world average of 450 tonnes per acre. Recycling rates and material productivity are much lower than the global average as well. Indian cities need to gear up to enable recycling and reuse of C&D waste in the face of a booming construction sector.

This guidance document, therefore, investigates the gaps in current approaches to C&D waste management in cities and helps to identify the steps needed in different phases of construction and waste disposal for effective mitigation.

Investigation

This national-level guidance framework has been developed based on assessment of ground-level situations in cities to provide deeper insight into action. This investigation primarily focuses on the preparedness and capacity for implementation of C&D Waste Management Rules, 2016, Environment (Protection) Amendment Rules, 2018 and the provisions of Clean Air Action Plans in cities. Field assessment in select cities across several states, including Haryana, West Bengal and Rajasthan, was carried out to understand the ground reality, barriers and opportunities. Insightful evidence is available from Gurugram, Kolkata, Howrah, Jaipur, Udaipur and Kota and a few other places that also represent a mix of Tier 1 and Tier 2 cities. The evidence alsocaptures administrative and operational nuances. Direct engagement with the state environment and urban development departments and interactions with ULBs have helped to capture the current status of C&D waste management and dust control measures.

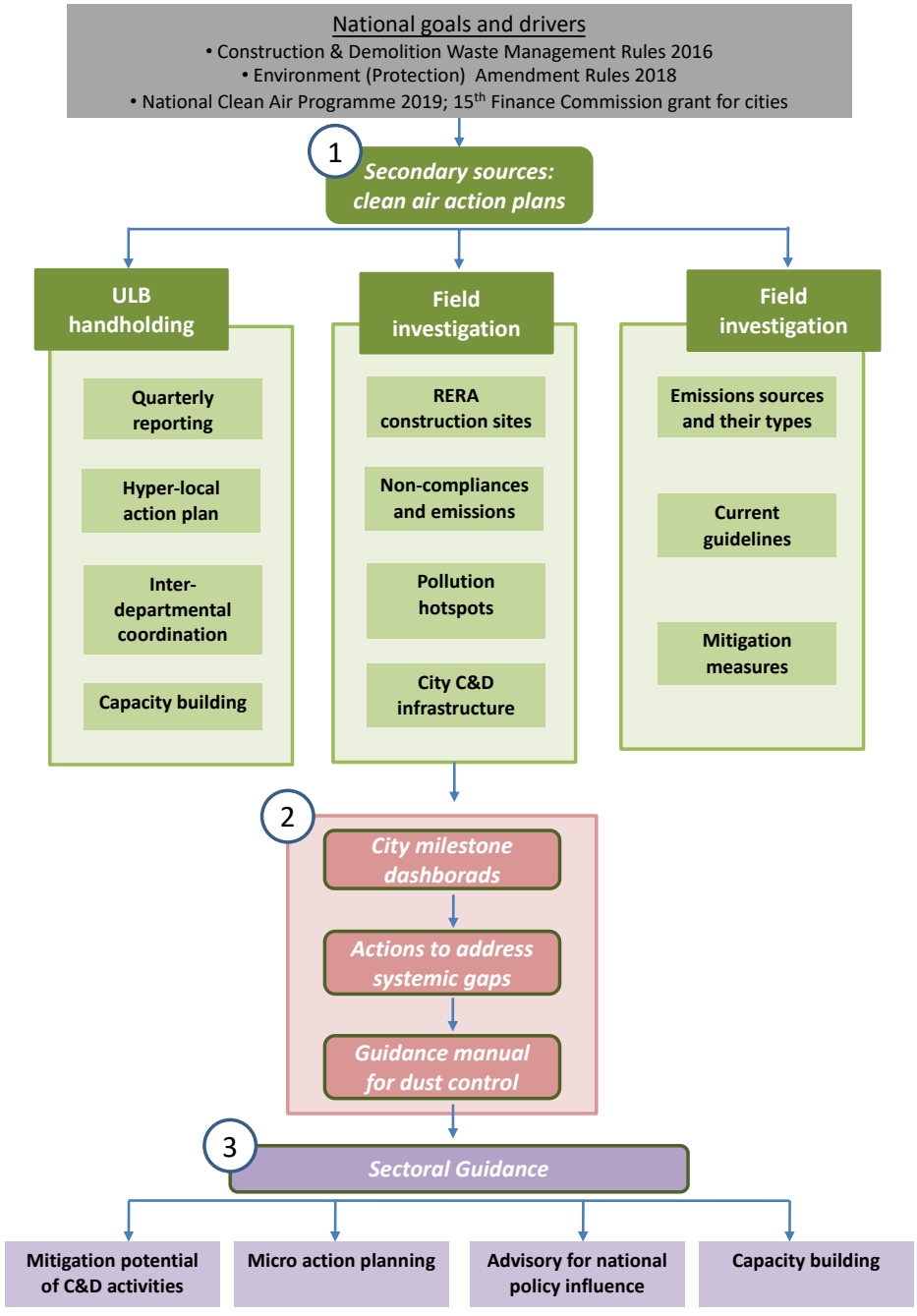
Field investigation has looked at C&D infrastructure (collection points, illegal dumping areas, material vending points, etc.), pollution hotspots (identified by independent research organizations) and construction sites available on the state RERA portal. This has also explored value-trade chain of C&D activities and also emissions associated with those activities. Field assessment has also been supported by a literature review.

This operational guidance framework at the city-scale and site-scale provides technical know-how on the procedures to contain fugitive dust from C&D activities and streamline operations. This framework has also identified systemic gaps in implementation of C&D waste management and dust control rules. Based on this assessment, an attempt has been made to identify the interim milestones that need to guide action and investment plans. This milestone dashboard is based on C&D Waste Management Rules and dust control rules for a cohesive approach.

In this context, the value-trade chain and emissions chain in cities have been assessed to understand operations, infrastructure, successes, challenges and mitigation potential in the C&D sector. There is very little understanding in cities about the mitigation potential of specific action for C&D waste management and dust control. This assessment has attempted to identify more clearly the activities that contribute to the pollution, locational aspects, the actors involved, and similar factors and processes. The identification helps to establish the nature of non-compliance. This assessment has been done at two levels: city and site level. The guidance has also been framed accordingly to guide action at the construction site level and at the city level and to minimize violation of rules and non-compliance.

This guidance framework on C&D waste management is expected to help cities to prioritize action and budgetaryallocation. It can also inform the current national-level monitoring and evaluation framework for tracking of progress and for a well-rounded impact in the C&D sector.

Figure 1: Methodology adopted for the investigation



Source: CSE

Highlights of key issues

Weak estimation on the quantum of C&D waste: Currently, there is little understanding of how much C&D waste is being generated in cities. The volumetric data on C&D waste in cities is either based on collection of unclaimed or legacy waste or at best an assumed proportion of municipal solid waste (about 20 per cent). Cities are investing in C&D waste recycling plants in absence of data on volume and sub-streams of C&D waste. This could result in challenges like an under-capacity plant and poor uptake of recycled C&D waste products. Further, a few regulatory mechanisms that gather information on the volume of C&D waste such as PARIVESH portal for environmental impact assessment of building and construction activities are facing the issue of gross under-reporting by project proponents. Moreover, there is no clear system for monitoring and regulating big or small demolition contractors. The demolition sector needs to be formalized through an official permit system. This will not only allow better management and material recovery but also enable better estimation of C&D waste.

It is important to quantify and characterize all sub-streams of wastes for system planning. For instance, new housing construction is bringing more new generation material like expanded polystyrene insulation (EPS), styrofoam, plastic spacers, bituminous material and asbestos embedded within new wall assemblies. These pose a serious recycling challenge. Thermoplastics (polycarbonate, polyethylene, polypropylene, PVC, etc.) can be recycled, but their recycling involves higher costs. Thermosets (epoxy adhesives) are difficult to recycle. They need special attention for system planning.

Poor understanding of systems and processes to design infrastructure for funding: An assessment of action taken by cities under the 15th Finance Commission's performance-linked grant reveals that funds are not going into setting up of systems that help in implementation of C&D waste management or dust control for a long-term impact. Instead, cities are investing in a way that will have only short duration impact. This requires detailed mapping of different phases of construction process, material handling and transport, system analysis, capacity assessment for recycling, among others, to be able to decide priority funding. Also, the system will need to integrate the informal sector. Swachh Survekshan 2021 has recognized the opportunity of involving the informal sector in the formal management of C&D waste. This can generate jobs and livelihood. Leveraging the existing informal setups and infrastructure has potential to reduce the need for additional infrastructure as well as high-value resource recovery.

Current implementation of C&D waste and dust control rules are ad hoc: This assessment has revealed that actions taken by cities for C&D waste management and dust control are largely ad hoc in nature. Currently, cities do not have adequate knowledge and administrative clarity regarding technological approaches, human resource, mandate and overall systems to implement C&D waste and dust control rules. Cities lack strategy and are in dire need of capacity building to be able to make informed decisions.

Current monitoring framework is not holistic: CPCB has established a quarterly progress monitoring framework consisting of several indicators that require cities to report progress on clean air action under NCAP. It is helpful. An analysis of C&D waste and road dust indicators reveals that there is a lot of emphasis on enforcement-related action. For instance, the monitoring system tracks the number of challans issued for non-compliance, enforcement of rules related to transportation of construction materials, number of sites with separate space to handle C&D waste or km travelled by mechanical sweepers to remove road dust, silt and so on. While such data is important and helps to ensure more discipline in implementation, it falls short of ensuring proper process and infrastructure development to address gaps in the infrastructure needed at scale for stipulated C&D waste management rules and dust control rules and sustained improvement.

Next steps

Need data and estimation of quantum of C&D waste to design systems: As C&D waste is a relatively new area of management, there is a lot of ambiguity on how to quantify C&D waste. Several methods ranging from per-capita multiplier, zero-based estimation, geographic information system-based extrapolation, area-based calculation to building information modelling, among others, are used globally. Institutional strengthening is needed to adopt some of the methods.

Moreover, city master plans can help project C&D waste generation based on the scope for development as per the city master plan and other construction programmes using GIS. CSE estimated that cities need to gear up for at least three times the volume of C&D waste they are planning to manage. For instance, Jaipur is planning for a C&D waste facility of 300 TPD capacity, but the projection using Jaipur Development Plan, 2035 shows generation of at least 1,000 TPD of C&D waste. Further, online portals like state RERA database and PARIVESH platform are good sources to understand the current volume of C&D waste. As these portals collect data such as location of the project and the floor area to be

constructed, cities can learn how much C&D waste is being generated using area-based calculation and TIFAC thumb rules. Estimation using this data can give a closer-to-ground picture on the volume of C&D waste being generated and guide operations, processing capacity and strategy for re-utilization.

Cities must create easily accessible databases of buildings along with their physical and legal attributes and also infrastructure projects. Excavated waste, or bituminous waste from roads, can be challenging for recycling. Construction and demolition permits need to be inventorized and associated waste management plans associated with them. The method for quantification also has to consider the new-age construction materials that are expanding, especially under the Pradhan Mantri Awas Yojana (PMAY) for the affordable housing sector. Urban local bodies and the construction industry should have the capacity to forecast waste generation from construction sites for proactive approaches.

Monitoring frameworks need qualitative milestones and quantitative information: Cities need a milestone-based approach to improve quality and effectiveness of C&D waste management and dust control methods. The provisions of C&D Waste Management Rules, 2016 and Environment (Protection) Amendment Rules, 2018 or dust control rules involve key requisites that are vital for addressing these subjects in a cohesive manner. Cities are also assessed and ranked based on the Swachh Survekshan programme of Government of India that ranks cities based on the service delivery in waste management sector. Overall, data and research, planning for collection points and a disposal system, digital tracking for enforcement, notification of C&D waste bye-laws, setting up of processing plants, streamlining of operations, public awareness and capacity building, and enforcement, among others, are milestones that will lead cities to scientific and effective implementation of C&D waste management and dust control rules. Also, characterization of C&D waste is necessary for management plans, including collection, transportation and storage, processing techniques and technologies used, and products to be manufactured from recycled waste. This characterization requires a strong monitoring and evaluation framework.

Need operational guidebook for each phase of C&D activities and appropriate capacity building: There are several factors that affect the mitigation potential of dust control measures in C&D activities: i) timing of activities, ii) technical know-how on how to carry out the activities with clear standard operating procedures and management information systems, and iii) designing adequate appropriate infrastructure for on-site management, segregated collection, material recovery

and utilization of recycled material. This will also require mapping of the full range of non-structural applications including pavements, filling of plinth, etc. for uptake of recycled materials. CSE's guidance framework addresses C&D activities at the city-scale and site-scale. Both demolition activities as well as smaller construction sites that do not require environment impact assessment will have to be brought within the ambit of proper management and enforcement. Regulators, municipal workers, developers and transport agencies need to be guided and trained on the effective conduct of these activities to limit dust emissions. A strategy to integrate the informal sector to optimize human resource for waste collection and segregation and disposal to further optimize the formal management is also required.

Budget priorities with regard to dust control and C&D waste management infrastructure need to maximize air pollution mitigation potential: Currently, budget allocation by cities in the sector is ad hoc and not linked with performance or assessment of mitigation potential of action. Understanding of the programme scope, infrastructure design, technology requirements, etc. is limited. Mitigation potential of action for C&D waste management and dust control and overall greening of the construction sector is not well understood. Priority in budget must be given to actions with high mitigation potential and long-term impact. This requires mapping of pollution generation potential of each phase of construction and demolition, material transfer, collection and recycling and the technological and infrastructure intervention needed for pollution control. While a lot of investments in the mitigation measures and technologies will have to be done by the construction agencies, it is necessary to map out the areas that will require public funding. ULBs will have to invest in monitoring systems and infrastructure, digital tracking and digital servers, geo-tagging and waste management sites, etc. Currently, there is lack of clarity about what is fundable and as a result the fund allocation for the sector is minimal and not well rationalized.

Need city-based assessment of administrative and operational aspects of C&D management to institutionalize the process: Current investigation into the volume data, budget, monitoring parameters, non-compliance, governance and procedural structures in a few cities of threes states: Haryana, West Bengal and Rajasthan, has revealed several institutional and governance aspects that need urgent attention. This investigation has revealed that these parameters related to institutional arrangements and governance systems vary from city to city. This requires assessment ofthe institutional architecture with clear delineation of roles of the departments in the entire chain to establish clear responsibility and accountability.

Integrate the construction industry to mainstream requirements of C&D waste management in construction planning and execution: Involvement of the industry in planning and execution of mitigation measures is currently weak. Big construction (more than 20,000 sq. m) that has to go through an environment impact assessment process has obligation to adopt measures to mitigate the effect of C&D waste. The environment management plans need to be monitorable. But the smaller construction sites that are numerous and widely dispersed across the city operate within a much weaker system. There are no clear approval and monitoring systems for them. Global good practices indicate a combination of fiscal penalty, tax incentive related to material recovery and also comprehensive waste minimization, and management tools and plans to guide the industry. ULBs need to move in that direction.

This guidance framework has highlighted the key challenges in the sector that need to be addressed for on-ground implementation. This provides detailed guidelines for each construction phase both at the site-scale and the city-scale to guide on-ground action. This analysis is focused more on the operational and practical aspects of C&D waste management in cities.

C&D waste—guidance framework

This is a guidance framework for management of construction and demolition waste (C&D) waste at the city level in India to minimize environmental impacts due to, and address material crisis in, the construction sector. While at one level the construction industry is generating colossal quantities of material waste, at another level its demand for primary and virgin material like minerals, stone, timber, sand, aluminum, etc. is also increasing with serious consequences for the natural environment.

States and construction industry have an obligation and mandate to implement the Construction and Demolition Waste Rules and Regulations, 2016 to create systems for on-site C&D waste management and re-use, develop systems and infrastructure for material handling, recovery and recycling from C&D waste, and to put adequate incentives in place for uptake of the recycled material.

In addition, air pollution control measures require adoption and stringent enforcement of dust control measures at construction sites. Formal adoption of dust mitigation measures at the planning and construction stages to minimize dust impacts of construction are also needed. So are detailed guidance on dust mitigation measures, technological approaches, on-site management of material storage, water supply and water sprinkling methods, effective dust barriers and suppression, management of stockpiles, and well-regulated concrete production, among others. Several official checklists of dust control measures are in place but detailed adoption and monitoring still remain a challenge.

As part of the monitoring and evaluation of C&D waste management under the NCAP, detailed indicators related to dust control and C&D management (linked to C&D Rules) have been provided by the CPCB to track and report progress. This detailed reporting in cities has shown several gaps in the system and infrastructure that need to be addressed.

Moreover, Swachh Survekshan, which evaluates and ranks ULBs on a number of points related to waste management for improved service delivery, has continuously improved the scoring points to push the ULBs towards a more robust system. The 2021 scoring scheme is two-pronged and divided into two categories

with equal marks. Section A comprises three indicators that target notification and enforcement of charges preferably built-in with building permission; mobile collection facility available on call and collection points designated at a reasonable distance from the generator; and a five sub-stream segregation at designated collection points. Section B focuses on use of unprocessed C&D waste in non-structural applications and use of recycled C&D waste in government and private construction activities.

In view of these regulatory mandates and requirements, cities need to develop robust systems for improved service delivery, minimize waste generation and maximize material recovery. This guidance is based on the regulatory requirements that cities need to adhere to as well as the gaps that have been noticed in implementation and in processes in selected cities. This reality check is necessary for practical guidance.

1. Approaches to quantifying C&D waste

Estimation of C&D waste

C&D waste has not been managed as a separate stream in India. It is most often mixed with municipal solid waste in cities. Cities have not yet developed comprehensive assessment and quantification system for C&D waste generation, so that infrastructure and systems for treatment and management can be planned accordingly. A significant portion of the waste is handled by informal markets and illegal filling beyond the municipal jurisdiction is quite common.

A broad estimate shows that India is able to recycle only about 1 per cent of the total C&D waste generated in the country. Of the 53 cities that were expected to set up recycling facilities, only about 13 have installed such facilities as of now. This is unacceptable at a time when demand for primary material including metals, minerals, wood, stones and sand is increasing in the construction sector.

Cities are investing in processing infrastructure incrementally. Delhi is a better example that had received its first C&D waste plant in 2010 with a capacity to process 500 tonnes per day (TPD) of C&D waste. This installed capacity has increased to 5,150 TPD today, a ten-fold increase. Delhi is now planning an additional capacity of 2,500 TPD. Similarly, Gurugram started off with 300 TPD of processing capacity and has increased it to 1,500 TPD. Delhi is perhaps closer to matching its processing capacity and the C&D waste generation. But doing so will also require disciplined enforcement to ensure 100 per cent collection of waste for processing and also market uptake of 100 per cent recycled product.

There is a lot of ambiguity globally around how to quantify C&D waste. Studies suggest several methods to determine generation of C&D waste at levels ranging from a project to a region.Site visit or direct measurement method is based on floor area of projects which needs to be gathered from a sample pool of developers. This makes the method time-, money- and energy-consuming. Per-capita multiplier method depends a lot on construction-related statistics. Estimation using geographic information system (GIS) and area-based calculation method use demolition area data of old buildings, the accuracy of which is not high. Building

AVAILABLE ESTIMATION OF C&D WASTE IN INDIA

In 2018, Building Material and Technology Promotion Council (BMTPC) estimated generation of 100 million tonnes of C&D waste annually in India. This number is a zero-based estimation with the existing housing stock of 110,139,853 urban and 220,695,914 rural (Census 2011), its rate of renovation and new construction of 5.75 billion sq. m area during 2005–12.

However, this number is far from the reality considering the fact that construction activities have exploded during the last decade, especially post-2015, when several Central government schemes including Smart City Mission, Pradhan Mantri Awas Yojana, Atal Mission for Rejuvenation and Urban Transformation, Swachh Bharat Abhiyan, among others, were initiated.

CSE has pointed out from time to time how during the initial years, the official estimation of C&D waste has remained unchanged despite the growth in the construction sector. For more than a decade, between 2000 and 2015, the official figure of 10–12 million tonnes per year estimation remained unchanged. Only in 2015 the estimation was revised to 750 million tonnes per year. This lack of capacity to estimate C&D waste is a challenge.

Table 1: Estimates on quantum of C&D waste generated in India

Year	Authority or institute	Estimate (million tonne per year)
2000	Ministry of Urban Development	10–12
2001	Technology Information, Forecasting and Assessment Council (TIFAC), Department of Science and Technology	12–15
2010	Ministry of Environment and Forests	10–12
2013	Centre for Science and Environment	530
2014	Ministry of Urban Development	Estimate redacted
2015	Ministry of Urban Development	10–12
2015	Development Alternatives and GIZ	750
2016	Ministry of Environment, Forest and Climate Change (press release announcing C&D Waste Rules 2016)	530
2017	Building Material and Technology Promotion Council	165–175

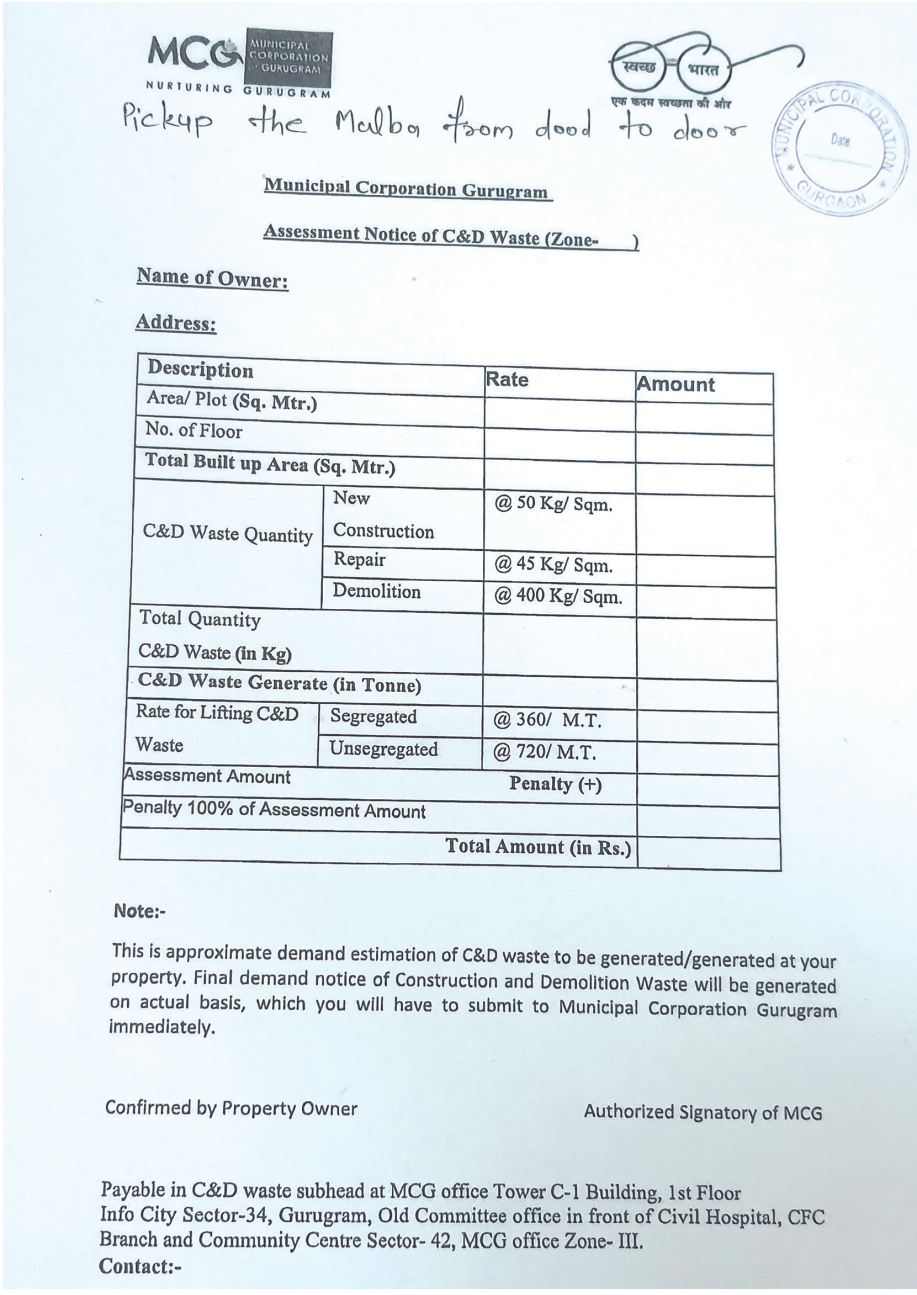
Source: Compiled from multiple sources

information modelling (BIM) is also based on demolition data but can offer better accuracy. While each method has its pros and cons and also a specific requirement of data, area-based calculation is the most popular method in scientific literature.

Moreover, the dominant approach is area-based calculation method—including the demolition area data. But India does not have sound mechanism for capturing demolition activities. This has been highlighted by NITI Aayog in its *Strategy on Resource Efficiency in Construction and Demolition Sector*. It has also been recommended that ULBs need to create an easily accessible inventory from construction and demolition permits.Only recently, Municipal Corporation of Gurugram (MCG) has adopted a methodology to estimate the amount of C&D

waste at the project level based on construction, renovation or demolition activity. In Gurugram, all projects are to mandatorily estimate and disclose the amount of C&D waste generation to MCG and pay the corresponding fee (see *Figure 2: Assessment notice issued by Municipal Corporation of Gurugram*).

Figure 2: Assessment notice issued by Municipal Corporation of Gurugram



MCG MUNICIPAL CORPORATION GURUGRAM
NURTURING GURUGRAM

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Pickup the Malba from dood to door

MUNICIPAL CORPORATION GURGAON Date

Municipal Corporation Gurugram

Assessment Notice of C&D Waste (Zone-)

Name of Owner:

Address:

Description		Rate	Amount
Area/ Plot (Sq. Mtr.)			
No. of Floor			
Total Built up Area (Sq. Mtr.)			
C&D Waste Quantity	New Construction	@ 50 Kg/ Sqm.	
	Repair	@ 45 Kg/ Sqm.	
	Demolition	@ 400 Kg/ Sqm.	
Total Quantity C&D Waste (in Kg)			
C&D Waste Generate (in Tonne)			
Rate for Lifting C&D Waste	Segregated	@ 360/ M.T.	
	Unsegregated	@ 720/ M.T.	
Assessment Amount		Penalty (+)	
Penalty 100% of Assessment Amount			
		Total Amount (in Rs.)	

