FEEDBACK FOUNDATION
Engaging Communities

# Waste Matters

## A handbook to better manage real estate construction waste in India

Godrej | PROPERTIES

May 2023

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We welcome your feedback on this handbook. Please reach out for any data requests, queries, comments or clarifications on sustainability@godrejproperties.com

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# Foreword

The sixth assessment report of the UN Intergovernmental Panel on Climate Change lists the clear and present danger to human well-being & planetary health, and, highlights a rapidly closing window of opportunity to secure a liveable and sustainable future. With buildings currently accountable for over 37% of global carbon emissions, decarbonising the construction sector is one of the most effective ways to mitigate the worst effects of climate change. It is well documented that solid waste contributes directly to greenhouse gas emissions through the generation of methane from the anaerobic decay of waste in landfills, and the emission of nitrous oxide from our solid waste combustion facilities. Furthermore, huge quantities of waste have adverse environmental impact such as loss of habitat when land is used to create new landfills.

Since 2021, construction activities have rebounded back to pre-pandemic levels in most major economies. As per United Nations Environment Program's 2022 Global Status Report for Buildings and Construction, an approximate of 100 billion tonnes of waste is generated by construction, renovation and demolition globally, with about 35% sent to landfills. As the world moves forward in mitigating waste more effectively, in the Indian context, one of our biggest challenges that inhibits better management of waste is the lack of reliable data on waste generation within the sector. To address this gap, Godrej Properties Limited commissioned this handbook - '**Waste Matters**', to specifically understand the quantum, composition and distribution of waste generated at every stage of construction. Further to our findings, this handbook provides actionable insights on waste reduction, segregation, traceability and recycling to effectively set us upon a path to reach zero waste to landfill thereby assisting in reducing emissions within the sector.

Our handbook concludes with general recommendations on waste management; waste production and transportation; reuse, recycling and processing; and final disposal for stakeholders within the ecosystem including developers, contractors, urban local bodies, policy makers and the government. For more tactical implementation, specifically for real estate developers, the handbook includes tear sheets that will help setting up a construction waste management framework to get started on mitigating this problem. As responsible developers, we should strongly believe that waste matters and through this handbook, we call upon the sector to acknowledge the criticality of integrating waste management as a core part of operations and to uphold higher standards of carbon neutrality. Together we can chart a roadmap for zero waste to landfill within the construction sector in India. At Godrej Properties, we are committed to playing our part and we invite you to join us on this important journey.

**Anubhav Gupta**

CEO Vikhroli, Chief ESG, Sustainability & CSR Officer
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# Executive Summary

Waste is a subject of growing concern globally. According to a World Bank report, in the year 2020, a total of 2.24 billion tonnes of municipal solid waste was generated. The report also estimates by 2100, waste generation in the world will peak at 11 million tonnes daily. Such predicted trajectories of waste growth are liable to have substantial implications for the environment as well as the health, well-being and prosperity of the human race.

Economic growth and urbanization are natural drivers of waste generation. Countries across the globe, especially the global South are experiencing urbanization at an unprecedented pace and scale. India is the second-largest urban community in the world. By 2050, we will add about 416 million people to our cities. New Delhi will overtake Tokyo as the world's most populous city, and Hyderabad and Ahmedabad will join Mumbai, Kolkata, Bengaluru and Chennai as mega-cities.

In the process of urbanization and city-making, a lot of material resources are consumed. The process also generates considerable waste, generally led by the manufacturing and construction sectors. Therefore, in the context of cities, waste generation must be understood both as an individual as well as an institutional problem – not only due to individuals living in cities, but also as a result of the process of creating and building cities.

Indian cities are going to experience waste generation at an unparalleled pace in the near future. Waste management preparedness, however, is worrisome. Currently, more than 70% of the waste generated in the country is openly dumped or carelessly burnt. Such poor management of waste is cause of concern due to its impact on climate, quality of air, water and other natural resources. Landfills in India are source of as much as 90% of the methane emissions. The challenge of waste management worsens due to presence of construction and demolition waste in municipal waste.

Construction and Demolition (C&D) waste is waste comprising of building materials, debris and rubble resulting from construction, re-modelling, repair and demolition of any civil structure. 150 million tonnes of construction and demolition waste is generated in India every year. However, only 1% of it is sustainably recycled. The remaining is disposed off on roadsides, vacant sites, in lakes, rivers or stormwater drains.

Effectively managing C&D waste is a challenge due to a variety of reasons, such as poor source separation, low demand for recycled C&D waste material, illegal dumping, landfill crises and inadequate waste regulations.

In India, the Ministry of Environment, Forest and Climate Change (MoEFCC) has defined Construction and Demolition Waste Management Rules for enforcement across the country. These rules are further implemented and enforced by Urban Local Bodies (ULBs) in conjunction with city-level terms and conditions. The country has also laid down standards and certifications to encourage the re-use of construction material waste. Despite these regulations, the management of C&D waste remains ineffective, along with poor understanding of effective techniques to manage such waste.

Another challenge in C&D waste management is lack of reliable data. From academics to government and non-government research institutes, various studies have tried to estimate the amount of construction and demolition waste generated in the country, at different times. A recent report by the Centre for Science and Environment throws light at the fact that all these estimates, if anything, highly vary from each other and may be underestimating the magnitude of the problem. They also do not necessarily relate to the pattern of city-making we are witnessing, which is more concentrated high-rise buildings, rather than low-rise individual homes. In addition to variability in quantum of waste estimates, the constituents identified of C&D waste are also generally limited.



This research attempts to bridge this gap by adopting a feet-on-the-ground approach to study and measure actual waste generated in the process of construction of mid-scale residential real estate in India. Carried out across 14 construction sites under development by Godrej Properties Limited (GPL) and Mahindra Lifespace Developers Limited (MLDL) across 4 cities (Bengaluru, Gurugram, Mumbai and Pune), this research provides answers to four key questions-

1. What is the quantum of waste (kg) generated per square feet of built-up area?
2. What are the constituents of waste generated at site?
3. How much waste is generated in each construction stage?
4. How does this waste travel and where does it end up?

Following a thorough approach of site selection, defining, measuring and collecting waste data and computing waste generated, this study allows for a more precise estimate of construction waste in the country, directing a more informed approach to waste management.

Key Findings

1. A total of 3.64 kg of waste per square feet of built-up area is generated at a mid-scale residential Mivan construction project in India.
2. About 141 different types of materials are found in construction waste, of which 95 materials are currently recycled.
3. Maximum waste is generated during the finishing stage of construction process, and concrete is the highest contributor of construction waste most of which is used in the core and shell stage.
4. Only 14% of waste generated on the sites surveyed is recycled, while remaining 86% is unaccounted for.

The problem of construction waste needs urgent and effective action. This handbook recommends practical action-points and guidance to adopt effective practices for developers in the country to manage and control construction waste.

**How can developers get started?**

1. Developers can set up systems and processes to manage construction waste at their sites by following four actionable steps outlined below:
   a. Set-up an Aspect-Impact Register for each stage of construction by adopting a risk assessment and management approach
   b. Institute a Construction Waste Management Plan - listing stage-wise requirements for both internal teams and external partners
   c. Build Awareness and Capacities of all teams to harness the collective potential of internal teams and external partners
   d. Update the General Conditions of Contract (GCC) to include Waste Management mandate to provide a clear contractual framework for all parties.
2. Suggested Operating Models for Construction Waste Management

   Given their internal organization structures, scale of operations and growth plans, developers can adopt any one of three suggested models to operationalize their construction waste management plan.

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# Why Waste

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# The matter of waste

## In the year 2020, we generated about 0.79 kilograms of waste each, every day.

As per a United nations report, the world population reached 8 billion in the week of 15th November 2022.[1] Among other things that we do well as a civilization – thinking, innovating, creating, and building – we unfortunately continue to generate excessive waste.

In the year 2020, we generated about 0.79 kilograms of waste each, every day.[2] That translates to a total of 2.24 billion tonnes of municipal solid waste.[i,3] This does not come as a surprise since on an average, 99% of all goods are trashed within 6 months of purchase.[4]

**99%**

**of goods are trashed within six months of purchase**

i Municipal Solid Waste includes residential, commercial and institutional waste.