Note:-

This is approximate demand estimation of C&D waste to be generated/generated at your property. Final demand notice of Construction and Demolition Waste will be generated on actual basis, which you will have to submit to Municipal Corporation Gurugram immediately.

Confirmed by Property Owner

Authorized Signatory of MCG

Payable in C&D waste subhead at MCG office Tower C-1 Building, 1st Floor Info City Sector-34, Gurugram, Old Committee office in front of Civil Hospital, CFC Branch and Community Centre Sector- 42, MCG office Zone- III.

Contact:-

Source: Municipal Corporation of Gurugram

Prevalent method of estimation in cities

Cities are mostly estimating C&D waste based on an assumption that a certain percentage of municipal solid waste is C&D waste. For instance, in Rajasthan, it is estimated at 20 per cent of the municipal solid waste, according to the tender notice released by the Directorate of Local Bodies (Government of Rajasthan). The notice entailed the quantity of municipal solid waste generated in 2017, based on which a total of 1,022 TPD of C&D waste generation was estimated for 29 cities.

The other method by which cities are keeping track of C&D waste generated is the receipt at landfills. For instance, there are two municipal dumping grounds in Jaipur: Sewapura and Mathuradaspura, the former received roughly 147 TPD and the latter 132 TPD of C&D waste in the month of December 2019. This results in about 280 TPD of C&D waste in Jaipur. Given the reality that C&D waste collected by cities is accidental as it is not specifically collected post construction and demolition activity, the assumption of 20 per cent of the municipal solid waste as well as relying on collection of unclaimed C&D waste or legacy waste is a gross underestimation.

Jaipur is coming up with a C&D waste processing plant of 300 TPD capacity. This capacity is adequate to process C&D waste that is coming to the two dumpsites. However, it will soon saturate as has happened in other cities. Cities need to keep ahead of this saturation and be geared for processing a much larger quantity.

Potential methods of estimation

For a better understanding on the quantum of C&D waste generated by cities, CSE has identified three assessment methodologies:

i. On-ground construction project data
ii. Projections using city master plans
iii. Estimation using PARIVESH platform

These methodologies are elaborated in the following sections.

On-ground construction projects data

Real Estate Regulation Authority (RERA) in each state has put in place an online construction project registration tool under the Real Estate (Regulation & Development) Act 2016. According to the Act, every real estate project with plot area above 500 sq. m or number of apartments exceeding eight has to register with the state RERA database. The project proponent must upload details like location, floor area, services for the construction project. This makes state RERA portals sound databases for learning the location and intensity of construction taking place on the ground.

CSE used Rajasthan RERA database and learned that Jaipur has about 268 live projects with a built-up area of 4,971,230 sq. m. According to Technology Information Forecasting and Assessment Council (TIFAC), every sq. m of built-up area generates about 50 kg of construction waste. On applying this thumbrule, to the built-up area added in Jaipur during 2018–20, a generation rate of 206 TPD of C&D waste is obtained. However, this generation rate represents only the formal construction projects with plot area above 500 sq. m or number of apartments exceeding eight inclusive of all phases. The dominant self-construction or informal construction sector and renovation-related C&D waste are not captured in this generation rate and need further analysis.

To estimate waste from demolition activities in Jaipur, CSE assumed that about 30 per cent of the projects within the city's municipal limits are brown-field redevelopment projects. A conservative floor area ratio (FAR) of 0.8 for these demolished old buildings and the TIFAC thumbrule (300 kg per sq. m) gives a per day generation of 201 tonne of demolition waste. This means that projects currently registered with RERA in Jaipur have the potential to generate about 407 TPD of C&D waste, as per this estimation (see *Table 2: Summary of potential C&D waste generation in Jaipur from projects currently registered with RERA*).

It is crucial to note that this generation rate largely represents the formal construction sector and that too for projects which have been registered with RERA. Jaipur is a city dominated with self-construction and independent housing. A majority of buildings are low-rise and do not fall under the ambit of RERA. Pradhan Mantri Awas Yojana (PMAY) affirms this at a national level as about 63 per cent of the dwelling units approved under the scheme are self-constructed under beneficiary-led construction vertical (BLC). In addition to self-constructed residential land use, other land uses such as institutional and commercial and renovation activities do not have their numbers accounted for in this estimation. C&D waste generation due to large infrastructure projects (such as Jaipur Metro) is also not included in the figure of 407 TPD. With this backdrop, the amount of C&D waste generating in Jaipur definitely surpasses 500 TPD.

Table 2: Summary of potential C&D waste generation in Jaipur from projects currently registered with RERA

Waste typology	Quantum of waste (TPD)
Waste due to construction	206
Waste due to demolition	201
Total C&D waste potential from currently registered RERA projects in Jaipur	**407**

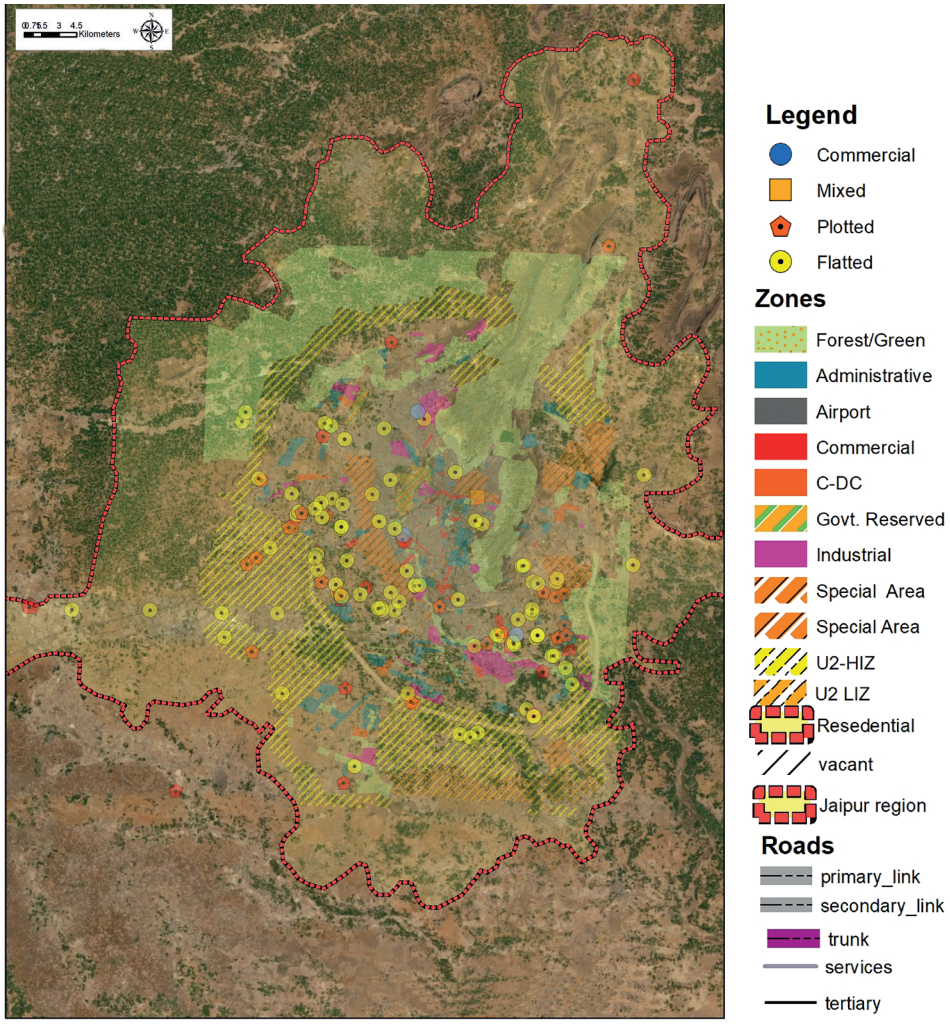
Source: CSE

Projections using city master plans

City master plans are an underrated tool that can help cities understand the magnitude of development and C&D waste generation in the near future. The boundary of the development area and the existing city limits have been overlaid in GIS to compute the land that is yet to develop (see *Map 1: Areas yet to develop as per the Jaipur Development Plan, 2025*). The area falling under green zones, water bodies and other no development zones has been excluded from this estimation.

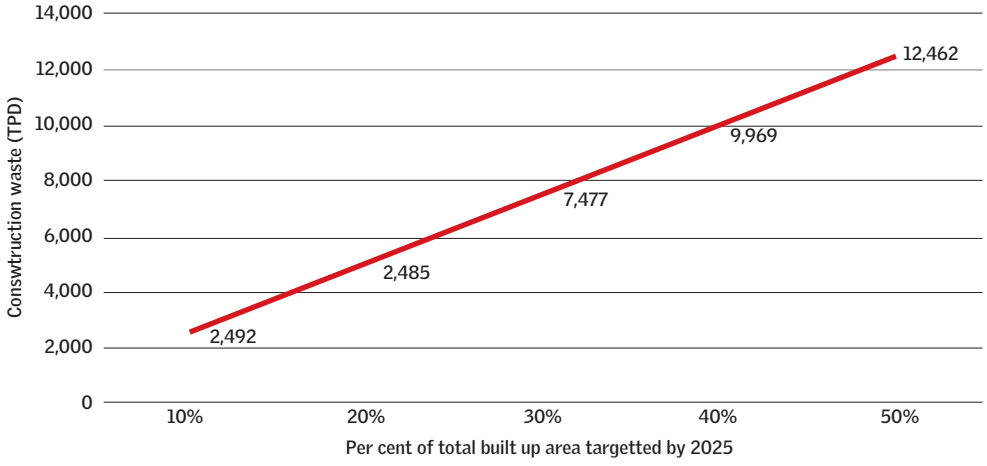
Jaipur has about 1,596 sq. km of urbanizable land as per the Jaipur Development Plan, 2025. This land will require substantial construction and is less likely to completely develop by the prospective year of 2025. Therefore, five construction

Map 1: Areas yet to develop as per the Jaipur Development Plan, 2025



Source: CSE

Graph 1: Estimation of construction waste generation from anticipated development in Jaipur by 2025



Source: CSE projection

scenarios have been developed considering that 10–50 per cent of the planned built-up area will be developed. This built-up area will generate matching construction waste (see *Graph 1: Estimation of construction waste generation from anticipated development in Jaipur by 2025*).

This estimation has revealed that residential land use alone is going to generate about 2,492 TPD of construction waste in the least construction (10 per cent of target built-up area by 2025) scenario. RERA data has shown that the 10 per cent scenario is more realistic compared to the other scenarios. Waste from commercial, institutional and industrial buildings will be an additional burden. Even if more than half of this quantum is reused for filling and as sub-base for roads, Jaipur will still have to manage not less than 1,000 TPD of construction waste from the new development. The fact of the matter remains that Jaipur needs to be geared towards collection of much more C&D waste than 300 TPD—the currently proposed processing capacity for the city. Improving collection efficiency must be the focus for Jaipur as the actual quantities of C&D waste will become clear on better collection.

So far in the study, as estimate of at least 1,000 TPD draws a closer picture for the city while it only forms a portion of the total C&D waste being generated without the waste from other land uses. To validate these inferences, CSE has adopted a third methodology for estimating C&D waste in Jaipur.

Estimations using PARIVESH platform

MoEF&CC's PARIVESH is another online platform that compiles information of projects seeking environmental clearance. Similar to RERA, this database was used to understand two facts: one, how are project proponents declaring generation of C&D waste; second, how aligned are these declarations with the TIFAC thumbrule for generation of construction waste. This comparison is vital to inform the construction industry as well as the government on the need to recalibrate their calculations and assessments for C&D waste generation. This data can be used by state governments for a sound C&D waste management system.

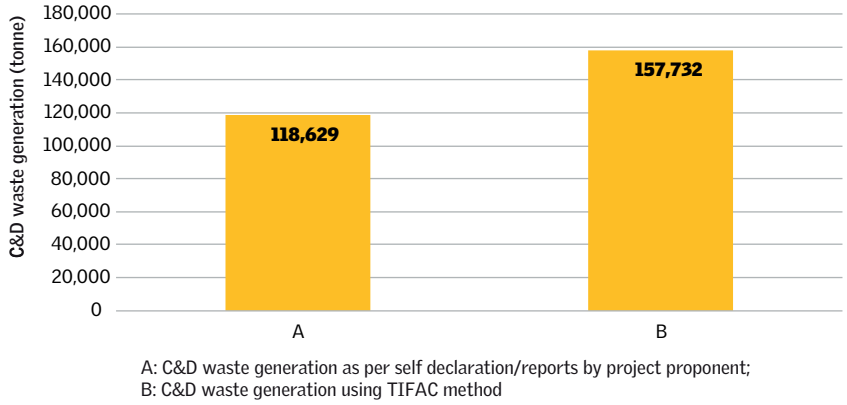
This estimation was conducted for the states of Rajasthan and West Bengal. PARIVESH is a single window system designed for gaining environmental clearance from the respective authority for construction projects, area development projects or townships, and infrastructure projects. The study considered the projects submitted to state-level Environmental Impact Assessment (EIA) authority, belonging to Category B and Category B1 projects with built-up area > 50 ha or built-up area > 150,000 sq. m, which requires environmental impact assessment report and category B2 projects with built-up area greater than or equal to 200,00 sq. m and < 150,000 sq. m. The types of projects include residential, commercial, institutional and mixed-use.

Form 1, Form 1A, Environmental Management Plan (EMP) and EIA report contain the quantity of construction and demolition waste as declared by the project proponent and built-up area for each project. These two values are crucial to meet the aim of this estimation.

For Rajasthan, 75 projects submitted for environmental clearance in the period 2018 to 2021 were considered. The total amount of C&D waste in a total built up area of 315.46 ha was found to be 118,629 tonne from the self-declaration reports. On the other hand, using the TIFAC formula, the total amount of waste was found to be 157,732 tonne (see *Graph 2: Comparison of C&D waste generation from reports submitted for EC vs as calculated using TIFAC for Rajasthan*). The total estimation of construction and demolition waste generation from projects using TIFAC is nearly 1.3 times more than what was declared by project proponents.

In the case of 137 other projects, for which the amount of C&D waste generation was not available in the reports and forms submitted by project proponents, total C&D waste generation using TIFAC thumbrules was found to be 397,700 tonne for a total built-up area of 7,824,439 sq. m or 782.44 ha.

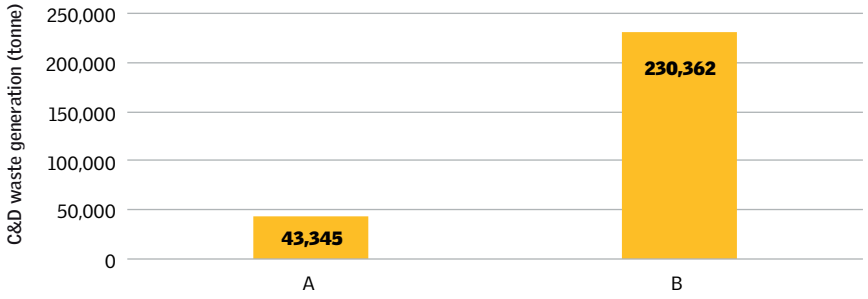
Graph 2: Comparison of C&D waste generation from reports submitted for EC vs as calculated using TIFAC for Rajasthan



A: C&D waste generation as per self declaration/reports by project proponent;
B: C&D waste generation using TIFAC method

Source: CSE analysis

Graph 3: Comparison of C&D waste generation from reports submitted for EC vs as calculated using TIFAC for West Bengal



A: C&D waste generation as per self declaration/reports by project proponent;
B: C&D waste generation using TIFAC method

Source: CSE analysis

This difference in declaration and estimation using TIFAC thumbrule was found in the case of West Bengal as well. C&D waste in 75 projects, with a total built-up area of 423.27 ha, was declared to be 43,345 tonne, whereas using the TIFAC formula, these projects generated about 230,362 tonne of C&D waste—a more than five times jump (see *Graph 3: Comparison of C&D waste generation from reports submitted for EC vs as calculated using TIFAC for West Bengal*).For another 98 projects where C&D waste generation was not provided by the project proponent, the total waste generation using TIFAC was found to be 398,133 tonne for a total built-up area of 8,465,817 sq. m or 846.58 ha.

2. City dashboards for cohesive action

C&D Waste Management Rules, 2016 and Environment (Protection) Amendment Rules, 2018 set the framework for C&D waste management and dust control in India. However, only a handful of cities have adopted these rules. A secondary investigation of Clean Air Action Plans submitted by million-plus population and non-attainment cities, available on the CPCB website, has revealed that the efforts cities are putting in for C&D waste management and dust control are largely ad hoc and not cohesive. For instance, cities are prioritizing setting up of recycling infrastructure before developing data inventories or setting up collection systems.

An overview of C&D waste management and dust control rules and global good and best practices has yielded milestones that can guide cities in addressing the subjects in a well-rounded manner. The following sections entail these milestones.

According to C&D Waste Management Rules, 2016, cities must put in place a mechanism for collection, transportation, processing, recycling and reuse to prevent illegal dumping and its adverse impact on the environment and public health. The key milestones that can enable this are as follows:

Milestone 1: Data and research

Availability of data (quantitative and qualitative) and associated background assessment is the first step towards establishing a scientific C&D waste management system. This includes data on volume of C&D waste generation, details on sub-streams and their characteristics (for their bearing on processing technology), data on waste generation by demolition activity, location and intensity of construction activity, demography and land use, projections for the future based on city development plans, existing transport fleet to haul C&D waste, dumping locations (both legal and illegal) and market rates to haul C&D waste. Such data is a precursor to planning and development of C&D waste management infrastructure and design of operations. CSE investigation reveals that cities do not have such data. Very few cities such as Kolkata, Gurugram and Delhi have volumetric data on C&D waste collected every day. Cities need to conduct studies on the waste they are currently collecting and start keeping inventories to guide further action.

Milestone 2: Planning for a collection and disposal system

Schedule III of the C&D Waste Management Rules, 2016 mandate cities to identify sites for collection and processing within 18 months of the notification of the Rules. However, in absence of appropriate data, sound planning for collection and disposal system and infrastructure has not been possible for cities. As a result, cities are currently devoid of designated collection points, a clear collection procedure, dedicated vehicle fleet, disposal point, etc. as required under the C&D Waste Management Rules, 2016 and for smooth operations. Cities like Delhi and Gurugram have demonstrated designation of collection points after the recycling facility is set up. In this scenario, these cities, especially Delhi, have risked and faced low C&D waste feed to the processing plant affecting its economic feasibility and low-to-no impact on illegal dumping even with such a capital-intensive investment in the plant. Therefore, cities must plan and develop a collection system first. To do this, cities not only need to identify appropriate area and location for collection, establish collection systems but also determine transport fleet size, identify transportation routes, location and capacity of processing plant, appropriate processing technology, strategy for reuse of recycled C&D waste among other things. Data and research under Milestone 1 will feed into milestone.

Milestone 3: Notification of C&D waste bye-laws

A crucial step towards adoption of C&D Waste Management Rules, 2016 is the notification of C&D waste bye-laws by cities. Bye-laws that guide and legally bind waste generators, ULBs, public authorities, service providers and other actors are necessary for scientific management of C&D waste. Cities need to legalize user fee for collection and disposal of C&D waste and take penal action against those failing to comply with the provisions in their bye-laws. So far, only the big cities like Kolkata, Delhi, Gurugram and Jaipur have notified their C&D waste bye-laws. Dissemination of these bye-laws is also important to ensure that the general public is aware of their duties and the city's C&D waste management system.

Milestone 4: Setup recycling infrastructure

A processing plant is a landmark step in enabling recycling and reuse of C&D waste. According to C&D Waste Management Rules, 2016, cities are to provide details of land for a centralized processing facility. The Rules also provide a timeframe for identification of site for the processing facility and its commissioning to take place within 18–36 months (for million-plus and below 0.5 million population cities respectively) from the date of notification of the Rules. This requirement places a lot of significance in this milestone and cities are expediting their efforts to procure a centralized facility. Since centralized processing plants are capital-

intensive in nature, appropriate planning and development of a collection system and outlining of operations is a must for a city to setup a centralized C&D waste processing facility and create products from recycled C&D waste efficiently. As discussed earlier, cities risk low waste feed and economic feasibility of the plant in absence of a sound collection system. While only large cities have set up a processing plant, small cities are yet to initiate this step. These cities have great opportunity to scientifically plan, develop infrastructure, outline operations and then procure the processing plant so that it operates feasibly.

Milestone 5: Mandatory use of recycled C&D waste products

C&D Waste Management Rules, 2016 mandate procurement of recycled C&D products to the tune of 10–20 per cent in government contracts. As the processing facility will generate recycled fine and coarse aggregates, cities need to establish demand for recycled C&D products at the same time. This needs to be done to bring as much recycled materials back into the construction cycle and close the loop under a circular economy as possible. To do that, cities or state governments need to create an enabling environment to maximize uptake of recycled C&D waste products. For instance, Public Works Department, Delhi Government had advised all departments to incorporate a clause in their tenders mandating 2 per cent and 10 per cent use of recycled C&D waste products in buildings and road works respectively in 2015. Later, in 2018, Government of National Capital Territory of Delhi (Office of the Director—Local Bodies) has notified for all departments to mandate use of recycled C&D waste products in their tenders in 2018. In response, South Delhi Municipal Corporation and North Delhi Municipal Corporation, among others, have mandated usage of recycled aggregates and other products in development works. Similarly, cities need to release a government order that mandates use of recycled C&D products in all public construction works as an effective instrument. Not many cities investigated have notified or implemented such mandates.

Milestone 6: Streamline operations

Once requisite infrastructure and legislative frameworks are in place, multiple actors or institutions need to work together to be able to efficiently collect, store, transport, process and reuse C&D waste while at the same time ensuring environmental compliance at all stages. To do this, ULBs need to establish inter- and intra-departmental communication, monitoring and reporting systems. The more decentralized the operations are, the higher will be the collection efficiency and reutilization rate for C&D waste. Decentralization of operations at the ward level, especially in the big cities, can enable efficient and effective operations.

Milestone 7: Enforcement

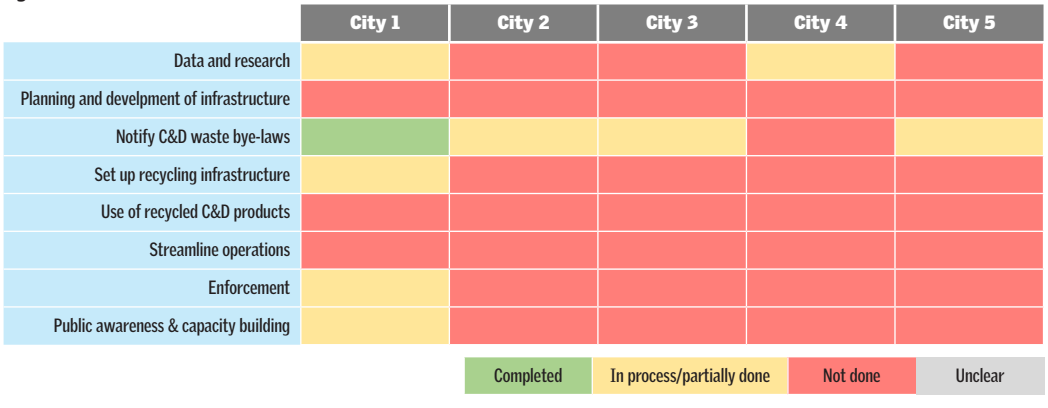
Cities need to establish enforcement systems specifying non-compliances, along with who penalizes and the penalty for respective non-compliance. Cities that have notified bye-laws, such as Delhi, Gurugram and Kolkata, have notified penalties as well but often face manpower crunch in enforcement. Dedicated resources such as a ground team to conduct day-to-day inspection and prosecution enable better enforcement. For instance, Gurugram has outsourced its surveillance and enforcement operations to Pragati Al Natural Resource Pvt Ltd and that has helped the city reduce instances of illegal dumping by 60 per cent. Similarly, cities can deploy service contracts for enforcement.

Milestone 8: Public awareness and capacity building

Every milestone above will require public intimation as well as capacity building. Cities will need awareness drives to inform citizens of their duties pertaining to C&D waste management. They need to be fully informed about the waste collection and disposal systems and the systems put in place. Similarly, ULBs and regulators will need to train their staff on the roles and responsibilities designated to them by the C&D Waste Management Rules.

CSE overlaid the above milestones with the ground status—measures cities have taken for C&D waste management (see *Figure 3: City milestone dashboard towards a scientific C&D waste management system*) in compliance with the C&D Waste Management Rules. This resulted in evidence for lack of well-rounded action on C&D waste management in cities. However, this milestone dashboard also helped establish city baselines and learn where they stand and what measures they need to take up to improve. Similarly, state governments could develop milestone dashboards to guide comprehensive action in cities.

Figure 3: City milestone dashboard towards a scientific C&D waste management system



Source: CSE

3. Dust control methods

The Environment (Protection) Amendment Rules, 2018 or dust control rules provide for mandatory implementation of dust control measures during construction and demolition activities. These measures comprise installation of wind breaks, water sprinkling systems, covering of material and C&D waste stockpiles and vehicles carrying construction materials, among others.

Cities have internalized these measures in the building permit system. For instance, Kolkata is asking for a general undertaking at the time of seeking building permission by the developer or project proponent. The developer or project proponent becomes subject to penalty should the building inspector find any non-compliance related to these dust control measures. However, there are plenty of other measures cities need to take to address dust pollution abatement from C&D activities in a cohesive manner.

The action for dust control can be classified into three categories: avoid impact, mitigate impact and emergency action. A three-stage action strategy based on these categories can help cities prioritize and implement actions related to dust control, i.e., to avoid and mitigate impact, and enable emergency action.

Avoid impact

The first stage involves avoiding impact, i.e., preventing dust emissions during construction-related activities. Use of green screens to cover buildings, covering of material and C&D waste stockpiles, use of wind barriers and black topping of unpaved roads are some of the measures employed at this stage.

Mitigate impact

The second stage is to mitigate impact, once dust has been emitted, the measures that can be taken to contain its adverse impact fall under this stage. This includes green belts, vegetative barriers and sweeping of roads.

Emergency action

The third stage is emergency action, which is needed in case of extreme pollution episodes. Cities must prioritize avoiding impact followed by mitigating impact and in a manner that the air quality scenario does not reach the third stage of emergency action in the long-run.

CSE mapped the ground action being taken in cities and classified it into these three categories (see *Figure 4: Categorization of dust control measures in cities*). This not only helped in understanding the nature of dust control action in cities but also provided information on the level of implementation of dust control measures. For a well-rounded redress, cities need to undertake measures to both avoid impact and mitigate impact and strive to prevent the need for emergency action.

The detailed guidelines on dust control measures have been given in the guidelines in *Chapters 7 and 8*.

Figure 4: Categorization of dust control measures in cities

		City 1	City 2	City 3	City 4	City 5
Avoid impact	Use of green screens, wind barriers, covering of material stockpiles and vehicles carrying amterials, wheel washing, black topping of unpaved roads and mechanization of material handling	Self-declaration by project proponents	Self-declaration by project proponents	Building bye-laws have been drafted but awaiting approval	Building bye-laws are being framed	Building bye-laws are being framed
Mitigate impact	Green belts, vegetative barriers, demarcation of storage areas for dust emitting materials, manual and mechanical sweeping of roads	Green belts and mechanical sweeping at selected stretches	Green belts at selected stretches and manual sweeping			Manual sweeping of internal roads
Emergency action	Water sprinkling, fog guns and halting of C&D activities	Water sprinkling	Five water sprinkling vehicles			Water sprinkling

Source: CSE

4. Budget analysis

Under the ongoing NCAP, NACs have prepared their respective Clean Air Action Plans to meet the target of reduction in particulate matter concentration by 20–30 per cent by 2024, taking 2017 as the base year. To help cities implement these action plans, the Central government is allocating funds in two ways. First is the funding under NCAP Phase 1 grant and the other is the 15thFinance Commission performance-linked grant to ULBs. While NCAP funding is channelized through State Pollution Control Board (SPCB), the ULB funding is routed through the Urban Development Department. ULB funding also seeks 5 per cent annual reduction in particulate pollution over five years. Both the funding systems are performance-oriented with a set target for air quality improvement.

CSE analyzed the fund allocation by cities under the 15th Finance Commission ULB grants using secondary as well as primary data sources. The analysis revealed that current budget allocations are ad hoc in nature. This is largely because there is no understanding on mitigation potential of actions for C&D waste management and dust control and overall greening of the construction sector. There is a strong need to align budgeting for these actions with their mitigation potential. Priority in budget must be given to actions with high mitigation potential and for a long-term impact.

According to the data received from ULBs on their spending under the 15th Finance Commission grant for clean air, the overall assessment shows that a majority of allocation has gone to actions such as repairing of major roads, removal of potholes, paving of open areas and parking spaces, installing water sprinklers at major traffic intersections and greening activities. Two cities were considered for this analysis: Jaipur and Kolkata.

Jaipur has received its funds in two instalments. The first instalment was largely invested in water and waste management and solid waste management with equal spending in two sectors. The second instalment involved 11 action points in which the majority of funds were earmarked for road repair, paving of open areas, installation of water sprinklers and development of green buffers (see *Table 3: Fund allocations in second instalment of 15th Finance Commission grant by Jaipur*). This was followed by investment in C&D waste management sector comprising of actions like purchasing of skip containers, tarpaulin covers and covered vehicles for transportation of C&D waste.

Table 3: Fund allocation in second instalment of 15th Finance Commission grant by Jaipur

Particulars and action points	Percentage of total funds
Greening of open areas and development of green buffers	27
Lining of all dump sites with technically designed green belts	2
Paving of open areas, repairing of major roads, paving of parking spaces and installing water sprinklers at major traffic intersections	40
Maintaining smooth and pot-hole free paving surfaces on city roads	5
Procurement of anti-smog gun for identified hotspots (high-level concentration of $PM_{2.5}$ and PM_{10})	1
Redesigning streets	2
Parking management	1
Development of skip containers for C&D waste	7
Tarpaulin and other logistics for C&D waste	
Transportation of C&D waste to dumpsites	
Repair and maintenance of SWM vehicles	2
Construction of composting pit and horticulture waste compost pits	2
SWM and vehicular pollution (IEC activity)	1
Total	**100**

Source: Jaipur Municipal Corporation

Similarly, Kolkata has allocated funds largely in the solid waste management and road dust mitigation sector (see *Table 4: Fund allocation under 15th Finance Commission grant by Kolkata*). Solid waste management activities are receiving about 44 per cent of the funds for the bio-remediation projects and purchase of BS-VI hopper-tipper-dumpers. About 27 per cent funds are going into foggers, mechanical road sweepers and water sprinklers, and 3 per cent for road development. About 5 per cent of the funds are earmarked for C&D waste processing facility and 7 per cent for green buffers and road side plantations.

These two city action plans and fund allocation bring evidence to the fact that cities are approaching cleaning of air differently. While Jaipur is prioritizing dust mitigation by road repair and paving activities, Kolkata is focusingmost on bio-remediation of landfills and reducing solid waste-related emissions followed by road dust suppression.

While allocation to other waste streams and sectors is not part of the focus of this analysis, a narrower view of what has been spent with respect to the management of C&D waste management shows that the approach is still inadequate and ad hoc.

Table 4: Fund allocation under 15th Finance Commission grant by Kolkata

Department	Activity	Percentage of funds
Solid Waste Management Department	Mechanical sweepers	10
	Mist cannons	10
	Water sprinklers	7
	Hopper-tippers	13
	C&D waste plant	5
	Bio-mining and treatment of legacy waste	30
	O&M of bio-remediation project at Dhapa	1
Lightning Department	Repair of air pollution control devices at crematoriums	7
Asphaltum Department	Installation of covers, accessories and dust barriers at batching plants and O&M contract of the plant	7
Roads Department	Development of SP Mukherjee road	3
Parks and Squares Department	Green buffers along the roads	3
Engineering Department	Development and O&M of road-side gardens and plantations at median strips	4
Total		**100**

Source: Kolkata Municipal Corporation

Clarity is needed with respect to fundable items in C&D waste management sector that require public funding as a lot of investments are expected to be done by the private sector. Infrastructure for monitoring, collection network, transport systems and related infrastructure, geo-tagging transport vehicles and centralized digital monitoring, including network of CCTV cameras, development of standard and checklists for construction agencies and the general public, waste management infrastructure, management and controls and MIS systems along with augmentation and capacity building of staff are several such areas that the ULBs need to invest that have largely been ignored in the budget.

5. Monitoring framework—qualitative actions but quantitative metrics

CPCB has set up a quarterly review process to ensure time-bound implementation of actions for improvement in air quality. This is to assess progress in implementation of the multi-sector Clean Air Action Plans in the NACs as part of the monitoring system of the National Green Tribunal (NGT). For the oversight and monitoring, a high-level committee under the Chief Secretary, state government, with representation from all concerned departments has been set up. Respective state environment and urban development departments along SPCBs are facilitating inter-departmental coordination. At the city level, all municipal corporations are responsible for coordination with the concerned departments for tracking and reporting quarterly progress.

Under this framework, CPCB has provided detailed sector-wise indicators to track progress. All NACs are expected to report progress against each of these indicators every quarter. Every quarter, departments are expected to coordinate to mobilize and document information to provide the status of action on each indicator. In addition, departments are to set targets and indicate progress against them for each indicator, while also stating deviations (if any) from them. They also need to provide details on fund allocation, funds released and utilized, and fund requirements for implementation of each action. Cities are required to provide supportive material, evidence and information as attachment for verification of actions as well.

There are 258 indicators in the framework distributed into the following categories: Capacity building and source apportionment (related to air quality), public outreach, road dust, construction and demolition waste (C&D), vehicles, industries, waste and biomass, and air quality data. This analysis has focused on C&D waste and road dust indicators.

One crucial observation on the indicators for C&D waste management and road dust is that the information sought for a majority of the indicators is quantitative in nature (see *Table 5: Indicators for C&D waste management and road dust in the CPCB monitoring framework*). For instance, the template asks for the number

of *challans* issued for the action of ensuring transportation of construction materials in covered vehicles. Similarly, the number of sites is being sought for the indicator to create separate space to handle C&D waste or km travelled by mechanical sweepers to remove road dust or silt. Such data or information will not be able to ensure cities achieve the desired action as stipulated in the C&D waste management rules and dust control rules.

Table 5: Indicators for C&D waste management and road dust in the CPCB monitoring framework

C&D1	**Construction activities**	**Information sought**
C&D1.1	Ensure transportation of construction materials in covered vehicles	Number of *challans* issued
C&D1.2	Strict enforcement of CPCB guidelines for construction (use of green screens, side covering of digging sites, etc.)	Steps taken
C&D1.3	Restriction on storage of construction materials along the road	Number of *challans* issued
C&D1.4	Covering of the construction site	Number of *challans* issued
C&D1.5	To create separate space or zone to handle solid waste, C&D waste and other waste in the city	Number of such sites established
C&D1.6	To mandate facility of tar road inside the construction site for movement of vehicles carrying construction material	Steps taken
C&D1.7	Promotion of the use of prefabricated blocks in building construction	Steps taken
C&D1.8	Enforcement of Construction and Demolition Waste Rules	Steps taken
C&D1.9	Control measures for fugitive emissions from material handling, conveying and screening operations	Steps taken
C&D1.10	Develop and implement dust control measures for all types of construction activities—buildings and infrastructure	Notification on dust control measures (Yes/No)
C&D1.11	Enforce restrictions on construction activities within urban airshed zones during high pollution period	Notification on high pollution period measures (Yes/No)
C&D1.12	Frame and implement policy for segregation of construction and demolition waste and provide a network of decentralized C&D waste segregation and collection sites across the city	Notification of the policy (Yes/No); number of C&D waste sites established
C&D1.13	Promote recycling of construction and demolition waste	Steps taken
RD1	**Road dust**	
RD1.1	Immediate lifting of solid waste generated from desilting and cleaning of municipal drains for its disposal	Steps taken
RD1.3	Regular cleaning of street surfaces and spraying of water to suppress dust	Steps taken
RD1.6	To take appropriate action to remove road dust or silt regularly by using mechanical sweepers	km travelled by mechanical sweepers

Source: Central Pollution Control Board

Each indicator in this template has brought out the corresponding baseline in the

cities visited in terms of what the cities are doing, the key actors involved and the kind of regulatory set-ups existing for C&D waste management and dust control. This interaction conducted with ULBs and other concerned departments has pointed out certain gaps in the current system.

CSE distributed these gaps across the categories of data and research, infrastructure, regulations, coordination, enforcement, communication and awareness and capacity building to inform specific action that needs to be taken to address each indicator comprehensively. This gave indicator-wise actions that cities must now target to eliminate the gaps identified (see *Table 6: Action to eliminate systemic gap to achieve CPCB indicator C&D1.1*). Unless these gaps are addressed, cities will continue to face challenges in effective implementation of C&D waste and dust control rules.

Table 6: Action to eliminate systemic gap to achieve CPCB indicator C&D1.1

Desired action to achieve Indicator C&D1.1: Ensure transportation of construction materials in covered vehicles					
Data gaps	**Infrastructure gaps**	**Regulatory gaps**	**Coordination gaps**	**Communication and enforcement gap**	**Capacity building**
1. Mapping of points selling construction materials and construction sites. Collate information on ongoing construction from WB HIRA, EIA portal and building permission documents. 2. Develop a database of transportation agencies (formal and informal)	1. Equip the transportation fleet (both ULB owned and contracted) with tarpauline covers and GPS. 2. Only GPS-enabled vehicles to be contracted. 3. Develop an MIS for challans issued.	1. Order to require only the trucks that are equipped with GPS, etc. (or a phase-in plan) to be used for transport of materials. 2. Mandate fleet owned by the ULB and concessionaire fleet to be equipped with GPS and covers. 3. Order to disclose vehicle fleet preparedness by the transport agencies. 4. Specify agencies for monitoring, enforcement and challaning of non-compliant fleet (with jurisdiction, i.e., inside and outside building premises, and on the road). 5. Notify penal action.	1. Establish a system at the ULB to harmonize actions between RTO, Kolkata Police, and buildings department. Include the air quality monitoring cell, experts to enable monitoring and compliance.	1. Stakeholder identification. 2. Time-to-time issuance of enhanced public notices defining responsibilities of stakeholders with proper illustrations. 3. Identified agency to issue challans (inside premises, outside premises and on the road). 4. A dedicated body (concessionaire) created at the ULB level that looks after the enforcement by inspecting and prosecuting offenders (by issuing challans) is an effective instrument. 5. MIS of challans issued.	Build capacity of transport agencies (formal and informal) to enable transportation of debris in a scientific manner.

Source: CSE

Similarly, each indicator was broken down into gaps distributed into seven

categories and actions were identified indicator-wise to eliminate these gaps. A summary of these actions for implementation of C&D waste management and dust control rules follows.

Actions to eliminate data and research gaps

Inventory of C&D waste generation

At present, cities do not have a system to keep track of C&D waste generated and collected. Only big cities have maintained an inventory of C&D waste collected. For instance, 579 TPD of C&D waste is collected across Kolkata. With traditional systems involving the informal sector active in cities, much of the C&D waste goes into backfilling and is not accounted for. Therefore, C&D waste generation data at ward level is needed so that it can be internalized in the formal system of collection, processing and recycling. This data needs to be entered with details on sub-streams (concrete, bricks and mortar, wood, steel and sand), geographic location, land use, floor area, typology and age of building (in case of demolition), etc.

Mapping of construction projects to understand generation and reuse potential

Currently cities do not have instruments to collate information on building construction or redevelopment geo-spatially. Such mapping is instrumental in understanding construction-intensive zones and sources of C&D waste. This enables ULBs to plan collection points, transportation and processing infrastructure and even recommend decentralized in-situ processing and reuse with a view to optimize the entire C&D waste management system. This mapping also helps plan a graded response in the event of high pollution periods. Online portals such as PARIVESH and state Real Estate Regulatory Authority (RERA) that comprise information on building construction projects along with details on size and location, etc., are useful sources for this mapping.

Identification of collection points

Cities have not yet designated collection points to improve collection as per the C&D Waste Management Rules, 2016. For instance, Kolkata is in the process of procuring a centralized processing facility but has not yet identified collection points and is planning a system that hauls C&D waste directly to the plant from the generation point. Studies have shown that intermediate collection points or transfer stations can optimize trips required to haul C&D waste from source to the processing plant in case of a centralized facility. For instance, North Delhi Municipal Corporation has designated a collection point in every ward at the store

of junior engineer's office (see *Images 1–4: Designated ward-level C&D waste collection points in Delhi*). This has increased collection and optimized the number of trips made to the processing facility. Cities like Gurugram are using information systems developed by a third party, i.e., surveillance and complaint database on illegal dumping, which helps in waste trip aggregations with effective short-haul and long-haul combinations.

Images 1–4: Designated ward-level C&D waste collection points in Delhi

Alipur C&D waste collection point

Rohini East C&D waste collection point

MITASHI SINGH

C&D waste manual for citizens

Currently, urban citizens are not very well informed about their duties. Generators do not know how to reach out to ULBs for collection, segregated storage of C&D waste on their premises, and what will happen to C&D waste after it is lifted from the premises. In absence of awareness on the formal system, generators will prefer the traditional and more accessible informal sector to collect C&D waste. A manual that describes the entire process of C&D waste management, its benefits and what the generators need to do in the context of the city needs to be prepared and disseminated widely.

Mapping and database of material vendors and sales of recycled C&D waste products

Currently, cities do not have clear or well-collated information on material vendors. This information is important in the context of monitoring and enforcement. Field visits to cities have revealed that materials are being stockpiled without covering them properly. The points of material vending receive a lot of vehicles to haul materials as well, making them crucial point-sources of dust pollution. Mapping of material vendors will enable better monitoring of whether stockpiles are covered, fugitive dust is controlled during material handling, and vehicles carrying materials are covered. This database will also enable capacity building of material vendors for long-term compliance with dust control norms.

A network of authorized material vendors will be required to increase uptake of recycled C&D products when the processing facilities get operational. Tracking quarterly sales of recycled C&D products will keep cities informed on the demand–supply dynamics that will further guide the requirement of processing facilities. Construction materials such as sand are stored on site without any covering material and demarcation of space for storage of materials is also not practiced.

Database of vehicles and transportation agencies

Cities use a range of vehicles for activities such as hauling of construction materials and drain silt, road sweeping, water sprinkling, etc. These vehicles could either be owned by the ULB or contracted from private vendors for the purpose. In order to inform policies and optimize operations, a database of vehicles used, their typology, use, fuel type, distance travelled, transportation agencies used (empanelled or authorized, and informal) and other details need to be maintained.

Standard checklist of measures for dust control

According to the Environment (Protection) Amendment Rules, 2018, there are several dust mitigation measures such as prohibition on grinding-cutting of

building materials, roadside storage of materials, and transportation of uncovered materials. These measures need to be adopted and complied with. Field visits to a few cities have revealed a few good practices, but mostly by large-scale developers (see *Images 5–11: Good practices related to dust control*). In order to make all developers as well as the general public aware of these measures, a standard checklist can be a helpful tool. The checklist will also lead to better compliance monitoring on linking with building permissions. CSE has developed this checklist (see *Chapter 9* and *10* of this report).

Images 5–11: Good practices related to dust control

Wind barrier around an under-construction building



Dust barriers on scaffolding around a building under construction or demolition



A vehicle wheel washing facility

MITASHI SINGH

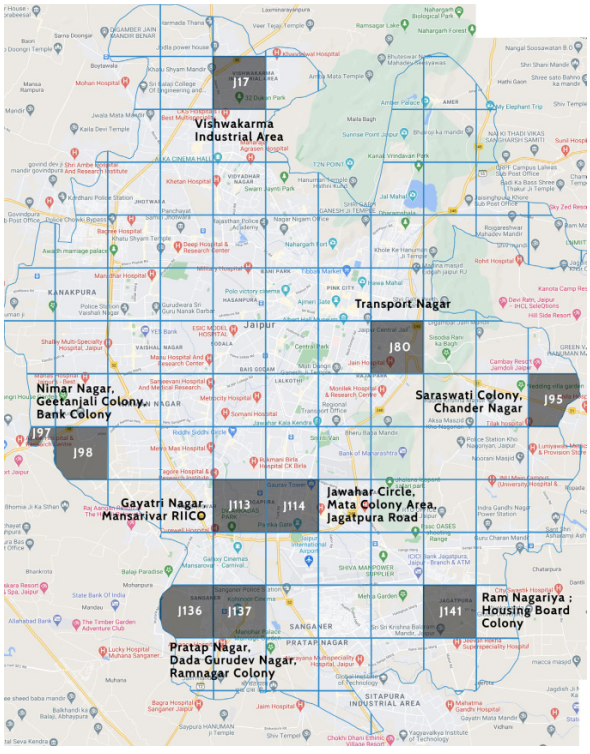
Guidelines for sustainable and safe construction site management

Knowledge and awareness on scientific construction site management is currently weak in cities. Appropriate stockpiling and handling of materials, space planning for material storage, planning for vehicle circulation, wheel washing zones, unloading of materials preventing fugitive dust emissions are some of the processes or measures on which the developers need to be guided.

Identification of urban airshed zones and source apportionment studies

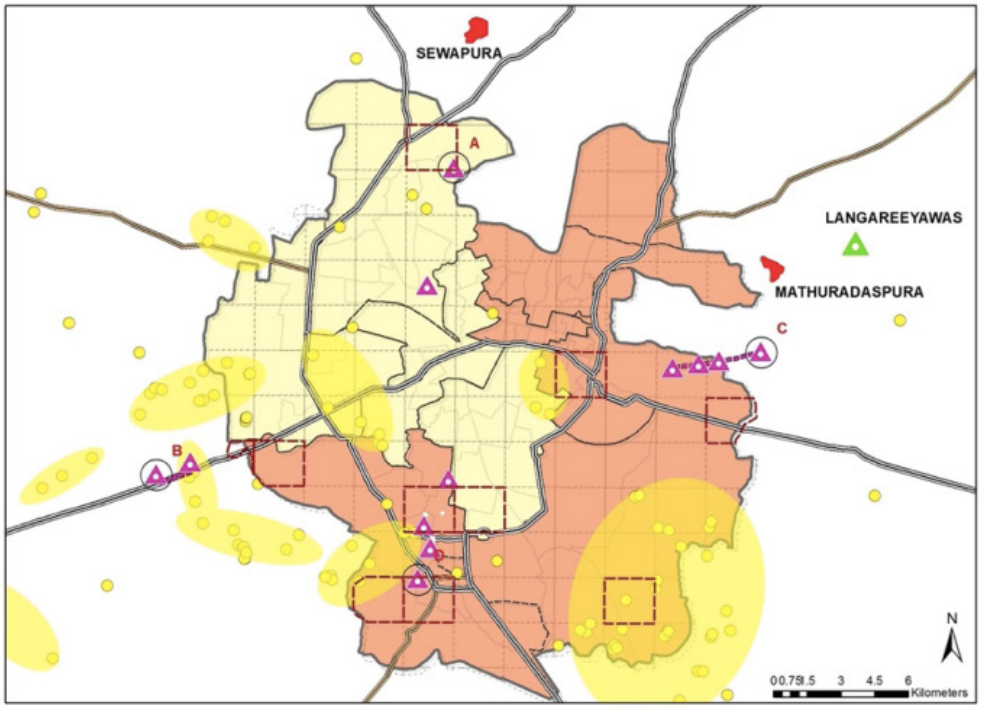
Cities have not identified their urban airshed zones properly and lack clarity on which sources contribute to air pollution and by how much. Studies to identify airsheds and source apportionment in each city are crucial for appropriate airshed management. Such studies will also result in long-term strategies for improving air quality as well as implementing emergency action in the event of severe pollution. Jaipur and Gurugram have prepared hyper-local action plans to guide airshed management. Grids of 2 x 2 km have been marked and overlayed on the city (see *Map 2: 2 x 2 km grid overlaid on Jaipur city for localized analysis and action*).

Map 2: 2 x 2 km grid overlaid on Jaipur city for localized analysis and action



Source: CSE

Map 3: Superimposition of construction projects, waste dumpsites and C&D waste processing plant over the grid



Source: CSE

Pollution causing activities such as building construction, waste dumpsites and C&D waste processing plants have also been marked (see *Map 3: Superimposition of construction projects, waste dumpsites and C&D waste processing plant over the grid*). Grids around pollution hotspots have been provided a detailed action plan comprising of preventive and mitigation measures for air pollution. Similar studies need to be conducted in other NACs to guide local action.

Actions to eliminate infrastructure gaps

Ward waste cell

For a closer-to-ground management of C&D waste, decentralization of resources and operations is vital. At present, cities function through a centralized system that leaves gaps in operations, monitoring and enforcement. With enormous construction activity taking place in urban areas and the need for day-to-day

compliance monitoring, decentralized units will optimize functions including maintenance of data inventories, increased collection, inspections and enforcement.

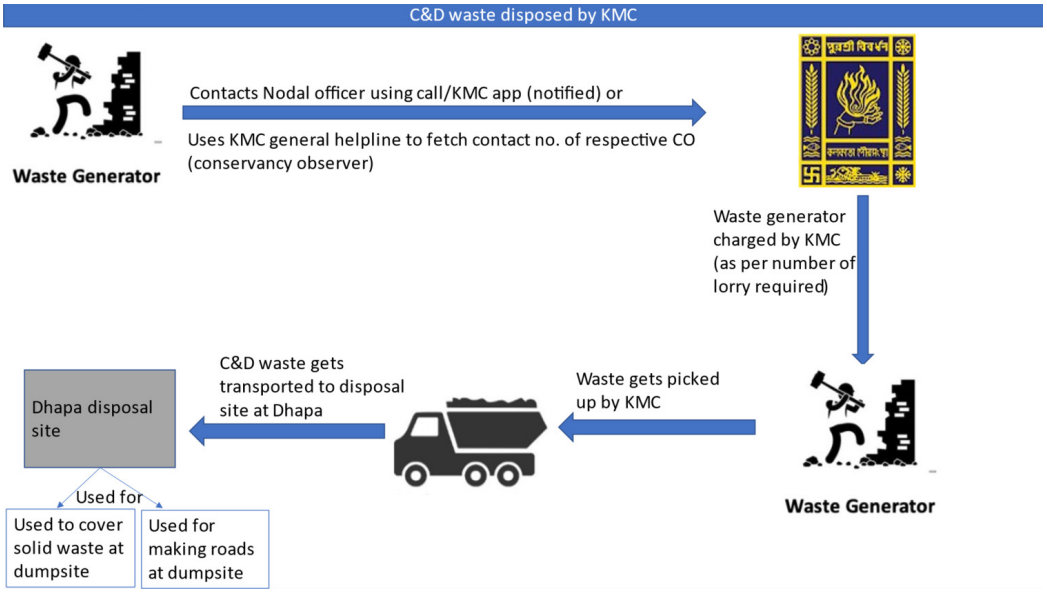
GPS in vehicle fleet

Vehicle fleets used to haul materials, mechanical sweepers and other vehicles in urban centres do not have GPS installed. In order to improve compliance monitoring, GPS-enabled vehicles (owned by ULBs as well as transport agencies) are needed to spot their location and intercept to check compliance as well as generate data for future assessment.

Dedicated helpline and MIS for collection requests and grievances

Cities across India are setting up dedicated helplines to smoothen the collection of C&D waste. For instance, in case of Kolkata, there is a mobile app and general helpline that connects to the KMC operator who further connects the caller to their local conservancy observer (see *Figure 5: C&D waste collection process established at KMC*). As the digital infrastructure is kicking in, cities are automating the process of waste collection that enables generators to raise collection requests, pay user fees, and share grievances by geo-tagging photos through one dedicated channel. This channel helps ULBs to manage and prioritize requests and respond promptly. Such automated systems help generate data and plan for infrastructure in the long run.