## By 2050, the world will generate waste equivalent to the weight of almost "one" Burj Khalifa every hour.*

The World Bank estimates that by 2050, waste produced annually will reach 3.4 billion tonnes and by 2100 peak at 11 million tonnes daily.[5]

Not only waste but the cost of dealing with it is also rising significantly. Growing by more than 80%, the cost of managing waste is expected to go from USD205 billion a year in 2010 to USD375 billion a year in 2025.[6]

Notwithstanding the financial burden, the predicted trajectories of waste growth will also have substantial implications for the environment as well as the health, well-being and prosperity of the human race.

It is, therefore, imperative to build a nuanced understanding of waste – where it comes from, and how we can manage it.

* Author's calculations based on secondary data.[7]

# Where is waste coming from?

**Increasing population, urbanization and economic development are natural drivers of waste generation.[8] At present, half of the world's population lives in cities. By 2050, two-thirds of the entire population will live in urban areas implying expansion of cities and towns at an unparalleled rate.[9]**

### The rise and role of cities

As an integral part of economic growth, the expansion and formation of cities brings with it access to greater opportunities, larger service provisions (including healthcare and education, benefits of modern technology and a higher quality of life.[10] Especially in the global South, with economies urbanizing at a fast pace, it is evident that the number of cities, and the number of people living in them will grow fast. In 2019, 22 of the world's 33 mega-cities (with population >10 million) were in Asia and Africa. By 2030, there will be 10 more mega-cities, 9 of which will be in Asia and Africa.[11]

### Cities expand Opportunities and Open-waste dumps alike

Cities offer a multitude of opportunities to its residents in various forms including more and better-quality jobs, higher wages, scope for manufacturing and services sectors, and greater innovation. Given the pace at which people are moving and settling into cities - both large and small, it is only natural that existing cities will expand, and new ones will take shape.

However, the discourse on city-making is not only about economic growth and opportunities. The unprecedented pace of this phenomenon has made governments, scholars and industry also look at urbanization from a climate change and environmental degradation lens.[12,13]

Globally, we extract about 100 billion tonnes of raw material out of the planet in just a single year. Roughly half of these raw materials go into the world's built environment.[14] And as cities expand, the consumption of materials for creation of buildings is also expected to increase. In South Asia, for instance, demand for steel, cement and sand for buildings is likely to almost quadruple in the four decades from 2010 to 2050.[15] Not limited to construction, the activities within the boundaries of a building consume about 75% of the earth's material resources.[16]

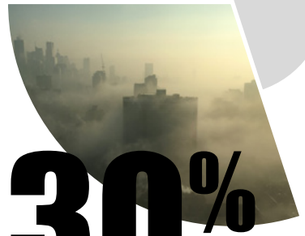
Even so, material consumption is not the only source of environmental degradation. The extent of consumption directly implies the extent of waste generation due to inefficient and environmentally unsustainable consumption.

Looking at sources of waste, we find that construction sector alone contributes to approximately 30% of the total waste generated globally.[17,18]

Therefore, in the context of cities, waste generation must be understood as both an individual as well as an institutional problem – not only due to individuals living in cities, but also as a result of the process of creating and building cities.

India is the second-largest urban community in the world. By 2050, we will add about 416 million people to our cities. New Delhi will overtake Tokyo as the world's most populous city, and Hyderabad and Ahmedabad will join Mumbai, Kolkata, Bengaluru and Chennai as mega-cities.[19]

The NITI Aayog in India has identified cities as engines of growth for the country in the time to come. This means accelerated demand for sustainable infrastructure and affordable housing, in addition to jobs and basic services. With over 65 cities with a population of more than 1 million by 2025, the Government of India has estimated that urban population will contribute 75% of the Gross Domestic Product (GDP).[20]



**30%**

**The construction sector makes up approximately 30% of the total waste produced globally**

**70%**

**of the waste generated in India is openly dumped or carelessly burnt**

The construction industry in India is expected to reach USD 1.4 trillion by 2025. There is an anticipated increase in demand for 25 million additional mid-end and affordable residential units, that would bring the size of the real estate industry alone up to USD1 trillion by 2030.[21]

This expected expansion in construction and real estate suggests that in the near future, Indian cities will experience waste generation at an unprecedented pace. The population of Mumbai already produces more than half a kilogram (kg) of waste each, every day.[22] Currently, more than 70% of the waste generated in the country is openly dumped or carelessly burnt,[23] making waste a growing cause for concern.

# Waste doesn't just disappear

### The growing burden of waste

The disposal of waste in urban areas poses significant challenges. With limited space and resources, cities often struggle to find suitable locations for waste disposal. Landfills and incineration facilities, which are the most common methods of waste disposal, require large areas and can be costly to operate.

Moreover, the municipal waste that reaches landfills is generally mixed with construction waste. This makes extracting and treating solid waste a challenge. Currently, only about 22-28% of waste collected is effectively treated.[24]

According to a report by the Intergovernmental Panel on Climate Change (IPCC), landfills are now the source of as much as 90% of all methane emissions – a gas which is 25 times more effective at trapping heat than $CO_2$.[25] Additionally, buildings account for as much as 60% of overall carbon emissions.[26]

From construction to demolition and disposal, buildings and their constituent materials, intensively use and consume energy resources, are sources of dust pollution, contribute to clogged drains and polluted rivers. The sector generates pollutants due to long waste-transportation routes and ineffective waste management value chains.

**~90%**

of all methane emissions come from landfills

What is Construction and Demolition (C&D) waste?**

**"Waste comprising of building materials, debris and rubble resulting from construction, re-modeling, repair and demolition of any civil structure"**

**As defined by Construction and Demolition Waste Management Rules, 2016, GoI

**Tonnage of Waste Dumped Per Day (metric tonnes) and Height of Garbage Mounds (feet) across 6 Cities in India***

* Living near Urban Landfills in India. WRI India.

# Where does C&D waste end up?

**150M**

Tonnes of Construction and Demolition waste Generated every year in India.

However, only

**1%**

of it is sustainably recycled. The remaining is disposed off through various other methods.[27]

# Roadsides, Vacant sites. Below flyovers, In lakes and rivers. Stormwater drains,

And yet no one to blame.

The Environmental Impact of Construction and Demolition waste

### URBAN FLOODING

C&D waste that is dumped in open drains and water channels clogs them and leads to urban flooding in monsoon.

### DUST POLLUTION

Waste is one of the primary sources of fugitive dust pollution.

### INJURIES

to waste workers dealing with unsegregated waste (glass, boulders, splinters, sharps)

### DESTRUCTION OF WATERBODIES

C&D waste dumped in wetlands, and riverbeds disrupts the hydrology and destroys the aquatic ecosystem.

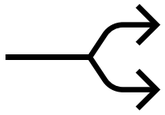
### GHG EMISSIONS

When construction waste is dumped in landfills, it generates methane gas, which is a potent greenhouse gas that contributes to global warming.

### OBSTRUCTING MOBILITY

When waste from construction or demolition is dumped on streets and footpaths, it blocks traffic and pedestrians, often causing traffic congestion, even accidents.

# Why is it hard to manage C&D waste?



## POOR SOURCE SEPARATION

Source separation is the segregation of different types of solid waste at the location it is generated. It is essential to avoid the waste from reaching the landfills and ensure reuse.

**Barriers**

» The regulatory mandate is limited to segregation of five materials.

» Lack of willingness and know-how with respect to cost efficient methods of source separation.

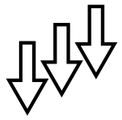
**Opportunity**

» Regulatory bodies can make comprehensive source separation a mandatory requirement for developers, requiring all stakeholders in the value chain to build in the required time, cost and know-how in their project planning.

» Building a Material Recovery Facility (MRF), a designated space for waste collection with separate storage areas for different waste streams, on site will enable efficient segregation and management.

**Case Study**

Public sector clients in the UK require contractors to prepare and implement site waste management plans despite this no longer being a legal requirement. These plans include a provision for source separation of the main types of C&D waste.



## LOW DEMAND FOR RECYCLED MATERIAL

There is low demand and insufficient marketplaces for source-separated C&D waste. It is pertinent that the material has a commercial ecosystem for buyers to match and drive supply and reuse.

**Barriers**

» Recycled C&D waste is perceived by contractors and clients as being of low quality.

» Recycled C&D waste products are taxed higher than conventional building material.

**Opportunity**

» Developing specifications and quality certifications for use of recycled materials will help buyers readily identify and source usable material.