Figure 5: C&D waste collection process established at KMC

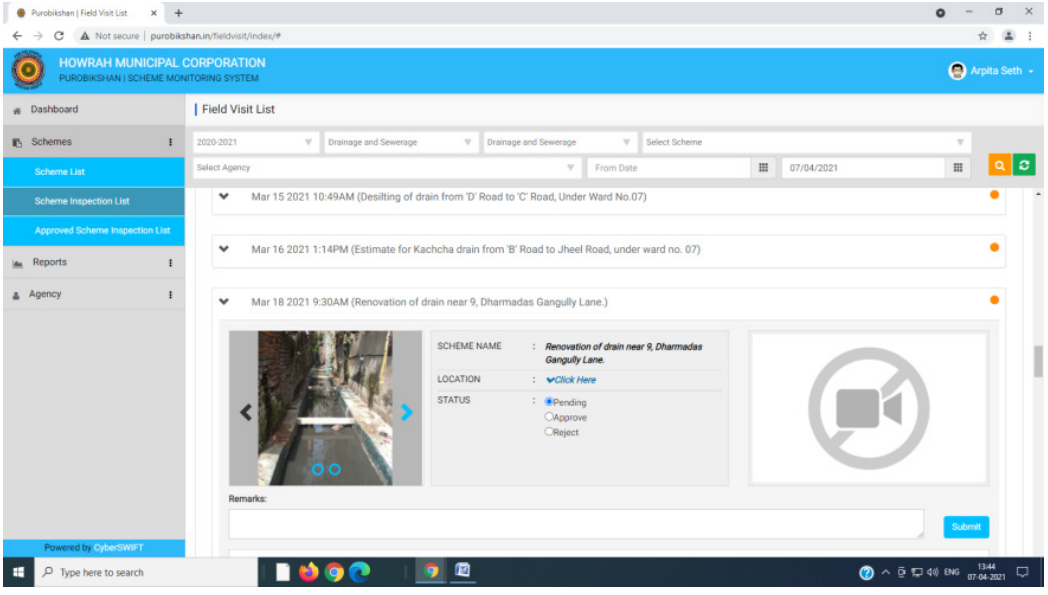


Source: Compiled by CSE

MIS of challans

CPCB QPR template asks cities to fill in the number of *challans* issued for a particular non-compliance. To keep a track of *challans* issued and the reason thereof, cities must setup MIS. Such automated systems also help track progress of municipal work contracts, and generate data and plans for policies in the long-run. Analysis of the data gathered in the MIS (a data base of non-compliances) will guide cities on information such as which are the maximum violations, where are they coming from and who is penalizing them. Such analysis helps in designing effective regulations, associated management practices, standard operating procedures (SoP), etc. For instance, Howrah Municipal Corporation has developed a MIS to track progress of desilting work contracts with photo evidence (see *Figure 6: Snapshot of scheme monitoring system adopted by Howrah Municipal Corporation*).

Figure 6: Snapshot of scheme monitoring system adopted by Howrah Municipal Corporation



Source: Howrah Municipal Corporation

Standard operating procedures

Cities are moving towards scientific management of C&D waste. There is a need to prepare a new generation of SoPs for different institutions involved in the process based on the C&D Waste Management Rules, 2016. These SoPs must guide those involved on appropriate segregation, collection, storage, transportation, processing and overall handling of C&D waste.

Air quality monitoring stations

In order to understand the impact of pollution-causing activities on their surrounding air environment, cities need as many monitoring stations as possible, especially around identified pollution hotspots.

Actions to eliminate regulatory gaps

Notification of C&D waste bye-laws

The assessment has revealed that cities are yet to notify their bye-laws for C&D waste management. Only big cities like Dehi, Gurugram, Jaipur and Kolkata have notified their C&D waste bye-laws either as part of their solid waste bye-laws (for example, Kolkata) or separately (for example, Jaipur). The bye-laws include user charges and penal action on failing to comply. However, the addressing of problems associated with C&D waste in a few city bye-laws may not be adequate and well-rounded. It needs to be elaborated to clarify the entire process of C&D waste segregation, storage, collection, transportation, processing and reuse as required under the C&D Waste Management Rules, 2016, along with generator responsibility. The rest of the cities are in the process of preparing their bye-laws for C&D waste management. They must include such details.

Notification of collection points and transfer stations

All these seven cities are yet to notify collection points or transfer stations for C&D waste. As per C&D Waste Rules, 2016, ULBs need to notify collection points and transfer stations for C&D waste that are identified based on adequate studies. This increases collection efficiency and optimizes transportation to bring down related cost and emissions.

Institutionalize self-declaration by construction sites

For building construction projects above 20,000 sq. m of built-up area, state PCBs ensure compliance with environmental requisites of C&D waste management. For projects smaller than 20,000 sq. m built-up area (that accounts for the majority of construction in our cities), ULBs have to devise instruments. Self-declaration and time-to-time reporting by project proponents to ULBs based on internal auditing as part of the building permission process can enable this. A list of non-compliances needs to be developed and notified along with corresponding penalty and clarity about the issuing agency or authority.

Notification to enable uptake of recycled C&D products

C&D Waste Management Rules, 2016 suggest replacement of 10–20 per cent of construction materials with recycled C&D waste. Currently, cities do not have

such mandate. To create an enabling environment for recycle and reuse of C&D waste, there is need for the government of West Bengal to notify mandatory use of recycled C&D products.

Notify checklist of measures for dust control and penal action for non-compliance

A specific address for each measure of dust control is missing from the cities. Cities are regulating compliance with dust control measures through a general undertaking submitted by the project proponent at the time of building permission. The undertaking states that the project proponent will comply with environmental norms. A detailed checklist with all the measures for dust control must be notified in each city, binding project proponents and other actors (material vendors, transporters, etc.) involved legally in the project. Penal action must also be specified for each non-compliance. The authority penalizing must also be specified.

Order to halt construction activities in the event of severe pollution

Currently, cities do not have a Graded Response Action Plans (GRAP) that brings construction activities to a halt when the AQI rises. Further, no authority is empowered to issue such a notice. Environment Pollution (Prevention and Control) Authority was the key body that regulated multiple pollution causing activities including construction in Delhi-NCR through a GRAP. This is now done by the Commission for Air Quality Management in the National Capital Region. Similarly, an order enabling an authority to halt construction activities in event of high AQI is required.

Actions to eliminate coordination gaps

ULBs are the key actor responsible for planning, making arrangements for collection, transportation and treatment of C&D waste, collecting user fee and imposing penalties. With setting up of C&D waste processing facilities in most cities on the public–private partnership model, much of the collection and transportation will be transferred to concessionaires. This makes concessionaires important actors in the entire process. State PCBs are the key regulators to check compliance with several environmental norms at different stages of building construction as well as C&D waste management. Local police is an actor who penalizes on certain non-compliances such as C&D waste outside building premises causing obstructions in the right-of-way and uncovered transportation of C&D waste. Currently, there is no system to harmonize actions between all these actors. As cities are in the process of setting up a new generation of services and systems, a dedicated cell needs to be created to monitor and enable inter- and intra-departmental coordination. This

cell must have representatives from air quality monitoring cells and experts to enable better monitoring and compliance.

Actions to eliminate enforcement gaps

Enforcement requires a closer-to-ground overview and is human resource-intensive. It requires inter-departmental coordination, which is difficult. ULBs that are usually short-staffed face challenges in deploying resources for day-to-day inspection and enforcement. Cities are now moving towards outsourcing enforcement responsibilities. For instance, Gurugram has appointed Pragati Al Natural Resource Pvt Ltd as an agency to enforce C&D waste rules, and this has helped the city clear 1.25 lakh tonne of C&D waste in seven months, making it the highest quantity cleared in five years. The enforcement agency has led to a 60 per cent reduction in illegal dumping.

In the era of digitization, cities are moving towards involving citizens in monitoring and enforcement mechanisms. Geo-tagging-enabled complaints are tools that can allow enforcement through citizens. Cities must develop MIS for *challans* issued. This will help identify and reduce cases of repeat offences. Further, building and expanding surveillance networks (CCTV cameras at illegal dumping hotspots) and remote monitoring can further streamline enforcement.

Actions to eliminate communication, awareness and capacity building gaps

In order to implement C&D waste and dust control compliances, the public, especially small-scale developers, need to be made aware of their responsibilities. Field investigation conducted in cities reveals that generators (especially non-bulk generators) are not aware of their duties with respect to C&D waste and dust control. Multiple violations have been observed such as failure to segregate, storage outside the building premises and illegal dumping. Illegal dumping is particularly rampant near construction sites. Heaps of C&D waste were observed along the highways and arterial roads in the cities visited.

A user manual that describes the entire process of C&D waste management, its benefits and what the generators need to do in the context of the city as well as a checklist that comprises all sources of dust in the construction process and associated compliance requirement needs to be prepared and disseminated widely. Events for target audience such as for small-scale developers, developers' associations, and architects and planners; and campaigns to maximize outreach to the public need to be designed.

The new generation of C&D waste management and emerging norms for dust mitigation require ample capacity building of all stakeholders involved. ULBs, WBPCB, developers' associations, civil society organizations, material vendors and transporters need to be trained on scientific handling of infrastructure to prevent dust emissions, coordination, communication and use of MIS and geo-tagging tools. All staff (municipal and concessionaire) responsible for collection, handling and transportation and treatment of C&D waste needs to be trained on respective SoPs (at the collection point, during transportation and at the processing facility, etc.). ULBs need to be trained on coordination, communication and use of MIS as well as planning and development of infrastructure. ULBs also need to be trained on non-compliances and efficient enforcement systems.

These actions will help cities in addressing C&D waste management and dust control comprehensively and nudge current systems towards implementation of C&D waste management and dust control rules. The data sought under each indicator in the quarterly progress reporting template is quantitative in nature, whereas the set of actions required to implement the indicator are qualitative. This is precisely what is currently amiss from the monitoring framework established by CPCB. Cities will have to focus on qualitative measures as identified in this assessment towards effective implementation of C&D waste management rules and dust control rules and overall greening of the C&D sector.

6. City assessments and a guidance framework

Impact driven performance

Cities are planning and implementing action towards C&D waste management and dust control and overall greening of the construction sector in different ways. Size of the city, local governance structures (comprising of actors, systems, functions, finances, etc.) and opportunities are some of the factors that require a deeper understanding. Therefore, CSE conducted secondary and field investigation in three states: West Bengal, Rajasthan and Haryana to capture the administrative and operational nuances. A mix of Tier-1 and Tier-2 cities like Gurugram, Jaipur, Udaipur, Jodhpur, Kota, Kolkata and Howrah was part of this investigation.

In this investigation, special focus was given to Tier-2 towns as they will form the bulk of urbanization and development according to a study by McKinsey Global Institute. Tier-2 towns (with population between one million and four million) will add roughly 27.4 million people and require at least 110 million sq. m of residential floor space according to estimates based on the study. These towns have an enormous opportunity to plan and implement action on clean air and take a step towards greening the construction sector.

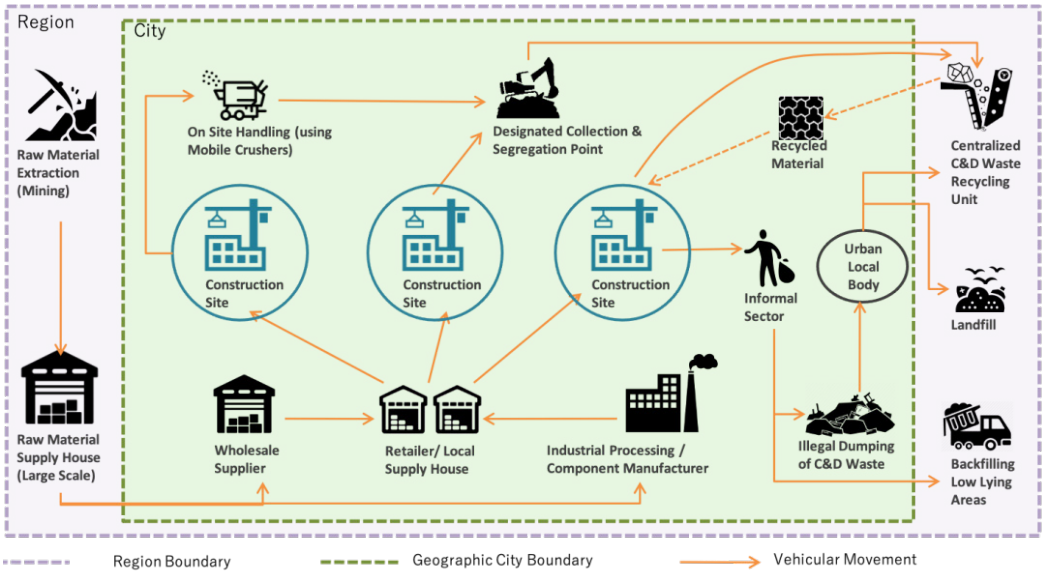
CSE studied the value-trade chain and emission chain in cities and understood operations, infrastructure, successes, challenges and mitigation potential in the C&D sector. As the previous sections have pointed out, cities do not have an understanding of mitigation potential of specific action for C&D waste management and dust control, so this assessment was done to understand which activities contribute, where are they located and which actors are involved. This has built an experience curve including on the nature of non-compliances.

This assessment was done at two levels: city and site; therefore, it has resulted in a two-level guidance that is based on non-compliances found in cities and informs on how to deal with them on-ground.

Understanding the value-trade chain

The construction life cycle can be broken down into a number of activities that take place either within the city boundary or outside of it regionally (see *Figure 7: Geographical distribution of construction and demolition activities*). Raw

Figure 7: Geographical distribution of construction and demolition activities



Source: CSE

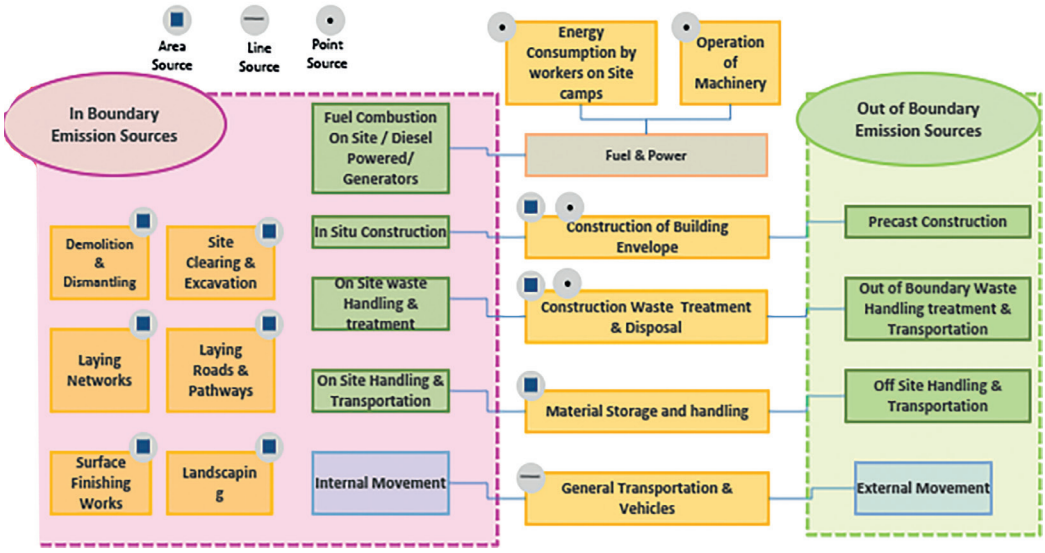
material extraction and storage takes place outside the city boundary. Activities move into the city boundary with material processing, distribution to wholesalers and retailers, use of materials at construction sites, generation of C&D waste, in-situ processing of C&D waste using mobile crushers, collection and storage of C&D waste at dedicated collection points and illegal dumping by the informal sector across the city as well outside the city boundary. Activities again move to a regional scale with a centralized C&D waste processing unit, manufacture of recycled products and backfilling (as new construction is mostly located at the city periphery).

To capture the value-trade chain, CSE mapped construction sites in cities as major sources of dust emissions using the RERA database. This mapping, along with other secondary sources, such as the comprehensive study on air pollution by IIT Kanpur, yielded construction hotspots that need to be addressed immediately. CSE visited these sites and hotspots and further understood the geographical exchange and expanse of C&D activities through interaction with ULBs. For instance, where the materials are being stored and sold, where C&D waste is taken, where C&D waste is processed (if it is) and illegal C&D waste dumping spots.

Understanding the emissions chain

Field investigation helped in understanding the nature and intensity of emissions activities and types of emissions sources. This is a crucial step for any city towards curbing particulate pollution and greening the construction sector. Various

Figure 8: Categorization of dust emission sources in C&D activities



Source: CSE

construction activities that contribute to air pollution can be drilled down to sub-activities like land clearing, excavation, C&D waste management, operation of diesel engines, demolition, burning and working with toxic materials. Fugitive dust emanates from construction sites, material selling points, C&D waste collection points, and processing sites, etc. All these activities are different types of emission sources—area, line and point sources. These emission sources can also be classified based on whether they cause direct or indirect emissions. Direct emissions can be grouped into in-boundary emission sources and out-of-boundary emission sources (see *Figure 8: Categorization of dust emission sources in C&D activities*).

Mitigation potential

Studies have shown that each small mitigation measure has enormous potential for curbing particulate pollution (see *Table 7: Mitigation potential of some dust-control measures*). However, this mitigation potential varies. For instance, sprinkling water on unpaved surfaces can mitigate dust emissions by 10 to 74 per cent according to the WRAP fugitive dust handbook.

CSE visited construction sites in some cities, as identified through the RERA database, to develop observations on the types and intensity of fugitive dust emissions taking place in various C&D activities. This visit suggested that there are two crucial factors that contribute to dust mitigation: 1) The timing of mitigation

Table 7: Mitigation potential of some dust-control measures

Source category	Control measure	Published PM10 control efficiency (per cent)
Construction and demolition	Water unpaved surfaces	10–74
	Limit on-site vehicle speed to 15 mph	57
	Apply dust suppressant to unpaved areas	84
	Prohibit activities during high winds	98
Materials handling	Implement wet suppressions	50–90
	Erect three-sided enclosure around storage piles	75
	Cover storage pile with a tarp during high winds	90
Paved roads	Sweep streets	4–26
	Minimize track out	40–80
	Remove deposits on road ASAP	> 90
Unpaved roads	Limit vehicle speed to 25 mph	44
	Apply water	10–74
	Apply dust suppression	84
	Pave the surface	> 90
Mineral products industry	Cyclone or multi-clone	68–79
	Wet scrubber	78–98
	Fabric filter	99–99.8
	Electrostatic precipitator	90v99.5

Source: WRAP fugitive dust handbook, 2006

measures, and 2) The method used for mitigation. CSE further understood these two factors to develop guidance on implementing mitigation measures.

Timeline of construction activities

A timeline of construction activities is vital to understand the dust pollution emanating from these activities. Such a timeline gives cities and regulators clarity on how to stagger mitigation efforts. To understand a typical construction timeline and related dust emissions, CSE conducted a consultative workshop with CPWD to establish a timeline of a typical construction activity in June 2021. In this workshop, an exercise was given to 62 CPWD engineers to arrange the given stages of construction in the correct order and in a timeline according to their experience. This exercise was based on a typical 24-month long construction project (see *Figure 9: A typical staging and timeline of a construction and demolition activity*). A site area of four–five acre was considered.

The results of the workshop revealed that in the first three months, the number of activities is limited. From the third month onwards, the number of activities

Figure 9: A typical staging and timeline of a construction and demolition activity

Activity or stage	Project timeline (in months)								
	1	3	6	9	12	15	18	21	24
Site clearing and excavation									
Transportation and vehicles									
Material storage and handling									
Construction of building envelope									
Emissions from operation of machinery									
Fuel consumption by workers on site									
Laying roads and pathways									
Surface finishing works									
Laying networks									
Landscaping									
Construction waste storage, treatment and disposal									

Source: Compiled by CSE

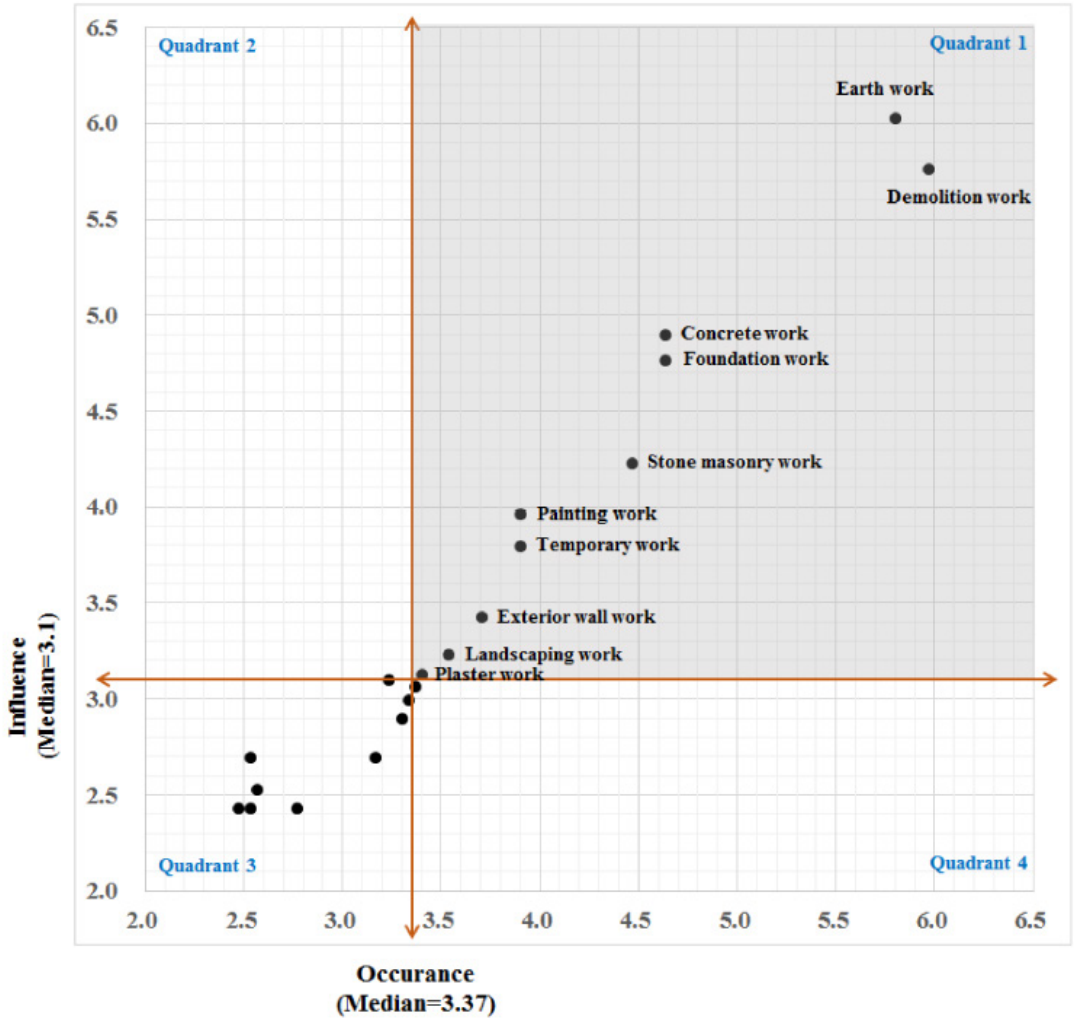
increases. From the 15th month, the activities intensify and involve dust generation from multiple sources that need to be looked at.

Research conducted by Department of Architecture Engineering, Kwangwoon University, Seoul, Korea, plotted the stages of construction that contribute the most and influence the fugitive dust emissions in a sample of 21 construction sites. Stages like earthwork and demolition work, followed by concrete work and foundation work were termed as the most dust generating activities among others, falling the quadrant 1 of the graph (see *Graph 4: Occurrence influence matrix for various dust pollution sources related to C&D activities*).

Mitigation measures: Technical know-how

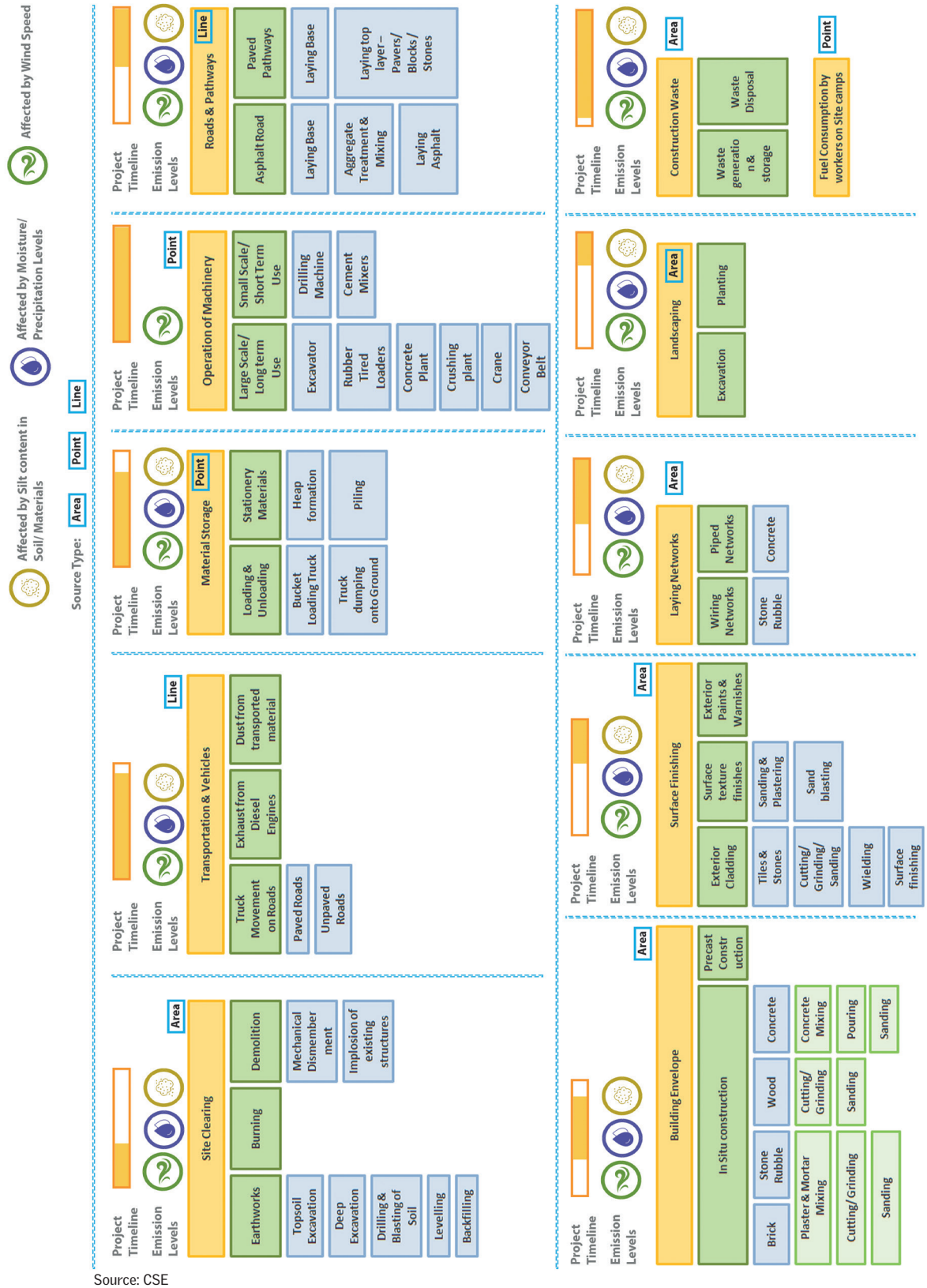
Other than the timing of C&D activities, the technical know-how on how to execute a certain operation can affect the mitigation potential. Silt content in materials, moisture or precipitation levels and wind speed are key factors contributing to dust emissions in C&D activity. Therefore, CSE has compiled a list of activities along with their staging in construction timeline and the factors that affect emissions from those activities. These factors lead to build guidance on how to curb dust emissions from those specific C&D activities.

Graph 4: Occurrence influence matrix for various dust pollution sources related to C&D activities



Source: https://www.researchgate.net/publication/324594182_Identifying_Effective_Fugitive_Dust_Control_Measures_for_Construction_Projects_in_Korea

Figure 10: Stages and components of construction activity causing air pollution



Source: CSE

7. Guidance manual for greening the construction sector—city-scale

Dust control has been guided in India since 1948 with legislations such as the Factories Act, 1948 and the Environment Protection Rules, 1986 have provided for dust mitigation measures in several processes and operations.[8&9] C&D Waste Management Rules, 2016 emphasize the collection, transportation, and disposal of waste in an environment friendly manner.These Rules were followed by CPCB guidelines on dust mitigation measures in handling construction materials and C&D wastes in 2017.CPCB has also provided guidelines for Environmental Management of Construction and Demolition (C&D) Wastes.[12] The latest framework for dust control are the mandatory compliance measures to be adopted by projects requiring environmental clearance and all construction and demolition activities as per the Environment (Protection) Amendment Rules, 2018.[13]

CSE assessed the regulatory frameworks along with guidelines such as the Council of Scientific and Industrial Research, National Environmental Engineering Research Institute (CSIR-NEERI) guidelines for control of dust pollution at construction and demolition sites and from demolition activities and transportation of debris and construction materials and internalized them in an in-depth guide for dust control related to C&D activities.[14] Several international guidelines were also considered.[15, 16 & 17]

C&D waste collection, handling and storage

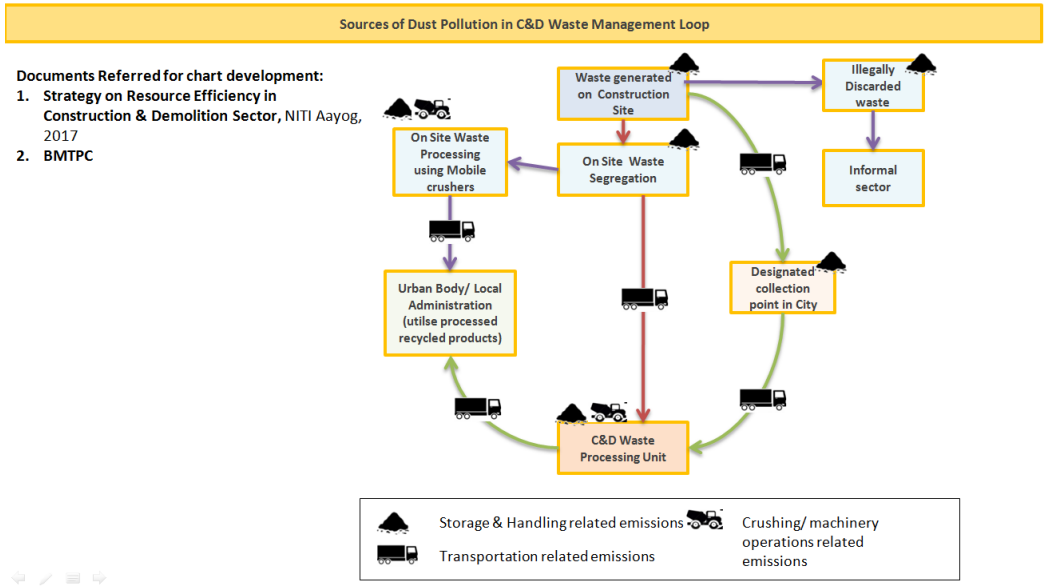
Handling and treatment of C&D waste involves all point, line and area sources of emissions (see *Figure 11: Emissions related to C&D waste handling*). In absence of collection points or a transfer station, C&D waste is either dumped illegally or used for backfilling, thus becoming a point source of emissions (see *Images 12 and 13: Illegal dumping of C&D waste*). ULBs can eliminate these emissions by providing dedicated collection points or transfer stations and arresting the dust emissions within them.

Images 12 and 13: Illegal dumping of C&D waste

SUGEET GROVER

APARNA CHOUDHARY

Figure 11: Emissions related to C&D waste handling



Source: https://www.eurei.com/pdf/publication/NA_MoHUA_Strategy%20on%20RE%20in%20C&D%20Sector_Jan%202019.pdf

C&D waste handling guidelines

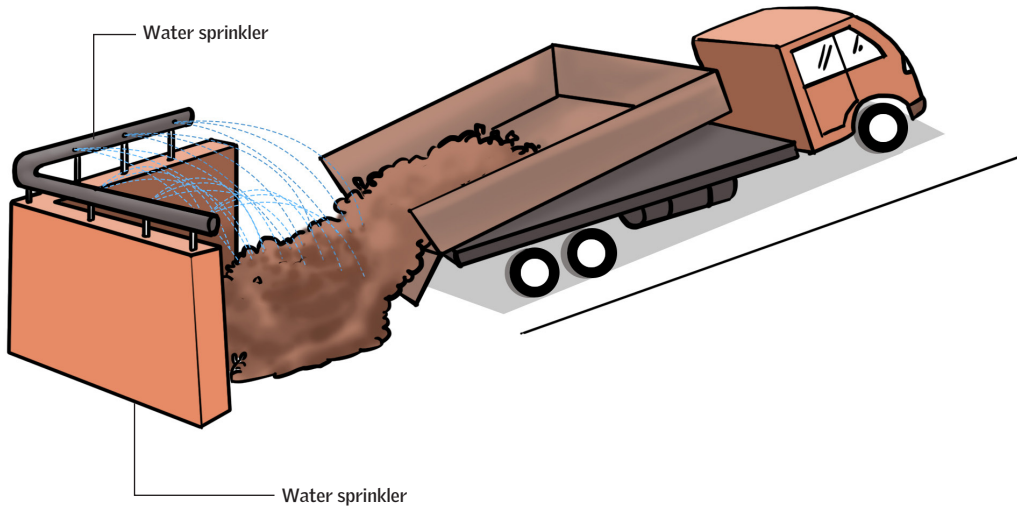
CPCB and CSIR-NEERI guidelines suggest dampening C&D waste stockpiles at collection points or transfer stations and using wind barriers to minimize fugitive dust emissions. CSE recommends minimizing the drop height and emptying the container carrying C&D waste slowly. Loading and unloading activities must be carried out in the downwind side of the waste stockpile. The stockpiles must be kept segregated with proper signage and away from the collection point boundary, sensitive receptors, water courses and surface drains. Water must be sprayed to suppress dust. Wind breaks (in the form of buildings, barriers, vegetation, etc.) need to be used to deflect the wind and stockpiles must be covered with non-cloth materials.

Table 8: C&D waste handling (unloading and loading) at waste collection points, transfer stations and C&D waste processing facilities

Existing regulations for dust mitigation	**CPCB guidelines (November 2017)** • The unloading activities at temporary and intermediate C&D waste dumpsites to ensure that dust-borne particles are damped either by water spray or aligning the waste disposal in such a way that minimizes dust dispersal (wind breakers). **CSIR-NEERI (2019)** • Dust suppressants should be applied to the top surface of the material to be transported or its entire surface area prior to loading. • Materials may be sprayed with dust suppressant, 15 minutes prior to handling or at points of transfer.
CSE recommendation	• C&D waste to be emptied slowly, while keeping the receiving container close to the loader (drop height to be kept at a minimum). • Water spray and wind breakers to be used while handling C&D waste; wind breakers to be installed near unloading and loading points. • Dust suppressants to be applied to the top surface of the C&D waste to be transported. • C&D waste loading and unloading activities to be confined to downwind side (side that is protected from the wind) of the storage pile.

Source: Compiled from mutiple sources

Figure 12: Water spray and wind breakers to be used while handling C&D waste, wind breaker to be installed near unloading and loading points



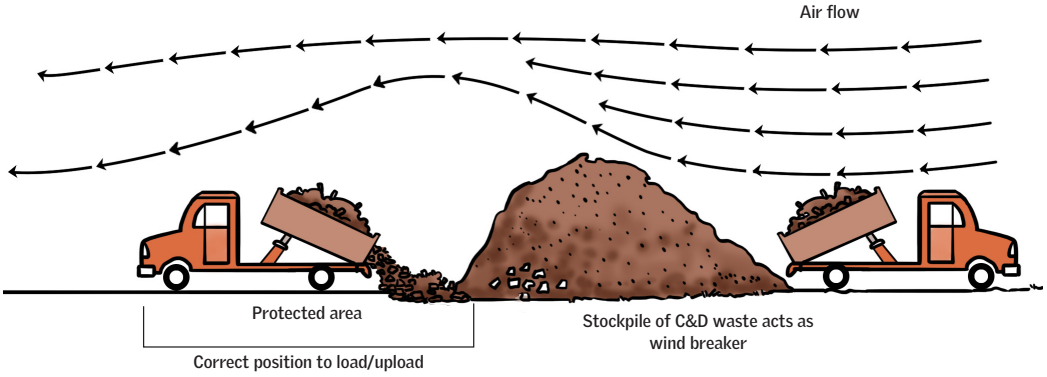
Source: CSE

Table 9: Waste storage and stockpiling at waste collection points, transfer station and C&D waste processing facilities

Existing regulations for dust mitigation	**CPCB guidelines (November 2017)** • All areas for storing C&D wastes and construction materials to be demarcated and preferably barricaded, particularly those materials that have potential to be dust-borne. **CSIR-NEERI (2019)** • For some materials, hard crusts can be built-up on storage piles by application of dust suppressants. Crusts reduce the dust blown off the storage piles. Care is required to avoid application of dust suppressants to a degree that may erode or settle the fines to the bottom of the pile. • Enclose stockpiles or keep them securely sheeted. • Make sure that stockpiles exist for the shortest possible time. • Do not build steep sided stockpiles or mounds or ones which have sharp changes in shape. • Stockpiles should be kept away from site boundary, sensitive receptors, water courses and surface drains. • A much more effective technique (than applying water to the storage pile) is to apply chemical agents (such as surfactants) directly to the storage pile, which permit more extensive wetting. • **C&D Waste Management Rules, 2016** • Every waste generator shall prima-facie be responsible for collection, segregation of concrete, soil and others, and storage of construction and demolition waste generated, as directed or notified by the concerned local authority in consonance with these Rules. • Waste generators that generate more than 20 tonne or more in one day or 300 tonne per project in a month shall segregate the waste into streams—concrete, soil, steel, wood and plastics, bricks and mortar—and submit waste management plans and get appropriate approvals from the local authority before starting construction or demolition or remodelling work and keep the concerned authorities informed regarding the relevant activities from the planning stage to the implementation stage and this should be on a project-to-project basis.
CSE recommendation	• Areas for storing C&D waste to be barricaded and demarcated with proper signage, contaminated materials to be stockpiled on impermeable surface. • Dust suppressants to be used on materials in which hard crusts are formed (upon usage of dust suppressants), however overusage to be avoided. • Stockpiles to be securely sheeted, enclosed and kept away from the site boundary, sensitive receptors, water courses and surface drains. • Steep sloped stockpiles to be avoided, instead gradual slopes to be used. • Minimize excessive stockpiling of waste and materials by phasing works and scheduling transfer for recycling. • Wind-breaks to be provided to deflect wind away from waste stockpiles.

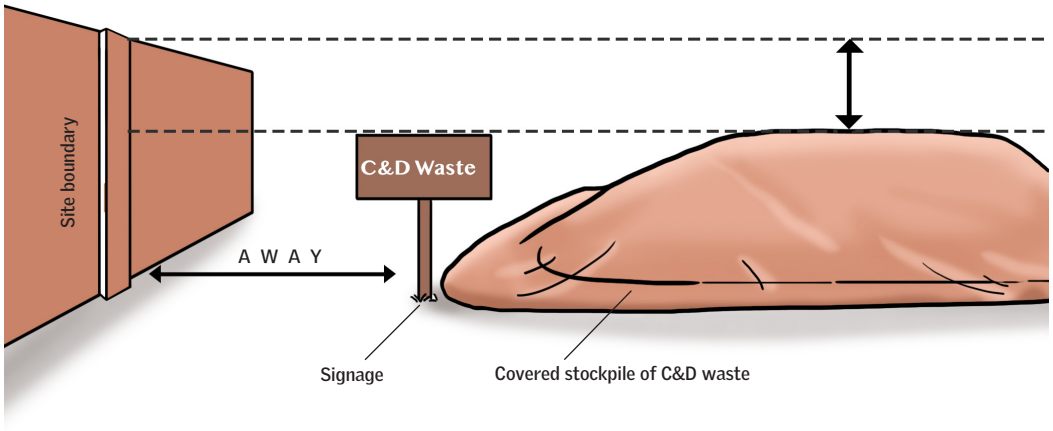
Source: CSE compilation

Figure 13: Material loading and unloading activities to be confined to downwind side (protected from the wind) of the storage pile



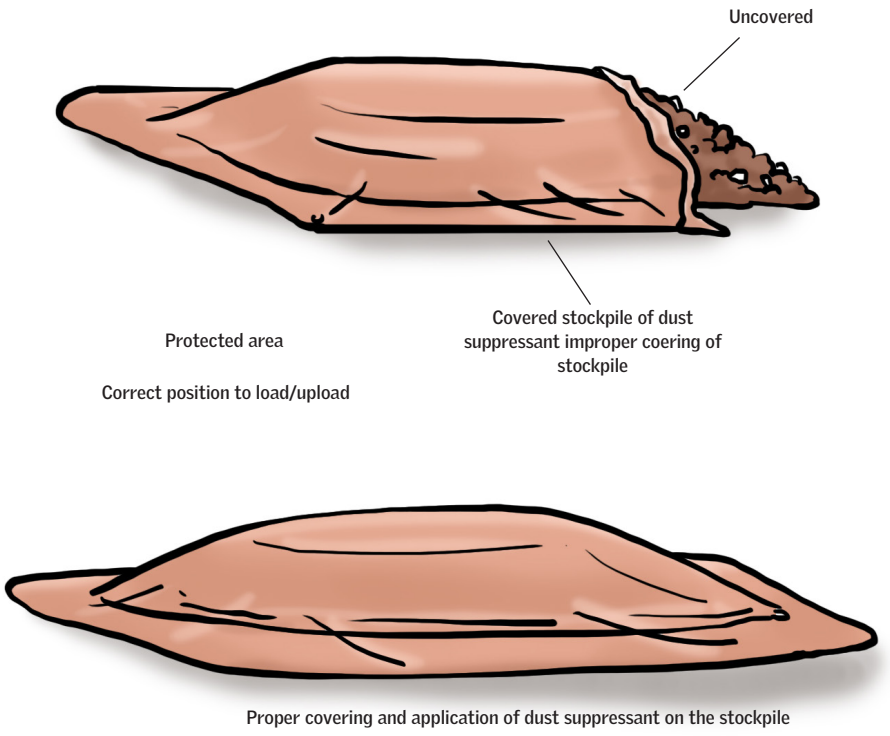
Source: CSE

Figure 14: Stockpiles to be securely sheeted, enclosed and kept away from the site boundary, sensitive receptors, water courses and surface drains



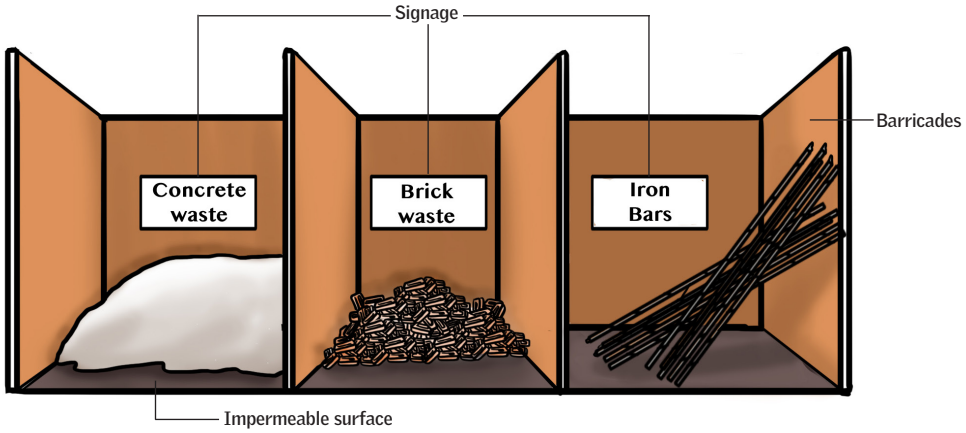
Source: CSE

Figure 15: Improper covering of stockpile and application of dust suppressants



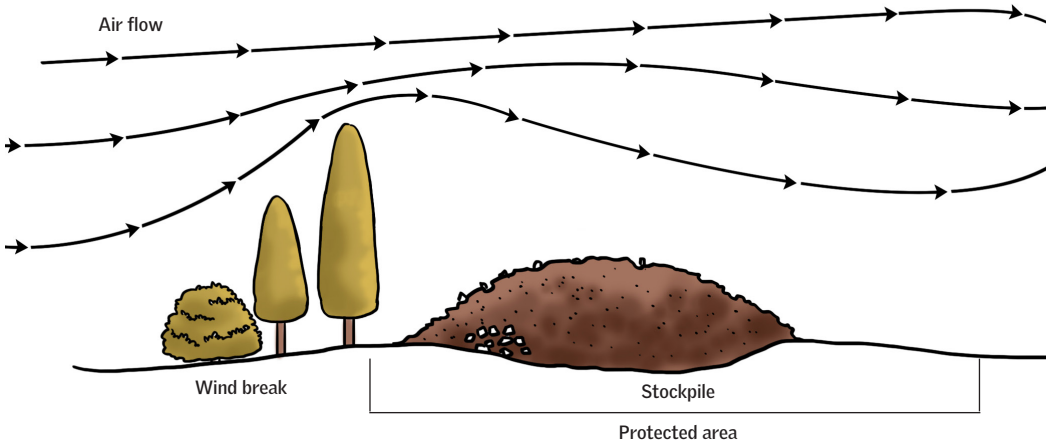
Source: CSE

Figure 16: Areas for storing of C&D waste to be barricaded and demarcated with proper signage, contaminated materials to be stockpiled on impermeable surface



Source: CSE

Figure 17: Wind-breaks to be provided to deflect wind away from waste stockpiles



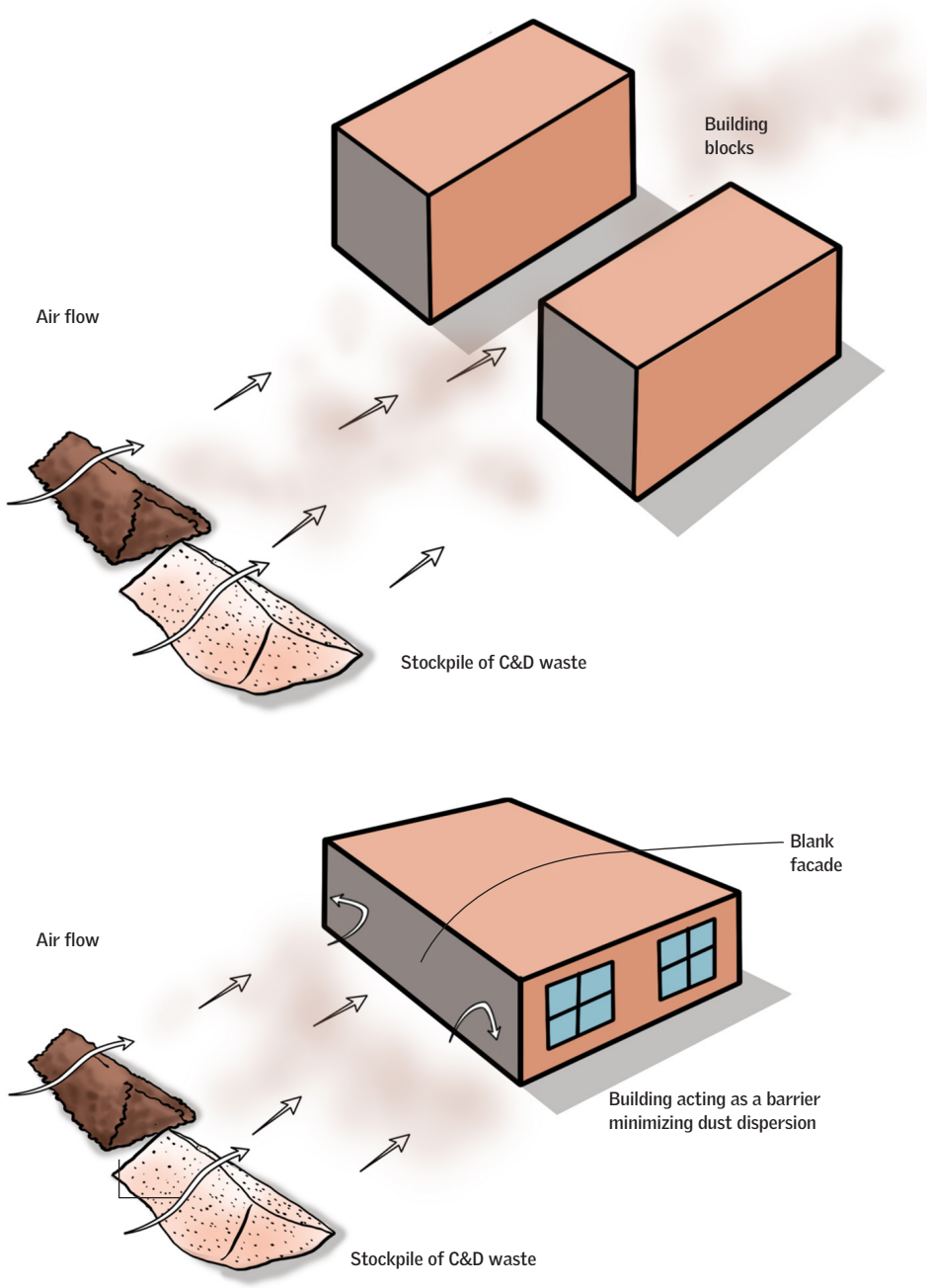
Source: CSE

Table 10: Site-level measures for design of transfer stations

CSE recommendations	• Allow private land to be used as collection and storage points subject to environmental clearance from pollution control boards. • Buffer zones to be created with the help of vegetation and landscape features for controlling dust; transfer station boundaries to be fenced. • The main building to be oriented facing predominant wind direction, this façade to ideally be kept without windows. • Wind-breaks to be provided to deflect wind away from waste stockpiles.

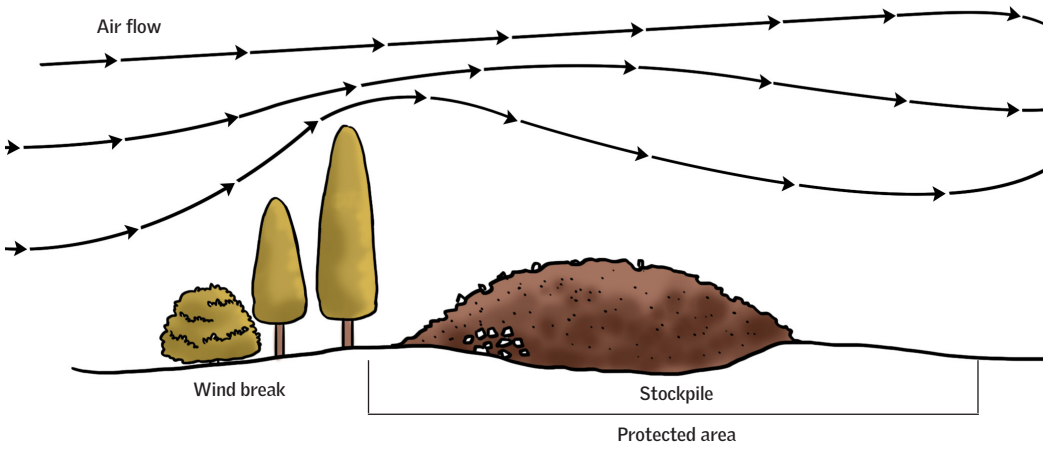
Source: CSE

Figure 18: The main building to be oriented facing predominant wind direction, this façade to ideally be kept without windows



Source: CSE

Figure 19: Wind-breaks to be provided to deflect wind away from waste stockpiles



Source: CSE

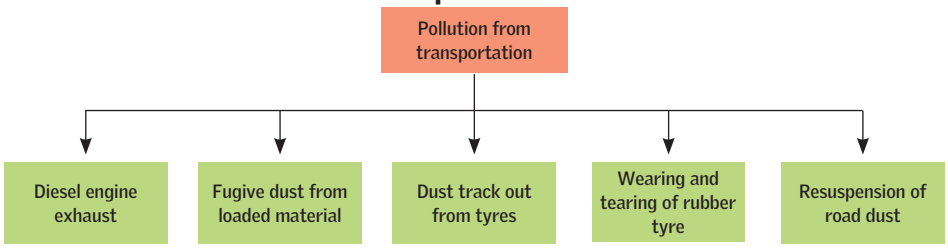
C&D waste and material transportation

Uncovered transportation of materials with silt content leads to fugitive dust emissions. Vehicular movement on unpaved staging areas, unpaved parking areas, unpaved material storage areas, unpaved access areas, and haul roads and paved roadways also emit dust. This makes this activity a linear source of emissions. Several non-compliances were found during the field investigation, especially uncovered trucks hauling C&D waste and materials (see *Images 14–17: Uncovered trucks hauling materials and C&D waste in cities*).