» Encouraging, requiring and incentivizing (through mandates and taxes) the use of products with a high recycled content will build intent for use of source-separated C&D waste.

» Publicizing case studies that illustrate the technical and economic benefits of using recycled C&D waste will develop greater understanding among market-players toward its benefits.

**Case Study**

In Australia, regions with strong market demand for recycled C&D waste materials and well-defined and publicised specifications supporting the use of recycled products have shown higher recovery rates of C&D waste.

## ILLEGAL DUMPING (FLY-TIPPING)

Illegal dumping is the dumping of waste illegally instead of using an authorized method such as door-to-door collection or an authorized landfill.

**Barriers**

» There is poor enforcement of waste dumping regulations.

» Recycling facilities are often situated on uneconomical routes from the construction sites.

**Opportunity**

» Applying high financial penalties include levying fines and exclusion from bidding for government contracts will act as deterrents.

» Enhancing surveillance will help in identifying localized causes of illegal dumping.

» Enforcing liability on main contractors such that they are responsible for actions of their subcontractors and have a ‘duty of care’ for the waste generated on their sites will ensure ownership and accountability.

**Case Study**

Netherlands has instituted a national ban on the disposal of reuseable C&D waste since 1997. Only certified C&D waste crushers and sorters are allowed to dispose non-reusable material which is, as defined by law, rubble contaminated with coal tar, asbestos or other chemicals.

## LANDFILL CRISIS

The staggering amount of waste going to landfills each year has outpaced its natural bio-degradation, making them environmentally unsustainable.

**Barriers**

» Landfill disposal of construction waste is inexpensive even if authorized facilities are used, and even less expensive if dumped illegally.

**Opportunity**

» Minimizing the amount of waste that is landfilled will allow time for processing of existing waste.

» Increasing the cost of landfill disposal will make alternative treatments or recycling cost competitive.

**Case Study**

Hong Kong introduced a C&D waste disposal charging scheme in 2005 and reported a 60% reduction in C&D waste sent to landfill in the following year.

## INADEQUATE WASTE REGULATIONS

The waste management ecosystem requires a high degree of inter-agency coordination and consequently well-defined roles and responsibilities for all stakeholders.

### Barriers

- Due to multiple stakeholders and governing agencies, there is absence of consistency and a clear strategy to ensure that policy, implementation, and enforcement are well-coordinated.
- Lack of reliable information on the quantities and destinations of C&D waste.

### Opportunity

- Effectively promoting C&D waste regulations across all stakeholders will ensure awareness regarding requirements and compliances.
- Licensing and regulating activities of C&D waste management facilities and vehicles transporting C&D waste will help in avoiding malpractices, creating more effective value chains, and ensuring transparent logging of waste destination data.
- Regulating activities on construction sites, including emissions from waste will contribute in promoting environmentally safe industry practices.
- Collecting and publishing data consistently will help in deriving insights and monitoring policy efficacy.
- Investing in research and development of new ways to manage C&D waste will help in leveraging technology for progressive, sustainable systems.

### Case Study

An industry body - 'Green Construction Board' has been constituted in the UK to advise on C&D waste management and to ensure that regulations are clearly and consistently applied.

# Applicable laws, frameworks and standards

### MoEFCC

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the nodal agency in the Central Government of India for planning, promotion, co-ordination and overseeing implementation of India's environmental and forestry policies and programmes. The MoEFCC has defined Construction and Demolition Waste Management Rules for enforcement across the country.

The MoEFCC mandates an Environmental Clearance issued by the State Environment Impact Assessment Authority (SEIAA), which lists General Conditions related to construction waste during a Project's Construction Stage as follows:

1. The solid waste generated should be properly collected and segregated. Dry / inert solid waste should be disposed of at approved sites for land filling after recovering recyclable material.
2. Disposal of muck, construction spoils, including bituminous material during construction phase should not create any adverse effect on the neighbouring communities and be disposed, taking the necessary precautions for general safety and health aspects of people, only in the approved sites with the approval of competent authority (Municipal Corporation or equivalent).
3. Any hazardous waste generated during construction phase should be disposed of as per applicable rules and norms with necessary approvals of the State Pollution Control Board (SPCB).
4. Safe disposal of wastewater and solid waste generated during the construction phase should be ensured.
5. Arrangement shall be made to ensure that wastewater and storm water do not get mixed.
6. All the topsoil excavated during construction activities should be stored for use in horticulture landscape development within the project site.

**Where are Construction and Demolition Waste Management Rules situated within the MoEFCC?**

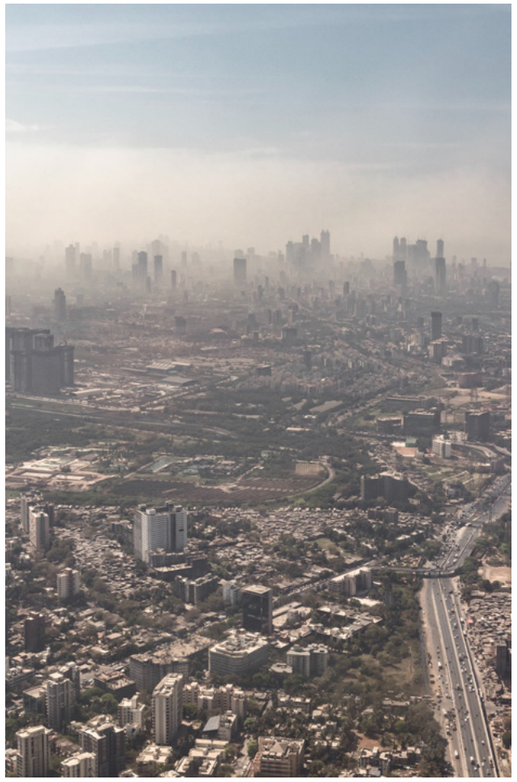
Ministry of Environment, Forest and Climate change, Government of India (MoEFCC)

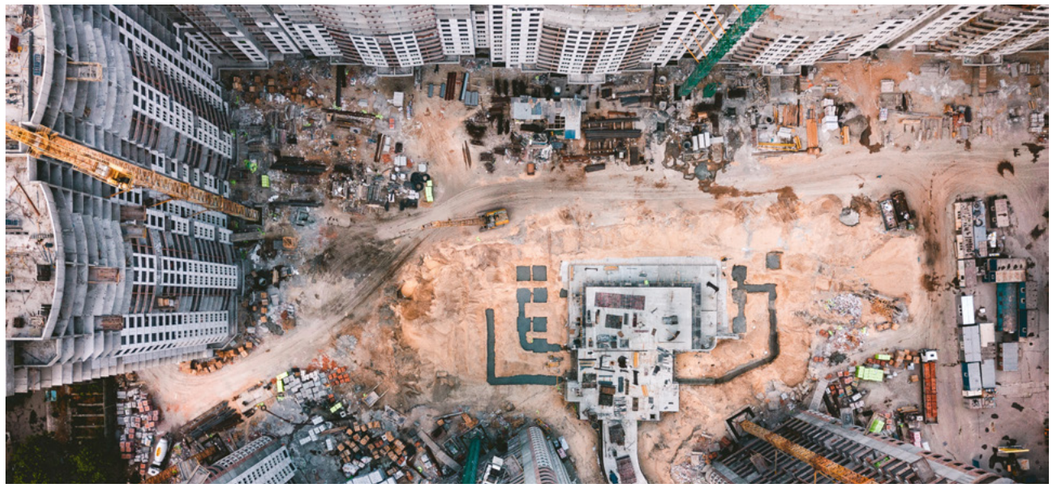
→ Environment

→ Waste Management

→ Construction & Demolition waste

→ **Construction and Demolition Waste Management Rules, 2016**





To ensure that these guidelines are followed at a city level, respective municipal bodies mandate that the developer/builder submit a Construction & Demolition Waste Management Plan for each site in alignment with the "**Construction and Demolition Waste Rules 2016**". Basis approval of submitted plan, the developer/builder can be allowed to transport Construction & Demolition/ Excavation Material from construction site to the approved unloading site subject to conditions laid down by their respective municipal bodies.