Images 14–17: Uncovered trucks hauling materials and C&D waste in cities

Credits: Sugeet Grover and Aparna Choudhary

Figure 20: Emissions related to transportation in and out of the site



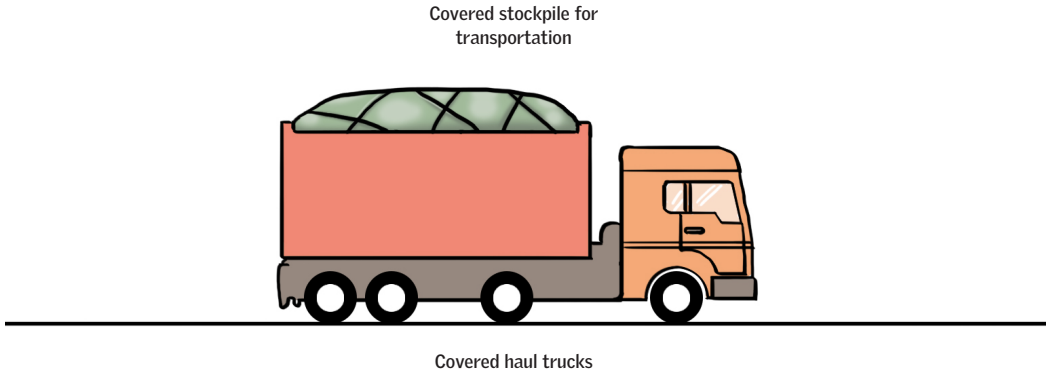
Source: CSE, 2021

The other types of dust emissions from vehicles range from diesel engine exhausts, fugitive dust from loaded material, dust tracks of tyres, wearing and tearing of rubber tyres, and re-suspension of road dust (see *Figure 20: Emissions related to transportation in and out of the site*).

Guideline

There is an array of guidelines as well as mandatory provisions of Environment (Protection) Amendment Rules, 2018 that inform or mandate measures for dust control. CSE recommends that in addition to covering vehicles with non-cloth material, dust must be suppressed by sprinkling water over the top of materials being transported, and washed or scrubbed off tyres of trucks.

Figure 21: Vehicles carrying C&D waste to be covered from above with jute, tarpaulin, plastic, etc., and the cargo compartment to be sealed



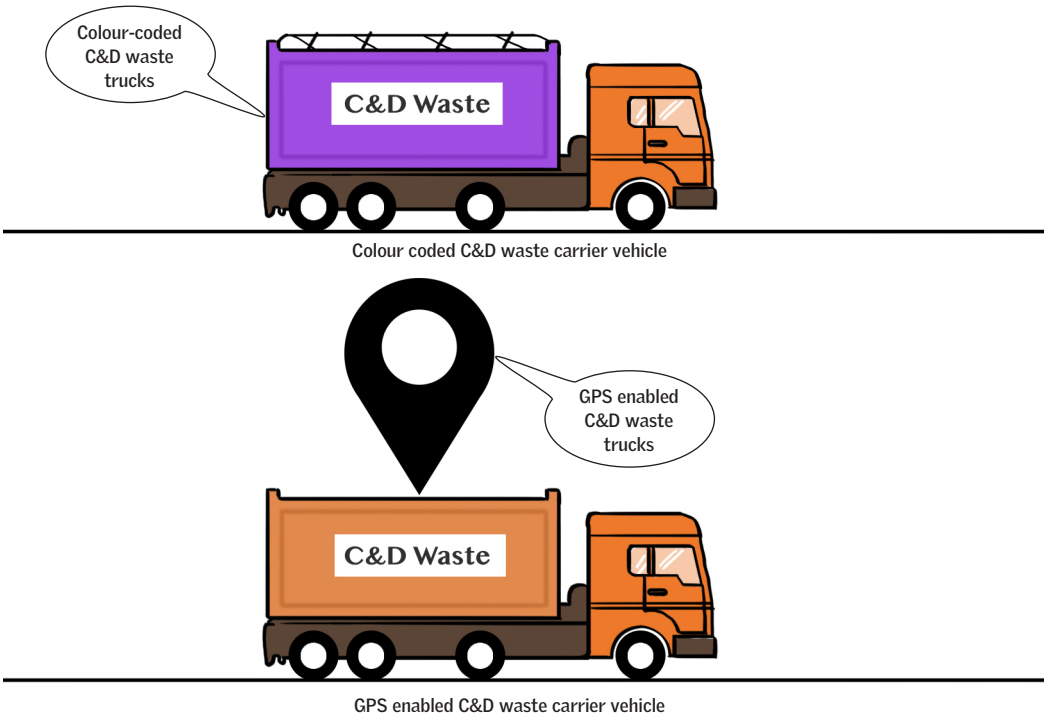
Source: CSE

Table 11: Transportation of building materials and construction and demolition waste inside and outside the site

Existing regulations for dust mitigation	**CSIR-NEERI (2019)** Dust control for debris and other construction material transportation • Closed vehicles like dumpers can be used for this purpose. • Dust suppressants should be applied to the top surface of the material to be transported or the entire surface area prior to loading. • Materials may be sprayed with dust suppressants 15 minutes prior to handling at points of transfer. **MoEF&CC Notification (2018)** • Uncovered vehicles carrying construction material and waste shall not be permitted (point no. 107) • Plastic and tarpaulin sheet covers shall be provided for vehicles bringing in sand, cement, murram and other construction materials prone to causing dust pollution at the site as well as taking out debris from the site. **CPCB guidelines (November 2017)** Dust abatement measures during transportation of construction material and C&D wastes • Transport routes for carrying construction material and C&D wastes to be identified—preferably to avoid residential, schools, institutional and hospital areas. • Transport material that are easily wind-borne need to be covered by a sheet made of either jute, tarpaulin, plastic or any other effective material.
	• Routes of transport vehicles within the construction site be damped by water (preferably treated wastewater) sprinklers. • As transport vehicles move generally during night time, the transport permit should also indicate the material and waste being transported, quantity being transported and place of loading and unloading destinations.
CSE recommendations	• Vehicles carrying construction and demolition waste to be closed from above and covered with jute, tarpaulin, plastic, etc. and the cargo compartment floor to be sealed. • A gap between the top enclosure of the container and upper surface of loaded material and waste to be maintained. • Dust suppressant to be applied to the top surface and entire surface area of the material being transported. • C&D waste and material carrying vehicles to be equipped with GPS for rationalization of routes to avoid sensitive receptors and residential, school, institutional and hospital areas. • Vehicles carrying C&D waste to be colour-coded for easy identification of authorized C&D waste transport vehicles.

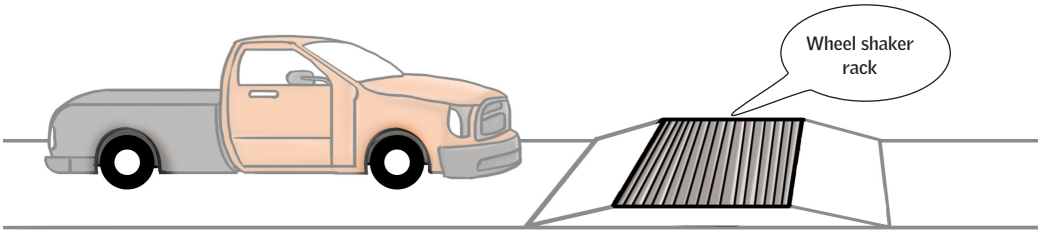
Source: CSE

Figure 22: C&D waste and material carrying vehicles to be equipped with GPS and vehicles carrying C&D waste to be colour-coded for easy identification of authorized C&D waste transport vehicles



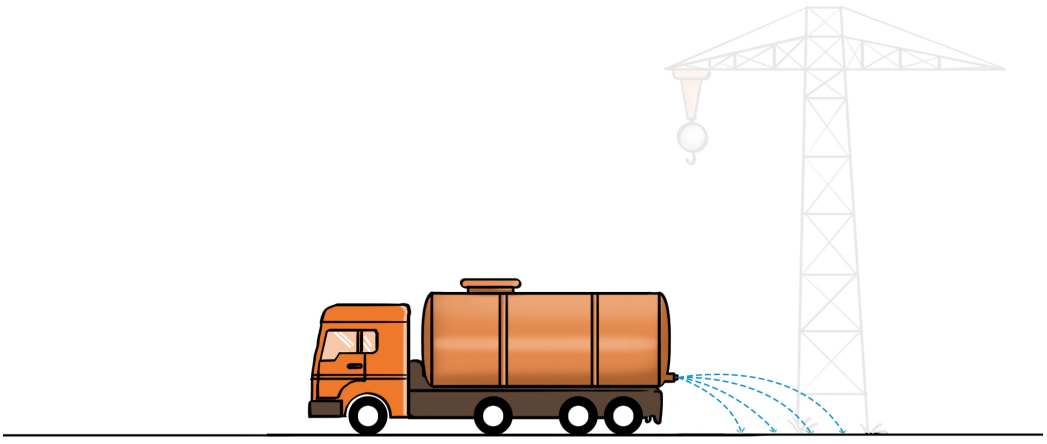
Source: CSE

Figure 23: Provisions for scrubbing off the dirt and mud from the tyre of vehicles to be employed, devices such as wheel shakers, wheel washers and grizzlies (rough surfaced areas that scrub off dirt from tyres) to be used



Source: CSE

Figure 24: Dust suppressant to be applied to the top surface or entire surface area of the material being transported

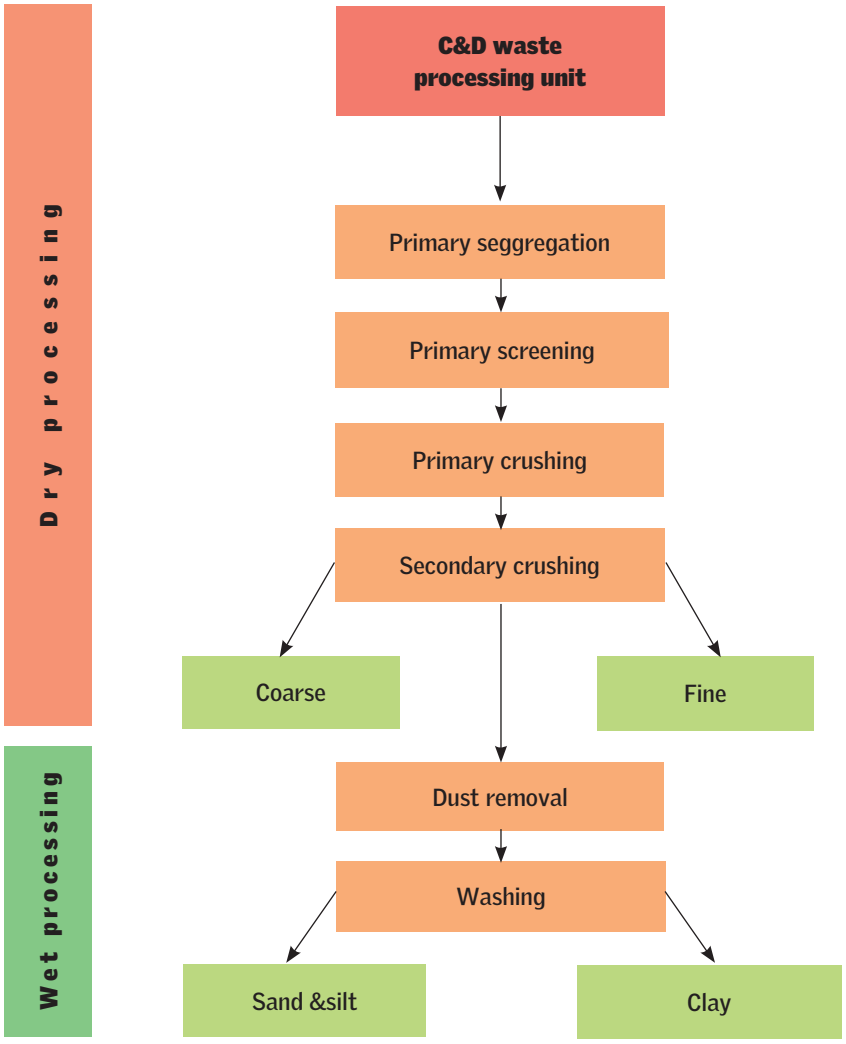


Source: CSE

C&D waste processing

At the C&D waste processing site, there are a number of operations that emit dust. These include segregation, crushing and screening operations that are a source of fugitive dust emissions (see *Figure 25: Emission sources in a waste processing unit*).

Figure 25: Emission sources in a waste processing unit



Source: http://re.urbanindustrial.in/live/hrdpmp/hrdpmaster/igep/content/e64918/e64922/e67075/e67087/GIZ_CD_eTraining-Manual.pdf

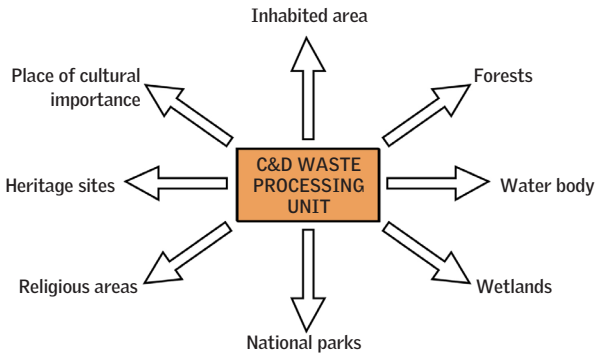
Guideline

Table 12: Selection and design of C&D waste processing facility

Existing regulations for dust mitigation	**Construction and Demolition Waste Management Rules, 2016** • The processing or recycling site shall be away from habitation clusters, forest areas, water bodies, monuments, National Parks, wetlands and places of cultural, historical or religious interest. • A buffer zone of no development shall be maintained around every solid waste processing and disposal facility exceeding an installed capacity of five tonnes per day. The buffer zone will be maintained within the total area of the solid waste processing and disposal facility. The buffer zone shall be prescribed on a case-to-case basis by the local authority in consultation with the concerned State Pollution Control Board. • A vegetative boundary shall be made around the processing or recycling plant or site to strengthen the buffer zone. **CPCB Guidelines on Environmental Management of C&D wastes (March 2017):** • The following distance restrictions to be considered with respect to setback distances from the outer boundary of C&D facilities, wherein it not be located within the following receptor setback distances: i. 200 metres from any industrial and commercial land use property ii. 100 m from the bank or high water mark of any watercourse or wetland or pond or lake iii. 150 metres of right-of-way boundary of a public highway iv. 50 metres from any other adjacent property
CSE recommendation	• The processing site to be located away from habitable areas, forests, water bodies, monuments, national parks, wetlands and places of cultural, historical or religious interest. • Locate land for centralized recycling facility within or close to the city based on receptor and habitation mapping, the location to be earmarked in the master plan. • A buffer zone of no development zone to be maintained around the waste processing facility as per Construction and Demolition Waste Management Rules, 2016. • The site for processing facility to be fenced and a vegetative boundary to be provided around it. • C&D waste processing facility to maintain distance from industrial areas or residential areas and water bodies, distances to be maintained as per CPCB guidelines on Environmental Management of C&D waste (2017).

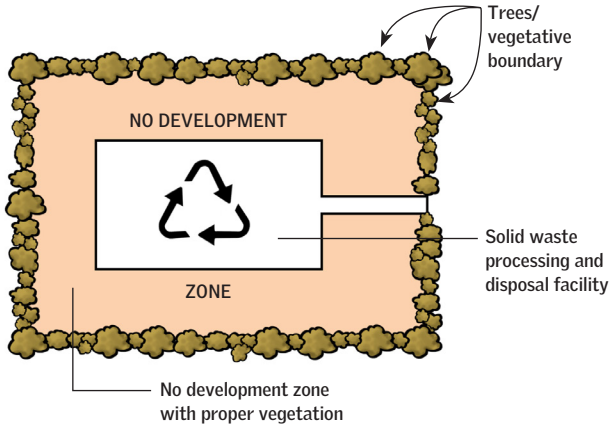
Source: Compiled from multiple sources

Figure 26: The processing site to be located away from inhabited areas, forests, water bodies, monuments, national parks, wetlands and places of cultural, historical or religious interest



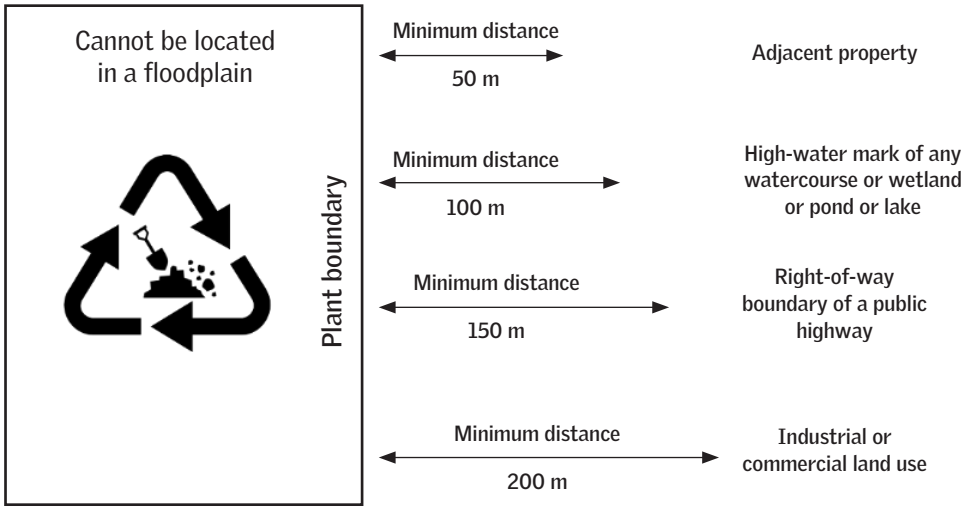
Source: CSE

Figure 27: The site for the processing facility to be fenced and a vegetative boundary to be provided around it



Source: CSE

Figure 28: The C&D waste processing facility to maintain distance from industrial areas, residential areas and water bodies, distances to be maintained as per CPCB Guidelines on Environmental Management of C&D waste



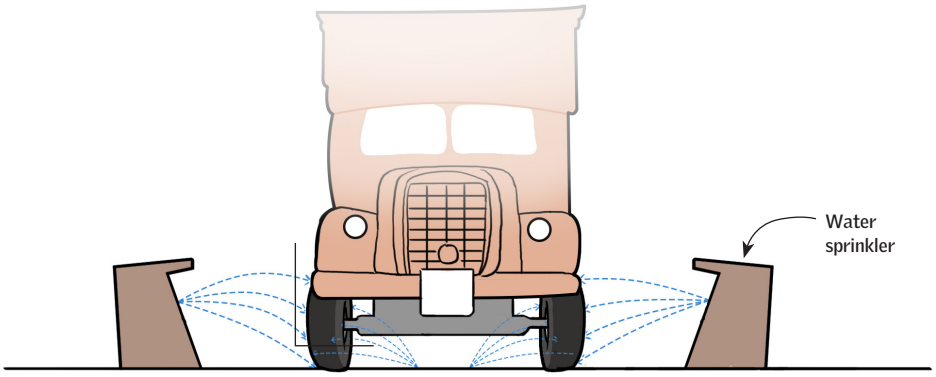
Source: CSE

Table 13: Entry and exit of vehicles from the C&D waste processing facility and transfer stations

Existing regulations for dust mitigation	C&D Waste Management Rules, 2016 • The approach or internal roads shall be concrete or paved so as to avoid generation of dust particles due to vehicular movement and shall be designed in a way that ensures free movement of vehicles and other machinery. • The processing or recycling site shall be fenced or hedged and provided with proper gates to monitor incoming vehicles or other modes of transportation.
CSE recommendation	• Approach and internal roads to and inside the site to be concretized or paved to avoid dispersion of dust particles due to vehicular movement. • Site entrances to be equipped with monitoring facilities to ensure accountability of movement of vehicles to and from the site; facility boundary to be fenced. • Under-body wash or wheel washing facilities for C&D waste or material carrying vehicles to be installed at the entrance. • Provisions for scrubbing off dirt or mud from tyre of vehicles to be employed, devices such as wheel shakers, wheel washers and grizzlies (rough surfaced areas that scrub off dirt from tyres) to be used. These devices to be cleaned regularly.

Source: CSE

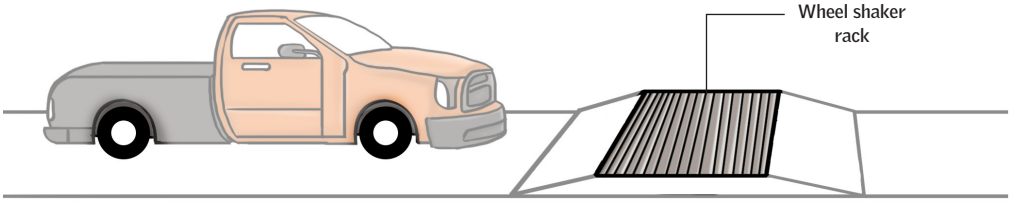
Figure 29: Under-body wash or wheel washing facilities for C&D waste or material carrying vehicles to be installed at the entrance



Washing the wheels of vehicles with dust suppressants

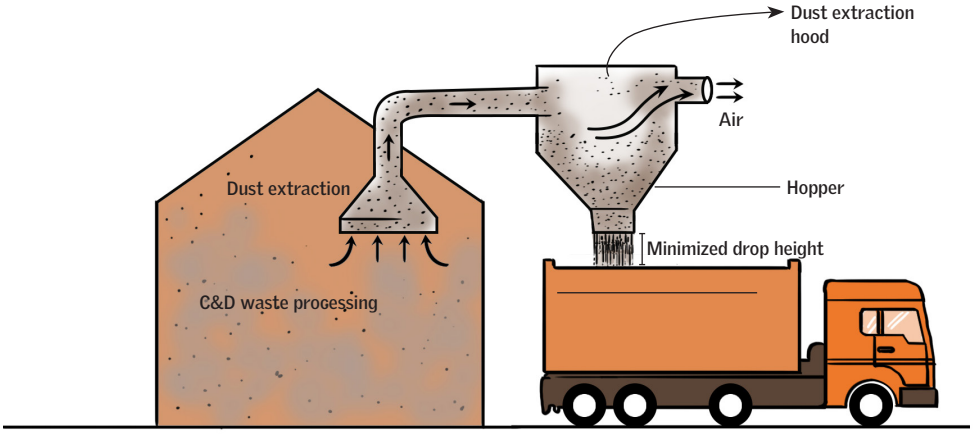
Source: CSE

Figure 30: Provisions for scrubbing off dirt and mud from the tyres of vehicles to be employed, devices such as wheel shakers, wheel washers and grizzlies (rough surfaced areas that scrub off dirt from tyres) to be used



Source: CSE

Figure 31: Dust extraction hood to be installed to control dust at the C&D waste processing facility, drop height of the hopper to be kept low to minimize dust dispersion



Dust extraction hood to be installed to control dust at the C&D waste processing facility

Source: CSE

Table 14: Segregation, feeding and crushing activities at the C&D waste processing facility

CSE recommendation	• Micro-sprinklers to be adopted during the crushing process to arrest the dispersion of micro-solid particles. • Conveyor belts to be enclosed at least from three sides, equipped with belt wipers and cleaned periodically to get rid of residual material. • Dust generating machinery or blasting operation to be enclosed and the ground underneath to have an impermeable surface. • The fallen debris from processing to be periodically collected and put back into the system. • A dust extraction hood to be installed to control dust at the C&D waste processing facility, drop height of the hopper to be kept low to minimize dust dispersion.

Source: CSE

Road dust suppression

Vehicular movement on unpaved areas, unpaved parking areas, unpaved access areas and roads with potholes causes road dust emissions (see *Images 18–20: Partially paved roads or roads laden with dust*). These are linear source of emissions and also include fugitive dust from loaded materials, dust trackout from tyres, wearing and tearing of rubber tyres and resuspension of road dust.

Images 18–20: Partially paved roads or roads laden with dust

MITASHI SINGH

Guideline

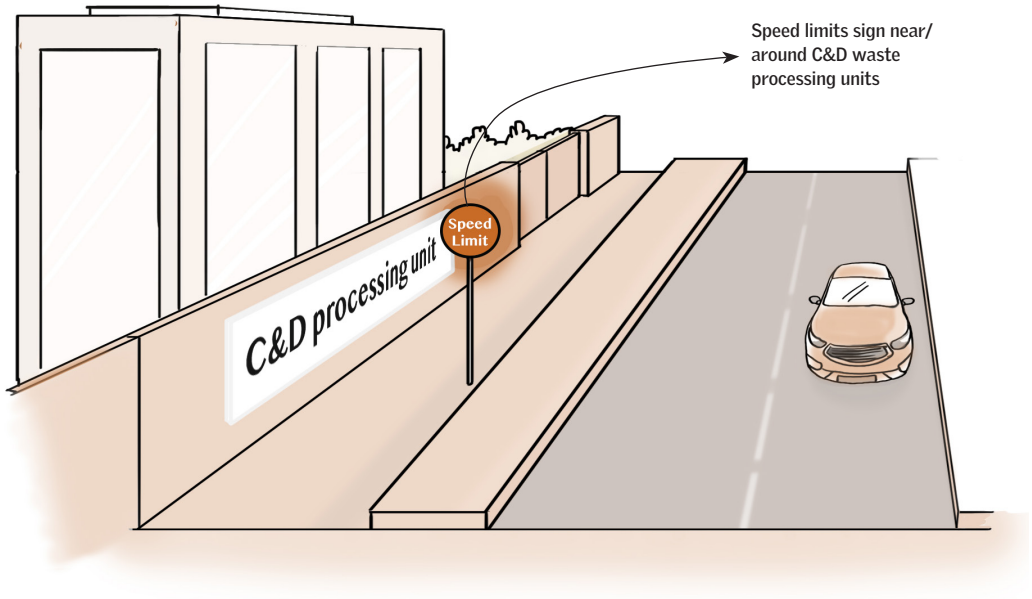
Existing guidelines for dust control including the Indian Road Congress recommendation on suppression of road dust by increasing vegetation along the roads, limiting vehicle speed and design of roads with sufficient strength so that potholes are not created frequently.