**Conditions for C&D / Excavation Material disposal by Municipal Corporation of Greater Mumbai**

1. Construction & Demolition (C&D) waste shall be transported with proper precautions and post deployment of adequate measures to safeguard against dispersal of particles through the air.
2. C&D waste shall be transported and deposited at the designated sites only. The landfill site (unloading site) should be governed by the Construction and Demolition Waste Management Rules, 2016 and Solid Waste Management Rules, 2016.
3. In the event, for any reason whatsoever, the consent given by the designated site/ agency is revoked or the time limit for the designated site has expired or the capacity of unloading site is exhausted, the builder/developer shall forthwith stop transportation activities. The builder/developer shall submit a revised Construction and Demolition waste management plan together with required valid documents for revalidation of existing C&D waste management plant.
4. C&D waste shall be transported through builder/ developer's transport contractor. The details of the same shall be uploaded in a monitoring portal system by the applicant at the time of actual transportation.
5. The deployed vehicles shall abide by all the R.T.O. rules and regulations. The builder/ developer shall ensure that the vehicles are properly covered with tarpaulin or any other suitable material firmly to avoid any escape/fall of waste on road from the moving vehicle. The body and wheels of the vehicle shall be cleaned and washed thoroughly to avoid spreading of waste on road.
6. A copy of approved Construction and Demolition management plan shall be provided with every vehicle under the specified approval. The developer shall issue a proper challan for every vehicle trip and that shall be acknowledged by the concerned agency at unloading site. The developer shall maintain record of C&D material transported and shall make it available to MCGM and / or Monitoring Committee whenever required for inspection.



**Definition of waste as per "Construction and Demolition Waste Rules 2016"**

Recognizing the problems arising from C&D waste, the Government of India notified "Construction and Demolition Waste Management Rules" in 2016. Definition of C&D Waste under the 2016 Rule is "Waste comprising of building material, debris and rubble resulting from construction, remodelling, repair or demolition of any civil structure".

They have also outlined duties and responsibilities of all relevant stakeholders in the matter.

| STAKEHOLDER | DUTIES AND RESPONSIBILITIES |
|---|---|
| WASTE GENERATOR | Properly collect and store waste within their premises ensuring no spill over or mixing with Municipal Solid Waste.<br>Deposit waste in designated locations as notified by local authority.<br>Submit the waste management plan and secure approval before starting construction/ demolition work.<br>Pay relevant charges for collection and disposal as notified by the local authority. |
| UTILITY SERVICE PROVIDERS AND THEIR CONTRACTORS | Prepare comprehensive waste management plan.<br>Collect and store waste securely and avoid local disruption or pollution.<br>Arrange with urban local authority for disposal upon paying the relevant charges. |
| LOCAL AUTHORITY | May contract third party for waste management, but as the main actor responsible, assume accountability for oversight and outcomes. Should do a feasibility study before finalizing the management plan.<br>Pass by-laws mandating C&D waste management and fix relevant charges and penalties.<br>Designate intermediate collection points and sites for processing facility, if needed, in collaboration with state agencies.<br>Examine and approve waste management plan of generators and collect relevant fees.<br>Make arrangements for collection, transportation and processing, in contract with the private party.<br>Establish C&D waste generation database by linking waste management permits and monitor compliance.<br>Carry out sustained Information Education Communication (IEC) activities for all stakeholders.<br>Create incentives for use of recycled products including through preferential purchase agreements in municipal contracts. |

| STAKEHOLDER | DUTIES AND RESPONSIBILITIES |
|---|---|
| STATE POLLUTION CONTROL BOARD/ COMMITTEE (SPCB/SPCC) | Monitor implementation of the Rules by local authority.<br>Authorise C&D waste processing facility as per criteria and monitor environmental compliance.<br>Prepare annual reports for Central Pollution Control Board. |
| STATE GOVERNMENT | Prepare policy document for C&D waste management.<br>Help cities identify land for waste management, where necessary.<br>Facilitate preferential procurement of recycled materials by all state agencies. |
| CENTRAL POLLUTION CONTROL BOARD (CPCB) | Prepare guidelines for C&D waste management.<br>Analyse data collected by State Pollution Control Boards and prepare annual compliance report for the central government. |
| BIS/INDIAN ROADS CONGRESS | Prepare standards for suitable utilisation of recycled material-based products from C&D waste in construction and in roads. |
| CENTRAL GOVERNMENT | Compliance facilitation by Ministry of Housing and Urban Affairs (MoHUA) and Ministry of Rural Development (MoRD)<br>Review of implementation by Ministry of Environment, Forest and Climate Change (MoEFCC) |

**Highlights of the C&D rules:**

- The Rules mandate use of recycled products in construction. Local bodies will have to utilize 10–20% of material from C&D waste in municipal and government contracts for construction.
- The tipping fee, which refers to the cost per weight levied for delivery of C&D waste to the recycling plant, as well as the terms and conditions of civic body with the concessionaire may be designed to keep the price of C&D waste recycled products about 20% lower than the corresponding conventional products.
- All large developers are accountable for collection and disposal of C&D waste.
- Local authorities are to give appropriate incentives to waste generators for salvaging, processing, and recycling, preferably in situ.
- Recycling facilities will have to be created at a safe distance from habitation with adequate buffer zone.
- Local authorities must create a database and update it once a year.



**Defining accountability and understanding current challenges**

There is significant variation in C&D waste transportation practices among Urban Local Bodies (ULBs). Typically, C&D waste is transported from the site to disposal sites on the payment of a minimal fee to transporters by the project owner or construction contractor. Many ULBs provide on-call pick-up services as well.

The ULBs then take the waste to the disposal sites. As ULBs suffer from chronic shortages in both human and financial resources, they are hard-pressed to monitor, collect and dispose of waste as stipulated by the law. As a result, unlawful disposal of C&D waste has become a common practice.

**DUST FROM WASTE**

Dust generated from construction waste is becoming a burning issue in the policy ecosystem. The National Green Tribunal (NGT) order and the Ministry of Environment, Forest and Climate Change's (MoEFCC's) Environment Impact Assessment (EIA) guidelines of 2010 stipulate precautions and mitigation measures to control the dust generated from construction activities. The projects that are found in violation are fined from INR 30,000 to INR 5,00,000, based on the built-up area. More recently, Urban Local Bodies (ULBs) in various metros and cities are turning a serious eye toward dust produced from construction activities. The Brihanmumbai Municipal Corporation (BMC) has planned to issue notices to developers if they fail to adopt measures to control dust generated on their construction sites. Haryana and Lucknow, Uttar Pradesh ULBs are also implementing low-cost techniques to measure and monitor dust generation at construction sites. Such rising concern and measures indicate the advent of newer and stricter regulations on the matter.

## Frameworks and Standards relevant to Construction Waste Management in India

### Swachh Survekshan

Swachh Survekshan (SS) was introduced by Ministry of Housing and Urban Affairs (MoHUA) in 2016 as a competitive framework to encourage cities to improve the status of urban sanitation while encouraging large scale citizen participation. It is the largest urban sanitation survey in the world.

In 2019, C&D waste management was introduced as a new indicator to reward Urban Local Bodies with a mechanism to manage C&D waste as per the C&D Waste Management Rules, 2016.

Since then, the ranking points for C&D management have been consistently increasing. A revised toolkit for Swachh Survekshan was launched by the MoHUA on 21st May 2022, increasing the ranking points from 100 to 120.

The points are divided as 50 for Management (**Section-A**), 50 for Processing (**Section-B**) and 20 for Digital documentation (**Section-C**).

### C&D Waste marking under Swachh Survekshan

For C&D waste, Bulk Generators are those that generate >=20 tonnes/day or 300 tonnes/ month per project, other generators are considered non-bulk generators.

All C&D waste collected from Bulk/Non-Bulk Generators should be segregated in the following five categories: Concrete, soil, steel, wood & plastics and bricks & mortar.

*Methodology for Assessment - 100% Direct Observation*

1. The assessor will visit collections points and all plant(s) and processing facilities updated in the MIS.
2. To ascertain the progress, the assessor will also interact with the officials in the plant.
3. The assessor will ask for the electricity bill and see other activities in the collection centre/ processing plant to verify the functionality of the facility.

**Where are Construction and Demolition Waste Management Rules situated within the Swachh Survekshan ?**

Government of India (GOI)
└ Ministry of Housing and Urban Affairs (MoHUA)
  └ Flagship programme Swachh Bharat Mission (SBM)
    └ **Swachh Survekshan (SS)**

4. Assessor will also observe if C&D waste is kept segregated in 5 categories – including BWG site.
5. On the basis of observation and verification of logbook/electricity bills, senior assessors at the back end will arrive at the efficiency level of the plant(s) and sub-indicator wise marks will be given.

*Scheme of Marking*

**Section-A:** Facilitation of collection, storage, and segregation of C&D waste: 'X' percent of C&D waste generated is stored, segregated in a designated area or space allocated by appropriate authorities and/or in C&D recycling plant.

| Facilitation of collection, storage, and segregation of C&D waste | Total Marks (50) |
|---|---|
| Mobile collection unit for citizens (on-call basis C&D waste collection facility – weekly schedule) available along with designated collection points duly geo-tagged within reasonable distance for C&D waste generator to bring and deposit | 20 |
| Notification of charges (including in-built charges at the time of permission for construction) for Collection & Transportation and Processing & Disposal of C&D Waste notified and enforced | 10 |
| All C&D Waste collected from Bulk/Non-Bulk Generators are segregated in the following five categories: Concrete, soil, steel, wood & plastics, bricks & mortar at designated collection points (if quantity is manageable) and processing plants. | 20 |

**Section-B**: Provisions made for use of raw C&D waste in municipal/ government/ municipality approved construction activities in non-structural applications or used by private agency: lower layers of road pavements, inner colony roads, filling of plinth and basement etc.

And / OR

Provisions made for use of material made from C&D Waste in municipal and/or government construction activity (if available) or used by private agency in kerb stones, structural concrete as manufactured aggregate, paving blocks, bricks etc.

| Processing and selling of C&D waste collected from non-bulk and bulk generators (within city or at a cluster level) | Total Marks (50) |
|---|---|
| >50% C&D waste either processed in the facility by making products or raw-material re-used –sold (with sale receipt) | 50 |
| 40% -50% C&D waste either processed in the facility by making products or raw-material re-used – sold (with sale receipt) | 40 |
| 30% -39% C&D waste either processed in the facility by making products or raw-material re-used – sold (with sale receipt) | 30 |
| 20% -29% C&D waste either processed in the facility by making products or raw-material re-used – sold (with sale receipt) | 20 |
| 10% -19% C&D waste either processed in the facility by making products or raw-material re-used – sold (with sale receipt) | 10 |
| <10% C&D waste either processed in the facility by making products or raw-material re-used – sold (with sale receipt) | 0 |

**Section-C**: Maintenance of digital documentation of reported data

| Weekly Processing Logbook, Sale Register & Vendor details (if outsourced) digitally maintained (e.g. excel file) by ULB are linked with SBM portal | Total Marks (20) |
|---|---|

## STANDARDS

### Building Materials and Technology Promotion Council (BMTPC)

In 2018, the BMPTC released guidelines for use of aggregates obtained from recycling broken concrete (recycled concrete aggregates) in granular foundation or sub-base uses, embankment construction, and soil construction works. Construction debris-derived recycled aggregates can be used to the extent of 20–50% in concrete, blocks, and pavers, among other things

### Bureau of Indian Standards (BIS)

The BIS 383 revised standard of 2016 allows for specific uses of recycled coarse and fine aggregates in plain concrete, reinforced concrete, and lean concrete within certain restrictions.

The suitability of recycled fine/coarse aggregate for road building was also validated by the Central Road Research Institute (CRRI).

### Indian Roads Congress (IRC)

The Indian Roads Congress (IRC) has issued 'IRC-121:2017- guidelines for use of C&D Waste in Road Sector' outlining what kind of materials from recycled C&D waste, and in what proportion, may be safely used for specific road construction/repair applications.

## GOVERNMENT CIRCULARS

As per a circular issued by the Ministry of Housing and Urban Affairs (MOHUA), dated 22nd May 2018, for use of recycled materials and products:

- Aggregates, both fine and coarse, are useful materials for road construction, and a sufficient combination of aggregates may be supplied to meet consumer demand for buildings and road construction.
- The recycled products from concrete can also be used to make stones/tiles, paver blocks, prefab concrete slabs, park benches, compound walls, fence poles, underground cable covers, drain/manhole covers, and other downstream materials.



## APPLIED INNOVATION

In an initiative by **TERI** in Uttar Pradesh in 2019, inert material sorted out of C&D waste, before processing, use used as a soil cover in dumpsites in Lucknow, Uttar Pradesh. Inorganic waste was used for the granular sub-base layer of pavements in Meerut city.

**Godrej Construction** with first-of-its-kind manufacturing facility in Mumbai makes customized concrete blocks and pavers from recycled concrete called Tuff recycled concrete products. Capable of producing blocks and pavers of varying shapes and sizes at a full capacity of 170 cubic metres a day, they use C&D waste as a major ingredient in a fully automated and controlled environment.

## INDUSTRY APPLICATION

Saint-Gobain India developed 'green' gypsum boards using recycled gypsum. These boards are made from a combination of virgin and recycled gypsum obtained from construction waste.
The company has partnered with local waste management organizations to collect waste gypsum from construction sites for use in the manufacturing of gypsum boards.

**PROJECT APPLICATION**

**Supreme Court, Delhi**

The Central Public Works Department (CPWD) has adopted guidelines for use of recycled products and can help build confidence in the market. CPWD has used recycled aggregate products in the new building of the Supreme Court in Delhi. The products were purchased from New Delhi's Burari C&D waste recycling plant. The plant was processing about 2,000 tonnes per day of C&D waste and converting it into aggregates for use in ready mix concrete, cement bricks, hollow bricks, pavement blocks, kerbstones, concrete bricks, and manufactured sand. More than 16 lakh recycled concrete blocks from the plant have been utilized in the new Supreme Court annex building.

**Mumbai-Pune Expressway**

In the construction of the Mumbai-Pune Expressway, recycled sand obtained from C&D waste was used as a replacement for natural sand in the concrete mix. It used over 1.5 million cubic meters of recycled sand, which was obtained from construction waste collected from various sites in Mumbai and Pune. The recycled sand was processed and cleaned to remove any impurities before being used in the concrete mix.

# Data everywhere, but no straight answers

**As a pressing concern for urbanizing India, one of the fundamental challenges construction waste management faces is the lack of on-ground research and reliable construction waste data.**

From academics to government and non-government research institutes, various studies have tried to estimate the amount of construction and demolition waste generated in the country, at different times. A recent report by the Centre for Science and Environment, however, throws light at the fact that all these estimates, if anything, highly vary from each other and may be underestimating the magnitude of the problem. They also do not necessarily relate to the pattern of city-making we are witnessing, which is more concentrated high-rise buildings, rather than low-rise individual homes.

C&D waste generation figures for any region fluctuate depending on the type of construction/demolition activities of projects within it. They also vary based on the scale and methodology used in the assessment of waste. It, therefore, remains difficult to correlate findings and provide clarity on the quantum of C&D waste produced and its constituents for a typical construction site. This indicates that not only are the results and their interpretations specific to context and case, losing general applicability, there are also documentation issues ranging from poor book-keeping on construction sites to mis-managed waste management practices, at project as well as industry level. Furthermore, the resultant variability hinders policy makers, industry players and markets from using the data as a tool in urban planning, and developing relevant and effective policies regarding management of such waste.