Table 15: Measures for suppression of road dust

Existing regulations for dust mitigation	**Indian Road Congress IRC:SP:119-2018** • Road design should consider medium high canopy trees for dust prevention and mitigation of heat island effect. Section 2.5 lays down the strategy for planting, type of trees and plantation for various components of roads. On all unpaved areas, median and tree pits, plantation of native grass and hedges should be done, which should be able to withstand dust, should not attract cattle, etc. The guidelines provide the height of median and respective tree plantation. • Guidance on design of various drainage systems that could be adopted for roads is covered in Section 2.6. Bio-filtration systems like bio-swales, bio-planters and green cutters help to prevent resuspension of dust. • Plantation typology for roads that lie in industrial areas and busy arterials are covered in Section 2.7.5. In these areas, two rows of trees should be provided and in areas with low water table, the soil surface needs to be covered with mulch to absorb dust. Within the right-of-way, any unpaved area should not have exposed soil and needs to be covered with ground covers, shrubs, mulch or any other plantation. **CPCB Guidelines (November 2017)** • Dumping (unloading) and storage of construction material for use in on-going projects on public roadsides is prohibited (Point no. 15) **Construction and Demolition Waste Management Rules, 2016** • Every waste generator shall keep the construction and demolition waste within the premise or get the waste deposited at a collection centre so made by the local body or hand it over to an authorized processing facilities of construction and demolition waste; and ensure that there is no littering or deposition of construction and demolition waste so as to prevent obstruction to the traffic or the public or in drains (Point no. 4) **CPCB Guidelines (November 2017)** • Dumping (unloading) and storage of construction material for use in on-going projects on public roadsides is prohibited. **MoEF&CC Notification (2018)** • Construction material and waste shall be stored only in earmarked areas and roadside storage is prohibited.
CSE recommendations	• Vegetation to be planted on streets as per specification mentioned in IRC:SP:119-2018. • Bio-filtration systems can help in prevention of resuspension of dust, these systems such as bio-planters, bio-swales and green cutters to be incorporated on streets as per specification mentioned in IRC:SP:119-2018. • Vehicular speed limit to be specified close to the C&D activity hotspots such as C&D recycling facilities, etc. to prevent resuspension of dust. • Storage of C&D waste and material on streets to be prohibited, the streets next to heavy C&D activity sites to be cleaned up of dust and debris periodically. • Roads to be designed with sufficient strength and with proper drainages in order to avoid wear, tear, potholes or deformation of the road surface.

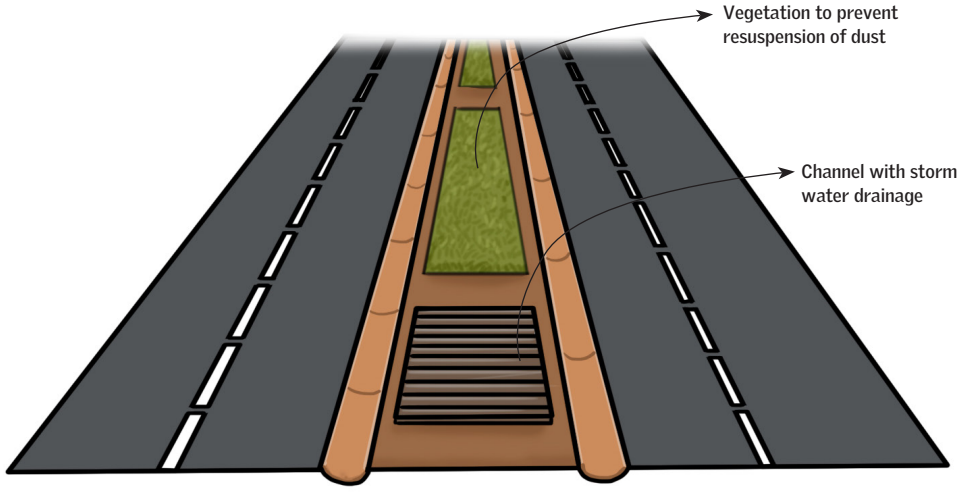
Source: Compiled from multiple sources

Figure 32: Vehicular speed limit to be specified close to C&D activity hotspots such as recycling facilities to prevent resuspension of dust



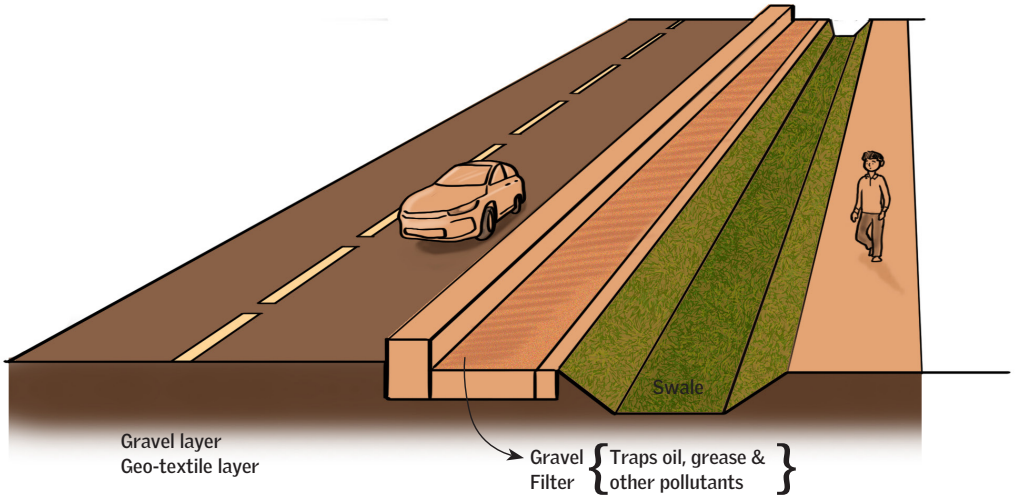
Source: CSE

Figure 33: Roads to be designed with sufficient strength and with proper drainage in order to avoid wear, tear, potholes or deformation of the road surface



Source: CSE

Figure 34: Bio-filtration systems can help prevent resuspension of dust; these systems such as bio-planters, bio-swales and green cutters to be incorporated on streets



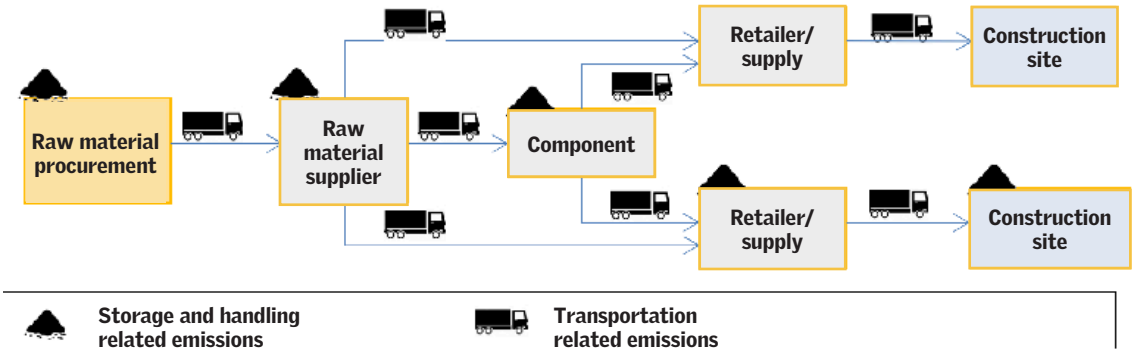
Source: CSE

8. Guidance manual for greening the construction sector—site-scale

Material storage and handling at construction sites

Fugitive dust emissions generated by stacking, loading and unloading operations, and importing or exporting bulk materials from one area to another fall in this category. This category also includes airborne dust emitted from active and inactive storage piles. Dust produced 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 eyes, nose and mouth to effects on the respiratory system.

Figure 35: Emissions related to material procurement, storage and handling



Source: https://www.researchgate.net/figure/Example-of-a-Construction-Supply-Chain-for-a-Building-Material_fig1_250291896

Guideline

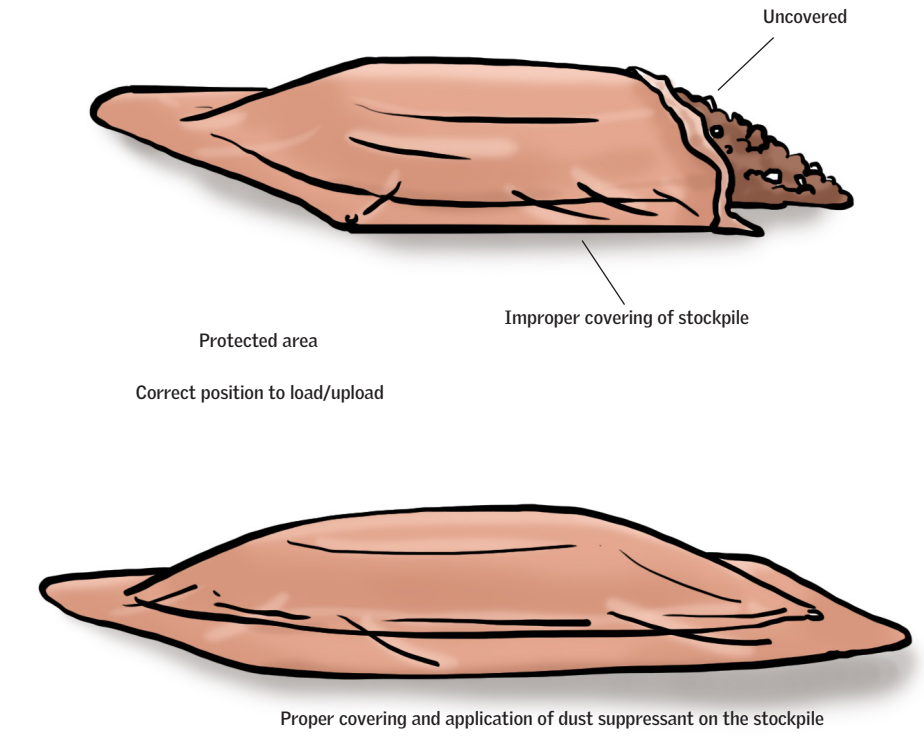
CPCB and CSIR-NEERI guidelines suggest covering material stockpiles and using dust suppressants to prevent fugitive dust emissions from material storage and handling. CSE recommends restricting stockpile height, dedicating an undisturbed storage space, segregation with signage and restricting drop heights as some of the measures that can reduce related dust emissions.

Table 16: Storage of construction materials at construction and demolition sites

Existing regulations for dust mitigation	**MoEF&CC Notification (2018)** • Loose soil, sand, construction and demolition waste or any other construction material that causes dust shall not be left uncovered (Point no. 106) • Construction material and waste shall only be stored in earmarked areas and road side storage is prohibited (Point no. 107) • Sand, murram, loose soil and cement stored on site shall be covered adequately so as to prevent dust pollution. **CPCB Guidelines (November 2017)** • All areas for storing C&D wastes and construction material to be demarcated and preferably barricaded, particularly those materials that have potential to be dust borne. • Sand and gravel: Sand and other fine aggregates to be stored in demarcated areas and covered. • Other fine materials: Preferably to be kept in sealed bags. • Cement bags to be stored in enclosed areas; loose cement to be stored in silos. **CSIR-NEERI (2019)** • For some materials, hard crusts can be built-up on storage piles by application of dust suppressants. Crusts reduce the dust blown off storage piles. Care is required to avoid application of dust suppressants to a degree that may erode or settle fines to the bottom of the pile. • Storage piles that are greater than 2.5 metre (eight feet) in height and not covered may have a road bladed to the top to allow water truck access or should have operational water irrigation systems that are capable of complete stockpile coverage. • Disturbed areas of construction sites, including storage piles of fill dirt and other bulk materials that are not actively utilized for construction purposes for a period of seven days or more must be stabilized with a chemical dust stabilizer or enzymatic dust suppressant. • Developers should avoid the use of long-term stockpiles on-site wherever possible, unless it performs the function of visual or noise screening. • Enclose stockpiles or keep them securely sheeted. • Make sure that stockpiles exist for the shortest possible time. • Do not build steep sided stockpiles or mounds or ones that have sharp changes in shape. • Stockpiles should be kept away from site boundaries, sensitive receptors, water courses and surface drains. • Fine or powdery material (under 3 mm size) should be stored inside buildings or enclosures.
CSE recommendations	• Areas for storing of materials and C&D waste to be barricaded (three-sided) and demarcated with proper signage, contaminated materials to be stock piled on impermeable surface. • Dust suppressants to be used on materials in which hard crusts are formed (upon usage of dust suppressants), however over-usage to be avoided. • Stockpiles to be securely sheeted, enclosed and kept away from the site boundary, sensitive receptors, water courses and surface drains. • Steep sloped stockpiles to be avoided; instead, gradual slopes to be used, stockpile height to be kept lower than that of a wind breaker. • Minimize excessive stockpiling of waste and materials by efficient procurement, phasing works and scheduling transfer for recycling. • CCTV cameras to be installed by bulk generators for monitoring of storage areas. • Waste storage points for segregation to be identified on a common site for multiple small projects in vicinity of each other. • Uncovered storage piles exceeding 2.5m height to have bladed roads for access of water trucks or other dust suppressant (such as water sprinkling) system to cover the entire stockpile. • Disturbed areas in construction sites which remain unutilized for seven days or more to be stabilized to avoid dust dispersion.

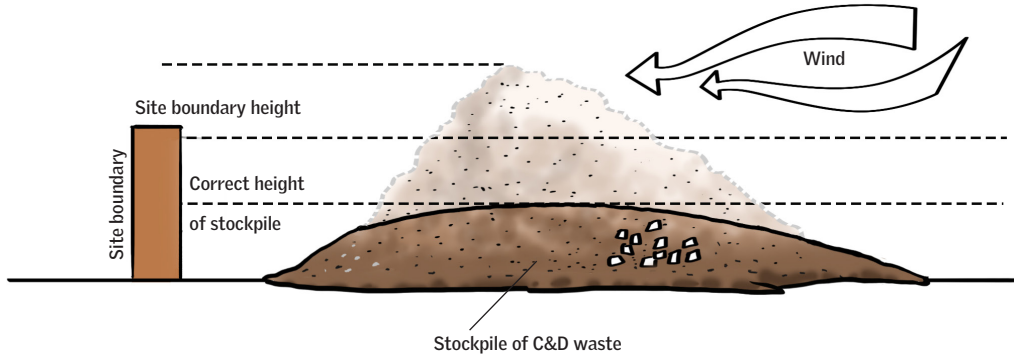
Source: Compiled from multiple sources

Figure 36: Stockpiles to be securely sheeted and enclosed



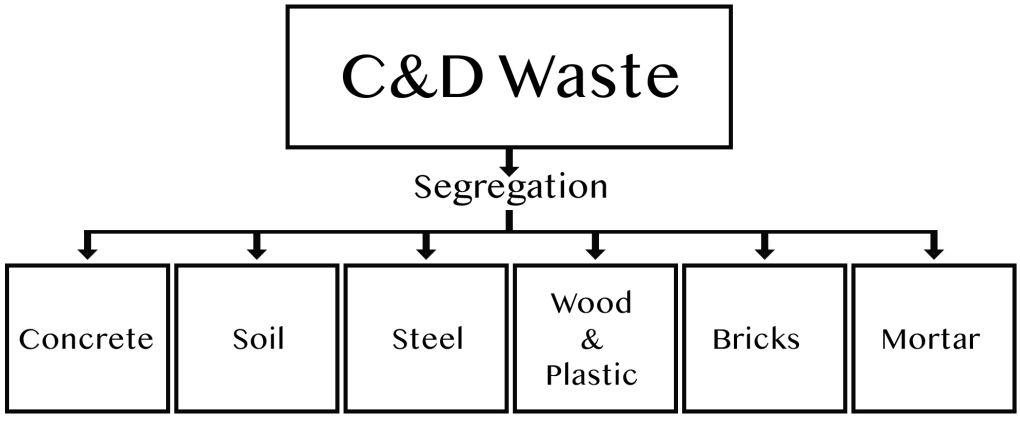
Source: CSE

Figure 37: Steep-sloped stockpiles to be avoided, instead gradual slopes to be used, stockpile height to be kept lower than that of wind breakers



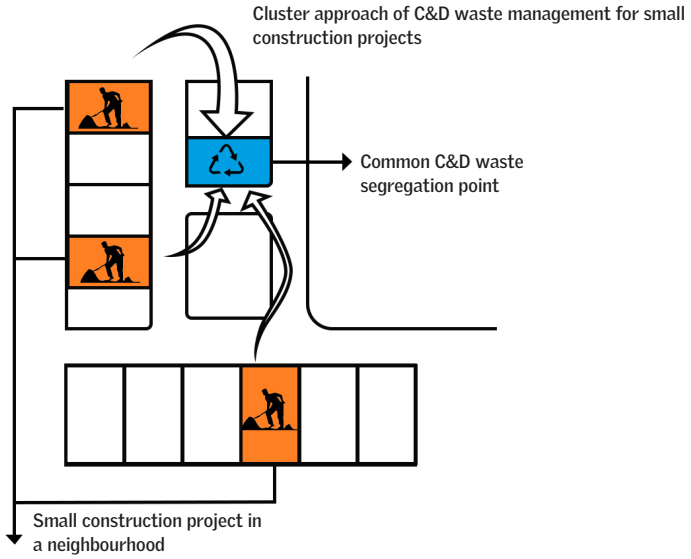
Source: CSE

Figure 38: Segregation of waste to be carried out into streams of concrete, soil, steel, wood and plastics, bricks and mortar and space for the same to be allotted



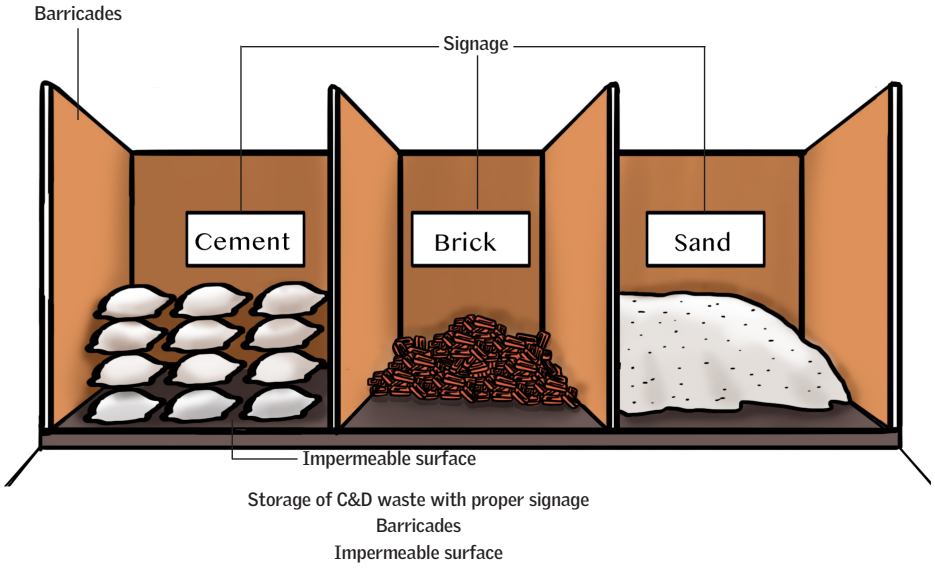
Source: CSE

Figure 39: Waste storage points for segregation to be identified on a common site for multiple small projects in vicinity of each other



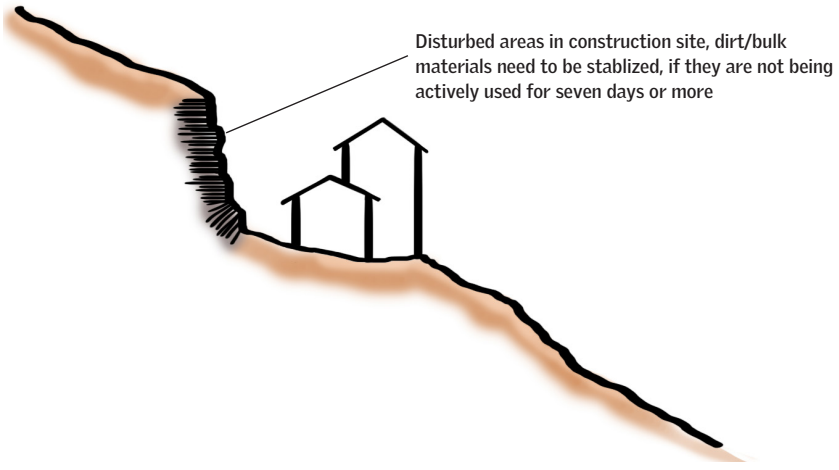
Source: CSE

Figure 40: Areas for storing of materials and C&D waste to be barricaded (on three sides) and demarcated with proper signage; contaminated materials to be stockpiled on impermeable surface



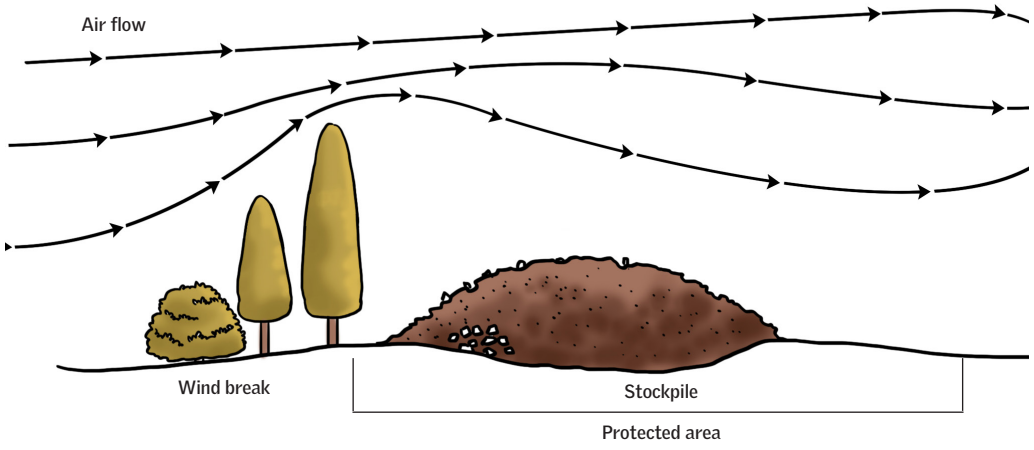
Source: CSE

Figure 41: Disturbed areas in construction sites which remain unutilized for seven days or more to be stabilized to avoid dust dispersion



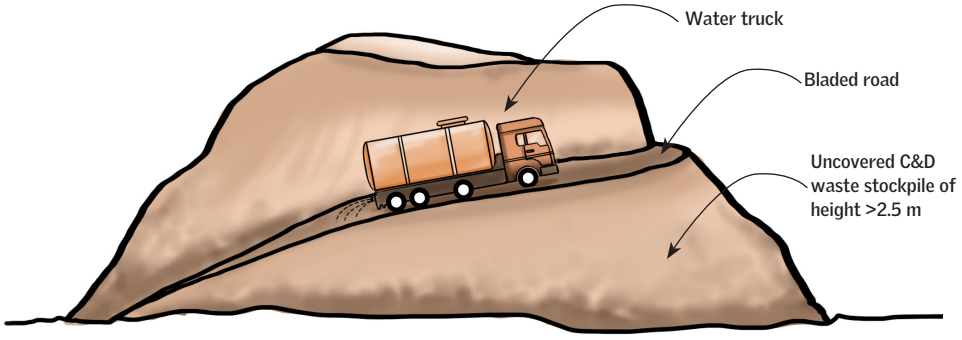
Source: CSE

Figure 42: Wind-breaks to be provided to deflect wind away from waste stockpiles



Source: CSE

Figure 43: Uncovered storage piles exceeding 2.5 m height to have bladed roads for access of water trucks or other dust suppressant (such as water sprinkling) system to cover the entire stockpile



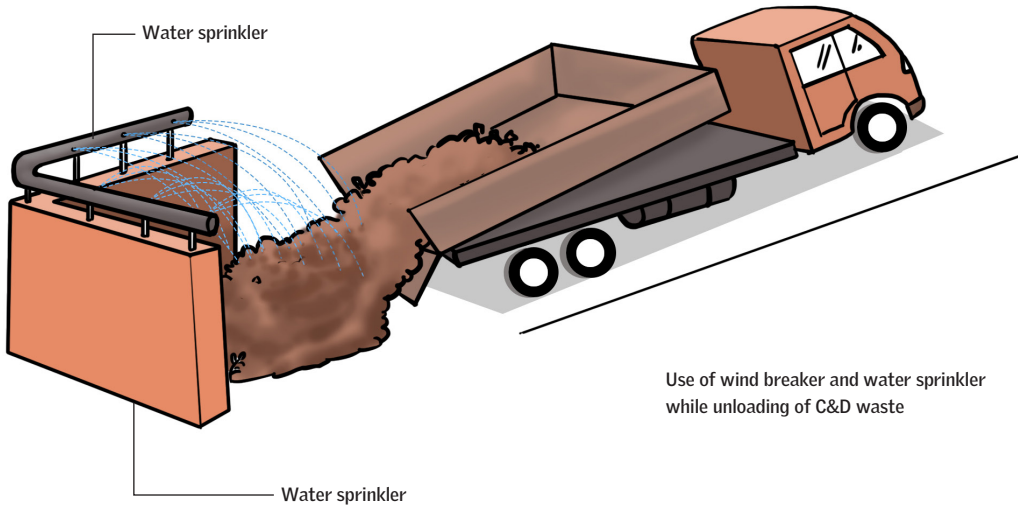
Source: CSE

Table 17: Handling (loading and unloading) operations at construction and demolition sites

Existing regulations for dust mitigation	**CPCB Guidelines (November 2017)** • The unloading activities at temporary and intermediate C&D waste dumpsites to ensure dust borne particles are damped either by water spray or aligning the waste disposal in such a way that minimizes dust dispersal (wind breakers). **CSIR-NEERI (2019)** • Dust suppressants should be applied to the top surface of the material to be transported or its entire surface area prior to loading. • Materials may be sprayed with dust suppressant, 15 minutes prior to handling and at points of transfer.
CSE recommendations	• Material to be emptied slowly, while keeping the receiving container close to the loader (to keep drop height at a minimum). • Water spray and wind breakers to be used while handling C&D waste, wind breakers to be installed near unloading and loading points. • Material loading and unloading activities to be confined to downwind side (side that is protected from the wind) of the storage pile.