Table

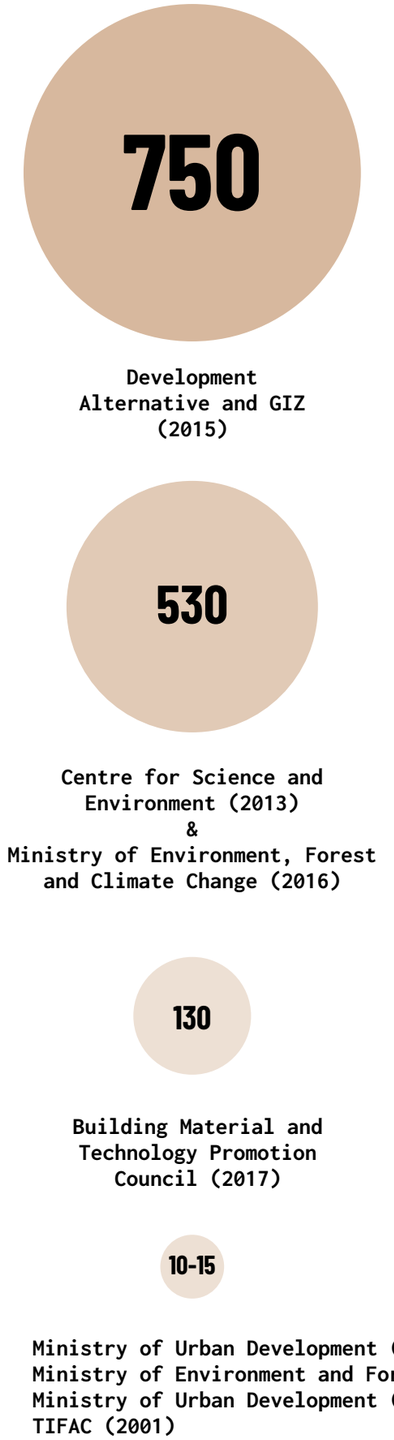
**C&D waste generation in select Indian cities**

| City | Population (Census 2011) | Daily CDW Generation (tonnes/day) |
|---|---|---|
| Mumbai | 12,442, 373 | 2,500 |
| Delhi | 16,787, 941 | 4,600 |
| Bengaluru | 8,443, 675 | 875 |
| Chennai | 6,500,000 | 2,500 |
| Kolkata | 4,496, 694 | 1,600 |
| Jaipur | 3,471, 847 | 200 |
| Patna | 2,514, 590 | 250 |
| Ahmedabad | 6,063, 047 | 700 |
| Bhopal | 1,917,051 | 50 |
| Coimbatore | 2,618,940 | 92 |

Source: Data adapted from survey by Development Alternatives, 2015

Figure

**C&D waste estimates for India across precedent studies (million tonnes/year)**




Source: 'Another brick off the wall' by Centre for Science and Environment (CSE), 2020.

In addition to variability in quantum of waste estimates, the constituents identified of C&D waste are also generally limited. Several studies across India, five of which are shown here, mention that 90% of C&D waste is composed of bulky materials. Bulky materials, which are dry and granular in nature, and stored in heaps, include concrete, gypsum, sand, cement, plaster, soil, gravel, and brick chips.

From the beginning till its end, construction as an activity uses a variety of material, both bulky and non-bulky, not all of which is consumed entirely in the process. The sector has also witnessed advancement in techniques adopted during various stages of construction, as well as demolition, suggesting changes in material composition in buildings, and thereby, in waste generated.

Table

**Indian construction and demolition waste percentage composition**

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

Source: 'Another brick off the wall' by Centre for Science and Environment (CSE), 2020.

Such state of information sheds light on two important points: 1) there is scope for creating research- and data- based understanding on construction-waste across various stages in building projects, and 2) construction waste management is a shared responsibility for all stakeholders to effectively address environmental and economic challenges of waste generation and leverage opportunities in waste management.

Reliable and credible construction waste data, relevant to region / country context, are important to design and implement appropriate measures for management of such waste.

Data and information will help all stakeholders – including the construction industry, contractors, local and national governments in the design and implementation of efficient value chains, standards, codes of conducts, policies and systems. They will also be able to create effective tracking mechanisms that will help to build and provide for the future.

The following sections of this handbook bring to light the subject of construction waste in India, to drive the discourse of waste management in an evidence- and data-driven approach.

02

# Our Approach

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# How we got started?

We studied, identified, and applied. To get a pan-India understanding of the scale and magnitude of the issue, we identified 14 construction sites under development by Godrej Properties Limited (GPL) and Mahindra Lifespace Developers Limited (MLDL). These are spread over 4 different major cities in the country (Bengaluru, Gurugram, Mumbai and Pune). These cities are fast growing centres of economic development that are seeing most of the construction activities in the country.

Our approach is predicated on experience in addressing realities of construction waste on ground. We started by looking at construction waste as estimated by the contractors working on the identified projects.

**Why contractor estimates?**

Contractors are typically required to integrate their estimates of material waste as part of their bids to secure construction contracts. As leaders in the real estate industry, both GPL and MLDL work with some of the best contractors in the market.

Skilled contractors generally base their estimates of material waste on their project assessments and benchmarking derived from years of delivery experience and acceptable industry standards. As these estimates are the basis on which contracts are signed off between contractors and developers, they can be a suitable starting point for waste estimation.

**Collecting contractor estimates of waste**

We captured the waste estimated by each contractor for various stages of construction to establish the average Contractor Estimated (CE) waste.

This estimate also includes service waste, from materials used to support the construction process, such as air filters and electrical cables.

**The data was compiled and summarized from:**

- Contractor worksheet across 14 projects mapping work done versus material used
- Contractor Bill of Quantities (BOQ) across 14 projects mapping material required for each construction stage
- Insights from structured in-person and telephonic interviews with multiple contractors across Bengaluru, Gurugram, Mumbai and Pune.

**Understanding potential limitations**

Contractor Estimated waste may not always be the most accurate measure of waste produced on site. To provide for and manage business risks of factors such as fluctuations in price, availability of material, underestimation, unexpected changes in construction plans and damage to material due to weather / breakage, contractors may overestimate material waste.

While this is helpful in their maintaining project timelines and overall profitability, it may lead to subsequent over-estimation of waste.

Additionally, contractor estimates do not account for all non-material sources of waste such as packaging materials.

**Contractor Estimate data sheet prepared for Godrej Nirvaan, Kalyan, Mumbai (Core and Shell Stage)**

| Material/item | % Theoretical waste/ floor | Qty required per floor/unit area | Unit | Wastage (kg) | Area (sft) | Stage | Waste kg/sqft | Core material | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Steel | 3% | 25 | Tonne | 750 | 5163 | Reinforcement | 0.1453 | Metal | 25 Tonne required per floor |
| RMC Concrete | 0-1% | 264 | m3 | 6441 | 5163 | Concreting | 1.2475 | Concrete | RMC density 2440kg/m3 |
| Mivan shuttering (metal) | 0.04% | 2775.10 | m2 | 19.98 | 5163 | Shuttering | 0.0039 | Metal | 18kg per sq. mt. |
| 3m metal pipe for RMC pumping | 0.01% | 1 piece | Nos | 30 | 5163 | Concreting | 0.0058 | Metal | Pipe waste when pressure is more |
| PP bags (polypropylene/plastic) | 100% | 55 bags | Nos | 8.25 | 5163 | Concreting | 0.0016 | Soft Plastic | 150gm per bag |
| Concrete Cover block | 10% | 1200piece | Nos | 7.2 | 5163 | Shuttering | 0.0014 | Concrete | 50-60gm per block |
| Curing compound bucket (HDPE) | 100% | 7 buckets | Nos | 18.375 | 5163 | Curing | 0.0036 | Hard Plastic | Empty bucket weighs 2.6kg |
| Grease | 100% | 100kg | kg | 100 | 5163 | Greasing | 0.0194 | Silicon | Grease dries up and chips off |
| Crush sand | 100% | 40bag | Nos | 1000 | 5163 | Concreting | 0.1937 | Sand | Slurry used for leveling chips off |
| Cement | 100% | 15 bag | Nos | 600 | 5163 | Concreting | 0.1162 | Cement | Slurry used for leveling chips off |
| Wall tie cover | 100% | 3 rolls | Nos | 3 | 5163 | Shuttering | 0.0006 | Soft Plastic | Few are reused, eventually wasted |
| Flute board (plastic) | 100% | 3kg | kg | 3 | 5163 | Shuttering | 0.0006 | Soft Plastic | Few are reused, eventually wasted |
| Rubber gloves | 30% | 50piece | Nos | 1.95 | 5163 | Shuttering | 0.0004 | Rubber | Most waste generated during concreting |
| Gum boot | 1% | 100 piece | Nos | 1.6 | 5163 | Shuttering | 0.0003 | Rubber | Most waste generated during concreting |
| Safety Jacket (polyester) | 10% | 50 piece | Nos | 0.5 | 5163 | Shuttering | 0.0001 | Hard Plastic | Every 12 slabs all jackets are changed |
| PVC pipe for curing | 4% | 100m | kg | 1.2 | 5163 | Curing | 0.0002 | Hard Plastic | Cuts due to rough usage |
| Pin Patti (MS) | 10% | 35000 nos | Nos | 42 | 5163 | Shuttering | 0.0081 | Metal | 120 gm per patti |
| Halogen lamp | 3% | 10nos | Nos | 32 | 5163 | Concreting | 0.0062 | Metal | Breaks during early morning pouring |
| Blockwork | 10% | 1000kg | kg | 100 | 5163 | Blockwork | 0.0194 | AAC Block | Wasted during rework and handling |
| Binding wire (GI) | 6% | 200kg | kg | 12 | 5163 | Curing | 0.0023 | Metal | Most waste due to handling and pouring |
| Iron Nails | 20% | 12 | m2 | 1 | 5163 | Shuttering | 0.0002 | Metal | Nails stuck chips outs during deshuttering |
| Thermocol | 100% | 0.5 | kg | 0.5 | 5163 | Shuttering | 0.0001 | Soft Plastic | Filled in backbox to avoid concrete |
| Backing box coin | 100% | 2 | kg | 2 | 5163 | Conduiting | 0.0004 | Metal | Each box has at least 8 coins waste |
| PVC conduit pipe | 10% | 3.5 | kg | 30 | 5163 | Conduiting | 0.0058 | Hard Plastic | Wasted during electrical work in shuttering |

**Measuring waste on sites**

In our experience, real-time measurement of actual waste provides the most accurate construction waste assessment. We applied our insights to the challenge of construction waste and developed a scientific process that allowed us to measure waste produced on site across all stages of construction.

Our teams were physically present on sites to observe work done and measure the waste generated to derive numbers for Site Measured (SM) waste. This process not only provided accurate estimates of waste generated, but also helped identify the sources of waste, which is crucial for both waste management as well as reduction efforts. In doing this, we also sensitized site teams toward the idea of construction waste. As they facilitated our quantification and assessments for waste generated at construction sites, our engaged efforts also helped them relate to the magnitude and gravity of the problem at hand.

**We adopted a feet-on-the-ground approach to waste measurement**

## PACKAGING MATERIAL WASTE

Cardboard box, wood packaging, paint container, cardboard roll, paper, thermocol, jute bag, rubber, film roll, grow bag, packaging plastic

## SAFETY MATERIAL WASTE

Gum boot, helmet, gloves, safety jacket, safety belt, dori

## CONSTRUCTION MATERIAL WASTE

Concrete, cement, glass, stone, sand, paint and other

## SERVICE MATERIAL WASTE

Halogen lamps/bulbs for construction activity post sunlight, air filters, electrical cables, extensions, adhesives and oils

### CONTRACTOR ESTIMATED

- This waste does not have salvage value and is not estimated by the contractor.
- This waste is estimated by the contractor during the BOQ finalization stage.
- Waste is estimated at every stage, separately for each core material
- This waste is generated from one-time use material across the construction life-cycle. Contractors maintain an accurate list of materials needed and consumed.

### SITE MEASURED

- This waste was measured accurately and quantified by on-ground team once the construction stage was completed.
- This waste was measured accurately and quantified by on-ground team once the construction stage was completed.
- Actual waste generated was measured at the end of construction stage.
- As our study does not cover the entire duration of construction, contractor estimates remain the most accurate assessment for this waste.

**Addressing the limitations of Contractor Estimated waste**

To address the limitations of Contractor Estimated (CE) waste, we looked at gaps in coverage. Going beyond material waste, we reviewed the quantum of packaging materials including soft and hard plastic, polypropylene (PP) bags, and cardboard.

We also identified waste from safety equipment such as gum boots, helmets, gloves, and safety jackets.

Specific to material waste, we measured the actual construction material waste remaining at the end of a construction process for an accurate assessment.

# What did we learn?

**Through this study we aim to achieve a deeper understanding of waste generated on construction sites for the industry and other key stakeholders to initiate informed, effective, and collaborative efforts toward managing construction waste and generating shared value for the ecosystem.**

**We hope to provide answers to pertinent questions-**

**What is the quantum of waste (kg) generated per square feet of built-up area?**

**What are the constituents of waste generated at site?**

**How much waste is generated in each construction stage?**

**How does this waste travel and where does it end up?**

# Our research methodology

Accurate estimation of waste generation at a construction site is critical to identifying and establishing effective waste management tools and processes. For this study, we established a quantitative measurement based model specific to real estate construction projects that can improve the accuracy of waste estimation at the project level.

During our research, we conducted on-site analysis of the construction process and its subsequent waste generation. Our model specifically integrates the mass balance principle, which suggests that all physical material that enters a construction site must either accumulate in construction or leave the site, contractor estimates and industry benchmarking by experts of different waste streams. This helped us determine the wastage levels of various materials used across different stages of construction.

We started by identifying suitable project sites for this research, developing, testing and strengthening the data capturing systems, as well as training and building capacity of the team to gather and analyze data.

In consultation with GPL and MLDL personnel, designated research teams were deployed at all 14 project locations with a dedicated project manager appointed as a single point of contact (SPOC) for all waste management data. Since the objective of the study goes beyond the total waste generated and disposed, there was a need to clarify the quantum of waste generated during each construction stage. For this, the SPOC ensured waste was physically weighed on site at the end of each construction process.

Our research process also included tracing the value chain of the waste materials generated to understand its life cycle inside and beyond the site boundary, which meant tracking waste material from site-aggregator to the eventual recyclers. This allowed us to map how the waste travels within the site, where it is currently going and understand the challenges of disposal and opportunities for management of each material.

Our on-ground research and analysis allowed us to identify opportunities and measures to strengthen the waste traceability and recycling ecosystem starting with measures that all developers / builders can readily adopt at construction sites to both minimize as well as effectively manage waste generation.

## PROCESS

**Step 1**
**Data collection on-site**

- Understanding material movement within the site;
- Understanding waste handling practices;
- Observing any on-going waste handling activities and storage yards; and
- Measuring waste generated during different construction stages.

**Step 2**
**Data collection off-site**

- Collecting waste generated estimation data from contractors;
- Collecting waste collection data from the site; and
- Collecting waste disposal data from the outward register on site.

**Step 3**
**Documentation and Analysis**

- Cleaning and analysing the data,
- Developing actionable strategies adaptable by and relevant to all developers;
- Designing a Standard Operating Procedure (SOP) for construction waste management;
- Computing the construction waste management cost; and
- Reviewing the general conditions of contracts and suggesting changes.

# Project site selection

Seven major cities drive the real estate research and industry outlook in the country. These are Mumbai Metropolitan region (MMR), National capital region (NCR), Bengaluru, Chennai, Hyderabad, Pune, and Kolkata. Our research includes 14 projects across 4 of these cities – Bengaluru, Gurugram (part of NCR), Mumbai (part of MMR) and Pune. All 14 sites are for residential group housing projects with building configurations and built areas similar to those of typical mid-segment residential real estate projects in India. 13 of these 14 sites used Mivan* construction methodology and 1 followed traditional techniques.

To understand the quantum of waste generated in a project completely requires a longitudinal study from initiation to project completion. A typical construction project of this scale, on an average, spans 3.5 years. Therefore, to study the entire construction cycle within one year of research, we identified the 14 sites such that the entire construction process could be studied in each of the four regions.