Source: CSE

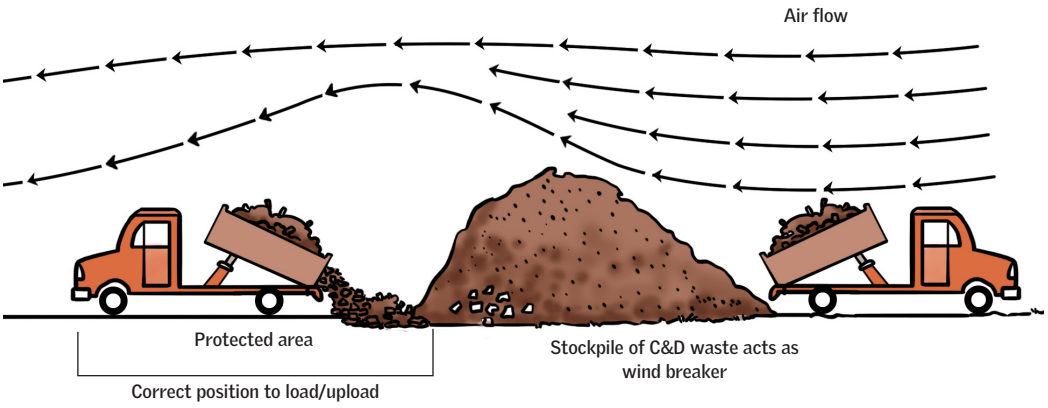
Figure 44: Water spray and wind breakers to be used while handling C&D waste, wind breakers to be installed near unloading and loading points



Use of wind breaker and water sprinkler while unloading of C&D waste

Source: CSE

Figure 45: Material loading and unloading activities to be confined to downwind side (side that is protected from the wind) side of storage pile



Source: CSE

Dust retention and suppression at construction sites

Construction sites are crucial sources of dust pollution. If cities can arrest the rising dust emissions at construction sites, they can reduce city-wide particulate pollution substantially. A construction site mainly involves area sources of emissions. With activities like site clearing and excavation, demolition and dismantling, construction of building envelope, laying of pathways for internal circulation, surface finishing works and operation of heavy machinery, a construction site has multiple sources of dust emissions (see *Images 21–24: Excavation, construction of building envelope, operation of heavy machinery among other dust sources at a construction site*).

Images 21–24: Excavation, construction of building envelope, operation of heavy machinery and other activities are dust sources at a construction site


Credits: Sugeet Grover and

Guideline

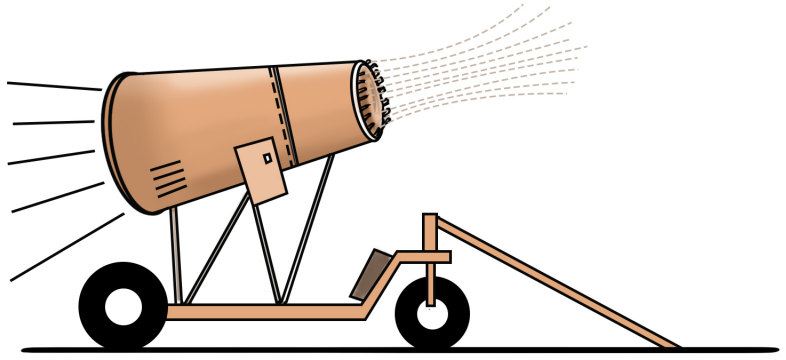
Table 18: Construction and demolition activities within the site

Existing regulations for dust mitigation	**CSIR-NEERI (2019)** **Demolition activities** Dust suppressants may be applied during the following situations: • Unpaved surface areas within 30 m (100 feet) where materials from demolition will fall. • Debris piles immediately following blasting and afterwards. • The surrounding areas following demolition (a distance of at least 30 m) • Unpaved surface area where the equipment will operate **MoEF&CC Notification (2018)** • Building and infrastructure projects requiring environmental clearance need to have dust mitigation practices in their Environmental Management Plan without which the project shall not be implemented. • Wind breakers of appropriate height that is one third of the height of the building and maximum of 10 metres should be provided. • Excavation of soil shall not be done without adequate dust mitigation measures in place. • Water sprinkling shall be adopted. • Dust mitigation measures shall be displayed prominently for easy public viewing. • Identification of construction and demolition waste processing and disposal site shall be done along with notification of required dust control measures at site. **MoEF&CC Notification (2019)** • Buildings shall be designed to follow the natural topography as much as possible. Minimum cutting and filling should be done. • Construction sites shall be adequately barricaded before the construction begins. Dust, smoke and other air pollution prevention measures shall be provided for the building as well as the site. These measures shall include screens for the building under construction, continuous dust and wind breaking walls all around the site (at least 3 m in height). **CPCB Guidelines (November 2017)** • Mount dust barrier sheet ex-tarpaulin, and plastic on scaffolding around the construction and demolition building, particularly side-facing residential areas.

CSE recommendations	• Dust suppressants to be applied while conducting demolition activities in conditions described in CSIR-NEERI (2019) • Dust mitigation practices to be part of environmental management plan for projects requiring environmental clearance. • Buildings to be designed with minimum interference to natural topography to ensure minimum cut and fill. • Wind breakers around the site to be installed with minimum height of 3m and maximum of 10m. Wind barriers should be firmly fixed to the ground. • The windward side (side facing the predominant wind) of the windbreaker to be periodically cleaned of any accumulated material. • Soil excavation to be practiced with proper dust mitigation measures in place. • Dust barrier sheets on scaffolding to be placed around the construction and demolition building site; all dust mitigation barriers to be displayed prominently. The sheets to be maintained free of holes or cuts. • Deconstruct instead of demolish. Undertake a pre-demolition visual assessment of recyclable content to decide on suitable demolition and deconstruction techniques to recover as much material as reasonably practical. • Appoint a C&D waste manager for the construction project responsible for implementation of waste management plans, plans for probable on-site reuse and recycling of forecasted waste. • Surfaces left exposed after completion of earthworks to be vegetated within 10 days of closure of operations. • Dust-generating activities being conducted in enclosed spaces to include negative pressure dust collectors to reduce fugitive dust emissions. • Fogging systems to be used in places with high levels of fugitive dust, fog droplets stick to dust particles and become heavier, thus helping in their settling down. • Dust causing construction and demolition activities to be avoided in extremely windy conditions, if possible.

Source: Compiled from multiple sources

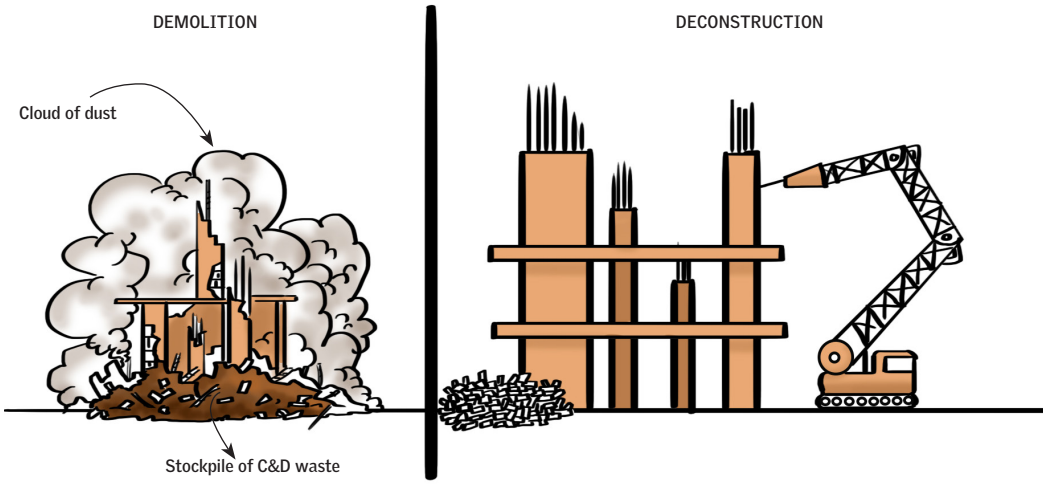
Figure 46: Fogging systems to be used in places with high levels of fugitive dust, fog droplets stick to dust particles and become heavier, thus helping in their settling down



Dust suppressant atomized mist

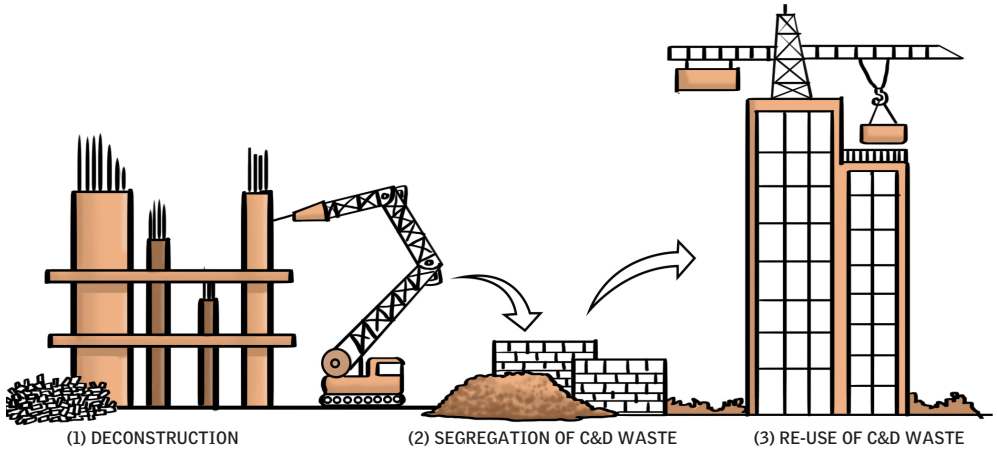
Source: CSE

Figure 47: Deconstruct instead of demolishing. Undertake a pre-demolition visual assessment of recyclable content to decide on suitable demolition and deconstruction techniques to recover as much material as reasonably practical



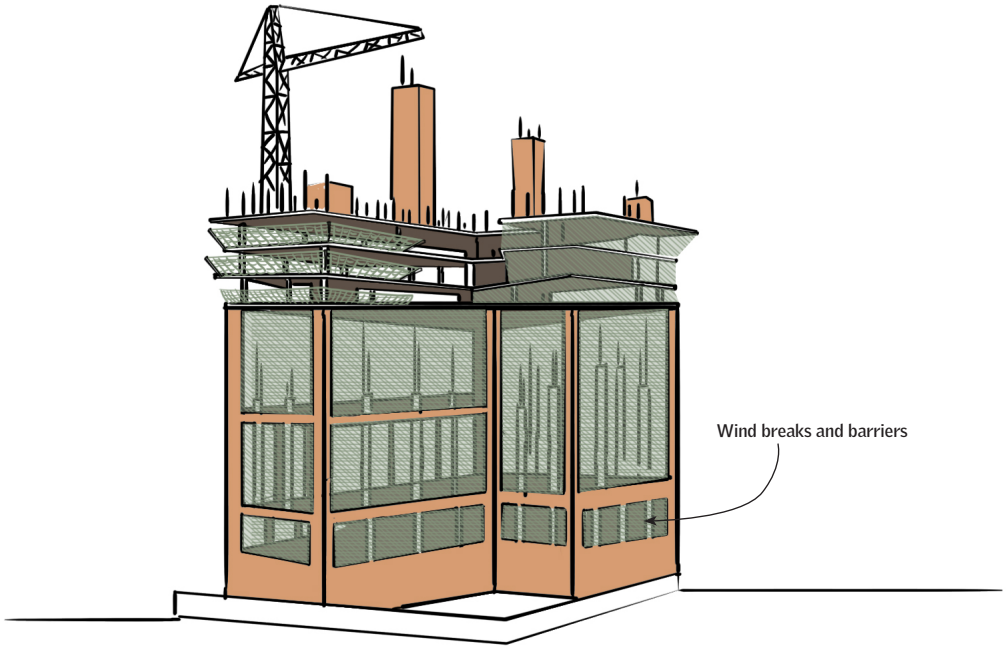
Source: CSE

Figure 48: Plan for probable on-site reuse and recycling of forecasted waste



Source: CSE

Figure 49: Dust barrier sheets to be placed on scaffolding around the construction and demolition building, all dust mitigation barriers to be displayed prominently. The sheets to be maintained free of holes or cuts



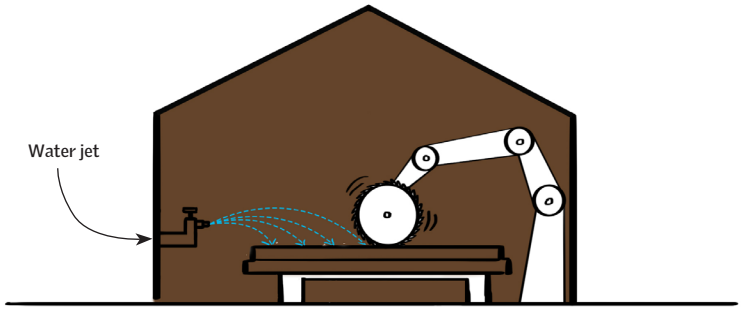
Source: CSE

Table 19: Crushing, grinding, etc. at a construction and demolition site

Existing regulations for dust mitigation	**MoEF&CC Notification (2018)** • Cutting and grinding of building materials in open area is not allowed. **CPCB Guidelines (March 2017)** • Use of water sprinklers is a good practice to suppress dust emission, similar practice to be adopted in stone crushing operations. **Environment (Protection) Rules, 1986** For stone crushing units, implementation of the following pollution control measures: • Dust containment cum suppression system for the equipment. • Construction of wind breaking walls. **MoEF&CC Notification (2019)** • Wet jet shall be provided for grinding and stone cutting.
CSE recommendations	• Cutting and grinding of building materials to be carried out in enclosed areas and a wet jet to be used during the process. • Water sprinklers to be used for dust suppression during crushing, grinding and other dust causing activities of building materials. • The fallen debris from processing to be periodically collected and put for reuse and recycling or disposal.

Source: Compiled from multiple sources

Figure 50: Cutting and grinding of building materials to be carried out in enclosed areas and a wet jet to be used during the process



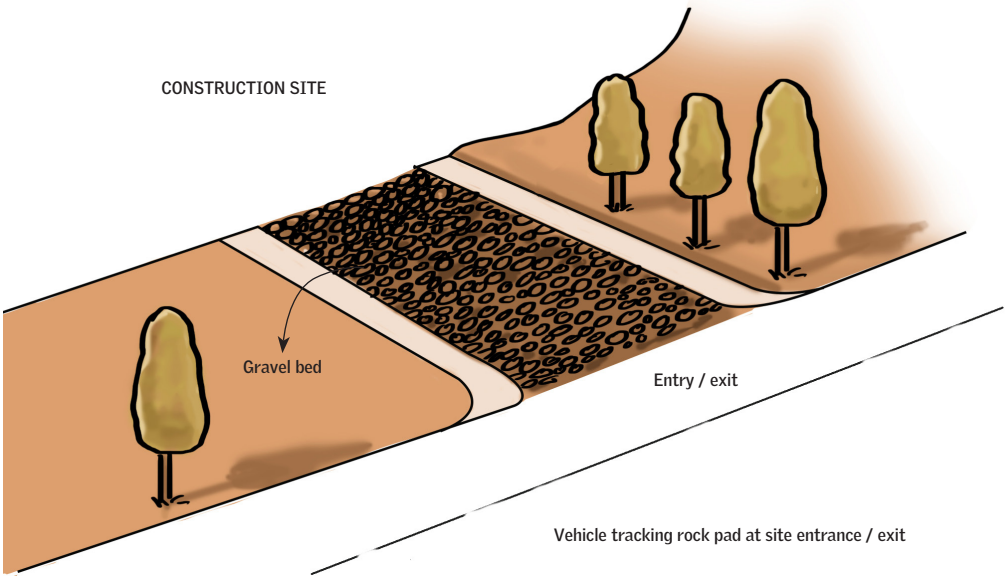
Source: CSE

Table 20: Design of roads within a construction and demolition site

Existing regulations for dust mitigation	**MoEF&CC Notification (2018)** • Paving or black topping of roads leading to or at construction site is required. **CPCB Guidelines (November 2017)** • Routes of transport vehicles within a construction site to be damped by water (preferably treated wastewater) sprinklers. **CSIR-NEERI** • Water can be sprayed on road surfaces to control emissions. Control efficiency of water depends on: • Amount of water (per unit road surface area) added during each application • Period of time between applications • Weight, speed and number of vehicles travelling over the watered road during the period between applications **MoEF&CC Notification (2019)** • Unpaved surfaces and loose soil shall be adequately sprinkled with water to suppress dust. • Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emissions standards to be operated only during non-peak hours.
CSE recommendations	• Paving or blacktopping of roads within a construction site or leading to a construction site to be carried out. • Roads (paved and unpaved) within a construction site to be damped by water sprinklers, preferably with the use of treated wastewater. Dust suppressants may be sprayed prior to handling of materials as per CSIR-NEERI guidelines. • Unpaved roads to be covered with a three–four-inch-thick layer of material with a low silt content (e.g., include gravel, slag, recrushed or recycled asphalt and road carpets). Vegetative cover may be used on very low traffic volume roads. • Speed limit to be set for vehicles inside the construction site and speed limit signs (readable from both directions) to be adopted; vehicles to move on paths defined in the construction site. • Provisions for scrubbing off the dirt and mud from tyre of vehicles to be employed, devices such as wheel shakers, wheel washers and grizzlies (rough surfaced areas that scrub off dirt from tyres) etc., may be used. These devices to be cleaned regularly.

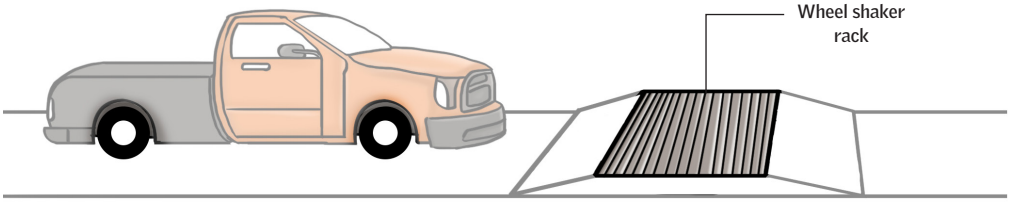
Source: Compiled from multiple sources

Figure 51: Unpaved roads to be covered with a 3–4 inch-thick layer of material with low silt content (e.g., gravel, slag, recrushed or recycled asphalt and road carpets). A vegetative cover may be used on very low traffic volume roads



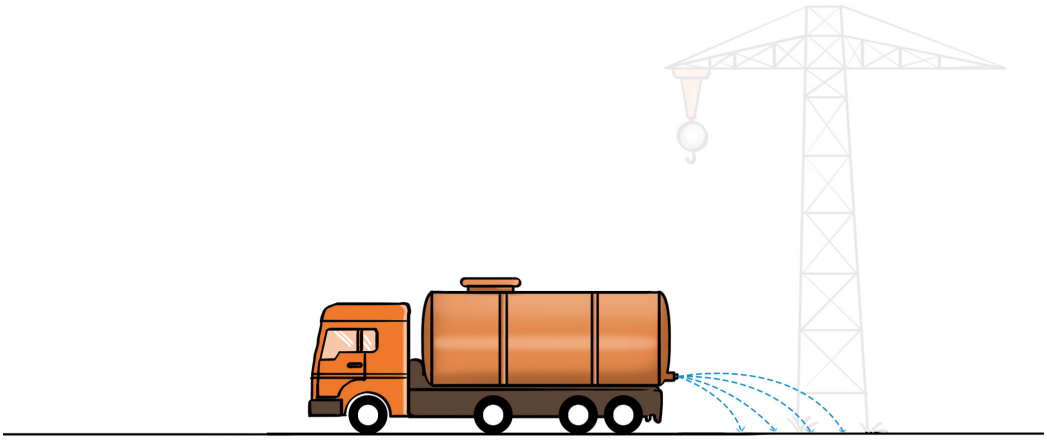
Source: CSE

Figure 52: Provisions for scrubbing off dirt and mud from tyres of vehicles to be employed; devices such as wheel shakers, wheel washers and grizzlies (rough surfaced areas that scrub off dirt from tyres) etc. may be used. These devices to be cleaned regularly



Source: CSE

Figure 53: Roads (paved or unpaved) within a construction site to be damped by water sprinklers, preferably with the use of treated wastewater



Dust suppressants for unpaved roads

Source: CSE

9. Next steps

This guidance framework has been designed to address the current gaps in implementation strategies noticed in several cities. This hands-on guide provides a template and roadmap for addressing those gaps as well as bring clarity in the methods, technology and management approaches, and to inform the funding plans and utilization.

Need data and estimation of quantum of C&D waste to design systems: As C&D waste is a relatively new area of management, there is a lot of ambiguity on how to quantify C&D waste. Several methods ranging from per-capita multiplier, zero-based estimation, geographic information system-based extrapolation, area-based calculation to building information modelling, among others, are used globally. Institutional strengthening is needed to adopt some of the methods.

Moreover, city master plans can help project C&D waste generation based on the scope for development as per the city master plan and other construction programmes using GIS. CSE estimated that cities need to gear up for at least three times the volume of C&D waste they are planning to manage. For instance, Jaipur is planning for a C&D waste facility of 300 TPD capacity, but the projection using Jaipur Development Plan, 2035 shows generation of at least 1,000 TPD of C&D waste. Further, online portals like state RERA database and PARIVESH platform are good sources to understand the current volume of C&D waste. As these portals collect data such as location of the project and the floor area to be constructed, cities can learn how much C&D waste is being generated using area-based calculation and TIFAC thumbrules. Estimation using this data can give a closer-to-ground picture on the volume of C&D waste being generated and guide operations, processing capacity and strategy for re-utilization.

Cities must create easily accessible databases of buildings along with their physical and legal attributes and also infrastructure projects. Excavated waste, or bituminous waste from roads, can be challenging for recycling. Construction and demolition permits need to be inventorized and associated waste management plans associated with them. The method for quantification also has to consider the new-age construction materials that are expanding, especially under the Pradhan Mantri Awas Yojana (PMAY) for the affordable housing sector. Urban local bodies and the construction industry should have the capacity to forecast waste generation from construction sites for proactive approaches.

Monitoring frameworks need qualitative milestones and quantitative information: Cities need a milestone-based approach to improve quality and effectiveness of C&D waste management and dust control methods. The provisions of C&D Waste Management Rules, 2016 and Environment (Protection) Amendment Rules, 2018 or dust control rules involve key requisites that are vital for addressing these subjects in a cohesive manner. Cities are also assessed and ranked based on the Swachh Survekshan programme of Government of India that ranks cities based on the service delivery in waste management sector. Overall, data and research, planning for collection points and a disposal system, digital tracking for enforcement, notification of C&D waste bye-laws, setting up of processing plants, streamlining of operations, public awareness and capacity building, and enforcement, among others, are milestones that will lead cities to scientific and effective implementation of C&D waste management and dust control rules. Also, characterization of C&D waste is necessary for management plans, including collection, transportation and storage, processing techniques and technologies used, and products to be manufactured from recycled waste. This characterization requires a strong monitoring and evaluation framework.

Need operational guidebook for each phase of C&D activities and appropriate capacity building: There are several factors that affect the mitigation potential of dust control measures in C&D activities: i) timing of activities, ii) technical know-how on how to carry out the activities with clear standard operating procedures and management information systems, and iii) designing adequate appropriate infrastructure for on-site management, segregated collection, material recovery and utilization of recycled material. This will also require mapping of the full range of non-structural applications including pavements, filling of plinth, etc. for uptake of recycled materials. CSE's guidance framework addresses C&D activities at the city-scale and site-scale. Both demolition activities as well as smaller construction sites that do not require environment impact assessment will have to be brought within the ambit of proper management and enforcement. Regulators, municipal workers, developers and transport agencies need to be guided and trained on the effective conduct of these activities to limit dust emissions. A strategy to integrate the informal sector to optimize human resource for waste collection and segregation and disposal to further optimize the formal management is also required.

Budget priorities with regard to dust control and C&D waste management infrastructure need to maximize air pollution mitigation potential: Currently, budget allocation by cities in the sector is ad hoc and not linked with performance or assessment of mitigation potential of action. Understanding of the programme scope, infrastructure design, technology requirements, etc. is limited. Mitigation

potential of action for C&D waste management and dust control and overall greening of the construction sector is not well understood. Priority in budget must be given to actions with high mitigation potential and long-term impact. This requires mapping of pollution generation potential of each phase of construction and demolition, material transfer, collection and recycling and the technological and infrastructure intervention needed for pollution control. While a lot of investments in the mitigation measures and technologies will have to be done by the construction agencies, it is necessary to map out the areas that will require public funding. ULBs will have to invest in monitoring systems and infrastructure, digital tracking and digital servers, geo-tagging and waste management sites, etc. Currently, there is lack of clarity about what is fundable and as a result the fund allocation for the sector is minimal and not well rationalized.

Need city-based assessment of administrative and operational aspects of C&D management to institutionalize the process: Current investigation into the volume data, budget, monitoring parameters, non-compliance, governance and procedural structures in a few cities of threes states: Haryana, West Bengal and Rajasthan, has revealed several institutional and governance aspects that need urgent attention. This investigation has revealed that these parameters related to institutional arrangements and governance systems vary from city to city. This requires assessment of the institutional architecture with clear delineation of roles of the departments in the entire chain to establish clear responsibility and accountability.

Integrate the construction industry to mainstream requirements of C&D waste management in construction planning and execution: Involvement of the industry in planning and execution of mitigation measures is currently weak. Big construction (more than 20,000 sq. m) that has to go through an environment impact assessment process has obligation to adopt measures to mitigate the effect of C&D waste. The environment management plans need to be monitorable. But the smaller construction sites that are numerous and widely dispersed across the city operate within a much weaker system. There are no clear approval and monitoring systems for them. Global good practices indicate a combination of fiscal penalty, tax incentive related to material recovery and also comprehensive waste minimization, and management tools and plans to guide the industry. ULBs need to move in that direction.

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India is awakening to the problem and potential of construction and demolition (C&D) waste. As more and more cities recognize this stream and formulate strategies for managing it, they are faced with challenges in the sector that need to be addressed comprehensively for on-ground impact.

Centre for Science and Environment has identified these challenges based on extensive on-field investigation. This report is a guidance framework for cities to help them draw strategies, as well as a practical handbook for dust prevention and control from C&D activities both at the site-scale as well as the city-scale.

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