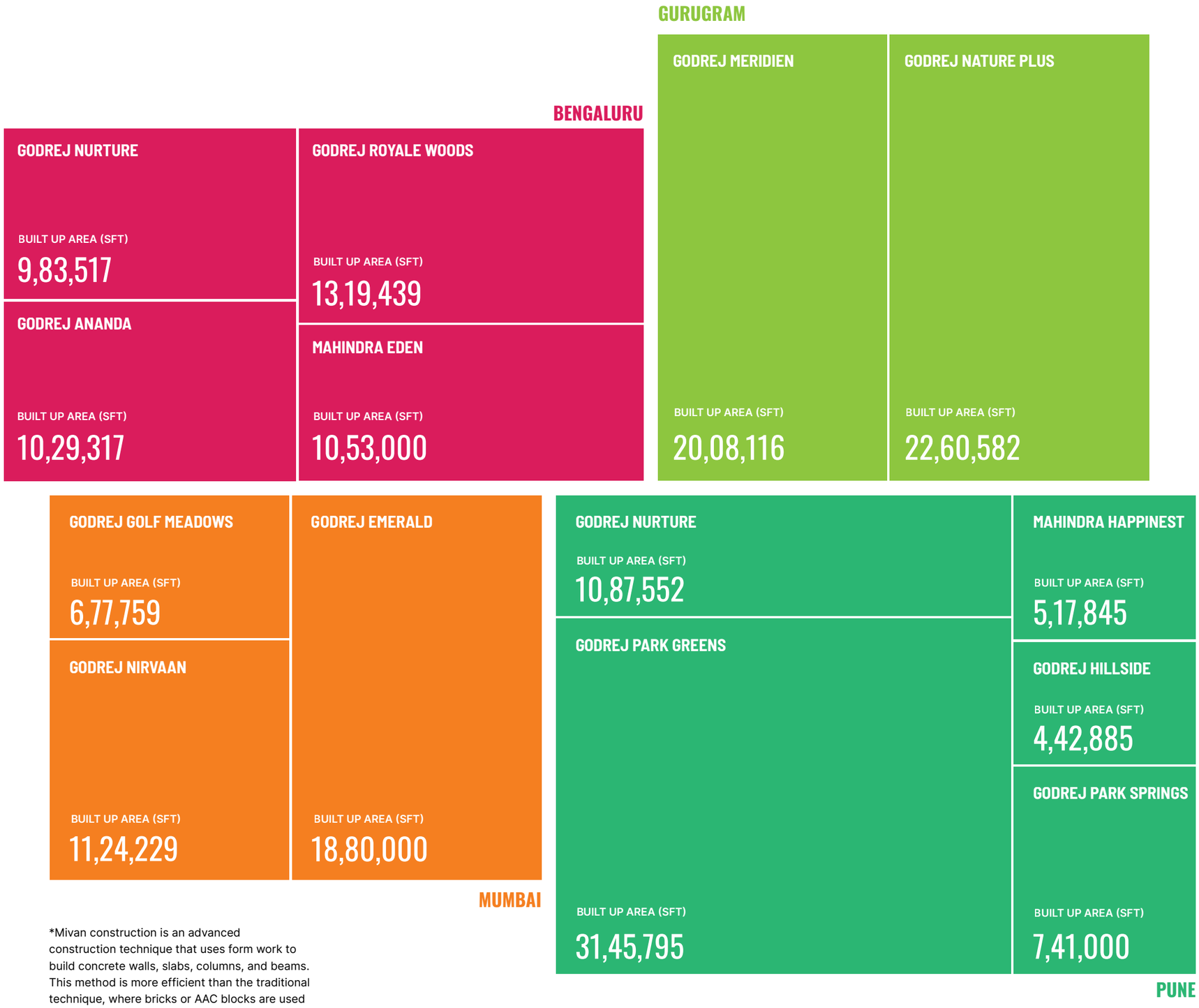
**14**
Construction sites under the study

**4**
Cities

**12**
GPL Sites

**2**
MLDL Sites

**18.27 MILLION**
Square feet of Built-up area under research study




*Mivan construction is an advanced construction technique that uses form work to build concrete walls, slabs, columns, and beams. This method is more efficient than the traditional technique, where bricks or AAC blocks are used as infill for columns, beams and slab structures.

# Stages and sub-stages of construction

**The construction cycle for a typical mid-scale residential project consists of three stages:**

## A. Site Preparation

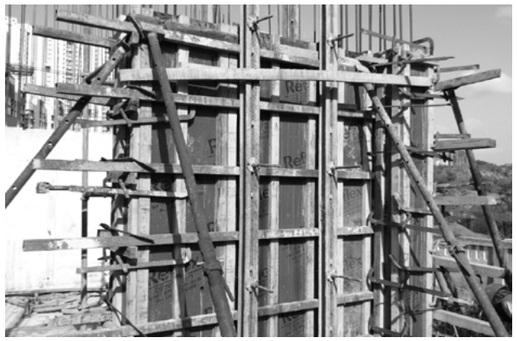
**Getting a construction site ready for building**

Clearing the land of any existing structures or vegetation, grading the site to create a level surface, and installing any necessary utilities or infrastructure.

## B. Core and Shell

**Building the structure**

Including the lift / staircase cores, walls etc. We have included internal conduiting within this stage.



## C. Finishing

**Completing the building**

The concluding stage where final finishes are applied and services integrated to provide a ready to move-in building.

**There are a total of 27 sub-stages under these three stages.**

## A. Site Preparation

**A1 - SITE SURVEY**

Assessing a site's physical characteristics to layout the building plan, and fixing the exact position of the building outlines, access roads, storage areas for supplies, locations for drainage systems, etc.

**A2 - BARRICADING**

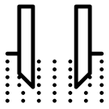
Erecting barriers or fences around a construction site to prevent unauthorized access, protect workers and the public from potential hazards, and ensure compliance with safety regulations.

**A3 - LAND CLEARANCE**

Removing any existing structures, vegetation, debris, and other obstructions from the construction site.

**A4 - PILING**

Strengthening the foundation of a building or structure by driving long, slender columns known as piles, deep into the ground.



**A5. SHORING WORKS**

Setting up temporary support structures and systems used to prevent the collapse of soil or existing structures during excavation or construction activities.

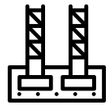
**A6. EXCAVATION**

Removing soil to a required depth in which the foundation of the structure will be placed using blasting, drilling, and other heavy machinery

**A7. TRANSPORTATION**

Transporting the blasted materials from excavation area to other part of the site for later consumption and sometimes to other construction sites for back filling.

## B. Core and Shell

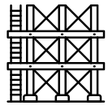


**B1. FOUNDATION**

Building structural system that supports and anchors the superstructure of a building and transmits its load directly to the earth.

**B2. REINFORCEMENT**

Adding strength and durability to a structure by incorporating materials, such as steel bars, mesh, or fibers, into the concrete in a manner that the two materials act together in resisting forces.



**B3. SHUTTERING**

Creating temporary molds or forms using plywood, steel, or other materials, to contain and shape wet concrete as it sets and hardens.

**B4. GREASING**

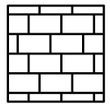
Applying construction grease to outer surface of any planned void in a slab for ease of removal post pouring.

**B5.CONCRETING**

Mixing, transporting, and pouring of concrete to create a solid, durable, and long-lasting structure.

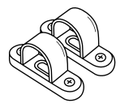
**B6. CURING**

Maintaining a controlled environment of moisture, temperature, and time to allow concrete or other construction materials to dry and harden properly.



**B7. BLOCKWORK**

Assembling individual blocks, such as Autoclaved Aerated Concrete (AAC) blocks, bricks etc. to create a wall and other structural elements.



**B8. CONDUITING**

Installing conduits, which are pipes or tubes, used to protect and route electrical wiring or other utilities through the building structure.

## C. Finishing

**C1. PLASTERING**

Covering rough walls and uneven surfaces in the construction with a plastic material, called plaster, which is a mixture of lime, cement, concrete, and sand along with the required quantity of water.

**C2. GYPSUM PLASTERING**

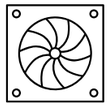
Applying a layer of plaster made from gypsum, a soft sulfate mineral which has good fire-resistance and soundproofing properties, onto the interior walls and ceilings of a building.

**C3. WATER PROOFING**

Making the building resistant to water penetration and damage to ensure the longevity and safety of the building.

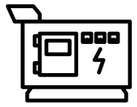
**C4. INTERIOR CIVIL WORK**

Constructing and installing various interior components and finishes of the building including flooring, partitioning, ceiling and wall finishes, doors and windows.



**C5. MEP WORKS**

Installing and maintaining the mechanical, electrical, and plumbing systems in the building including HVAC (Heating, Ventilation, and Air Conditioning), fire protection systems and lifts.



**C6. DG**

Setting up a diesel generator as backup power supply system to provide electricity in case of power outages, or as a primary power source until there is access to the grid.

**C7. FACADE**

Installing exterior finishes and cladding of the building for aesthetic (enhancing appearance) and functional (protecting from weather conditions) reasons.

**C8. PAINTING**

Applying paint or other types of coatings to various surfaces of a building to enhance appearance and provide protection against weathering, corrosion, and other damages.

**C9. LANDSCAPING**

Creating outdoor spaces around the building to enhance the aesthetic appeal of the property, create functional outdoor areas, and improve the overall quality of the built environment.

**C10. INFRASTRUCTURE**

Constructing and installing the basic infrastructure required for functioning of the building such as water tanks, roads, footpaths and other public infrastructure related services.

**C11. HANDOVER**

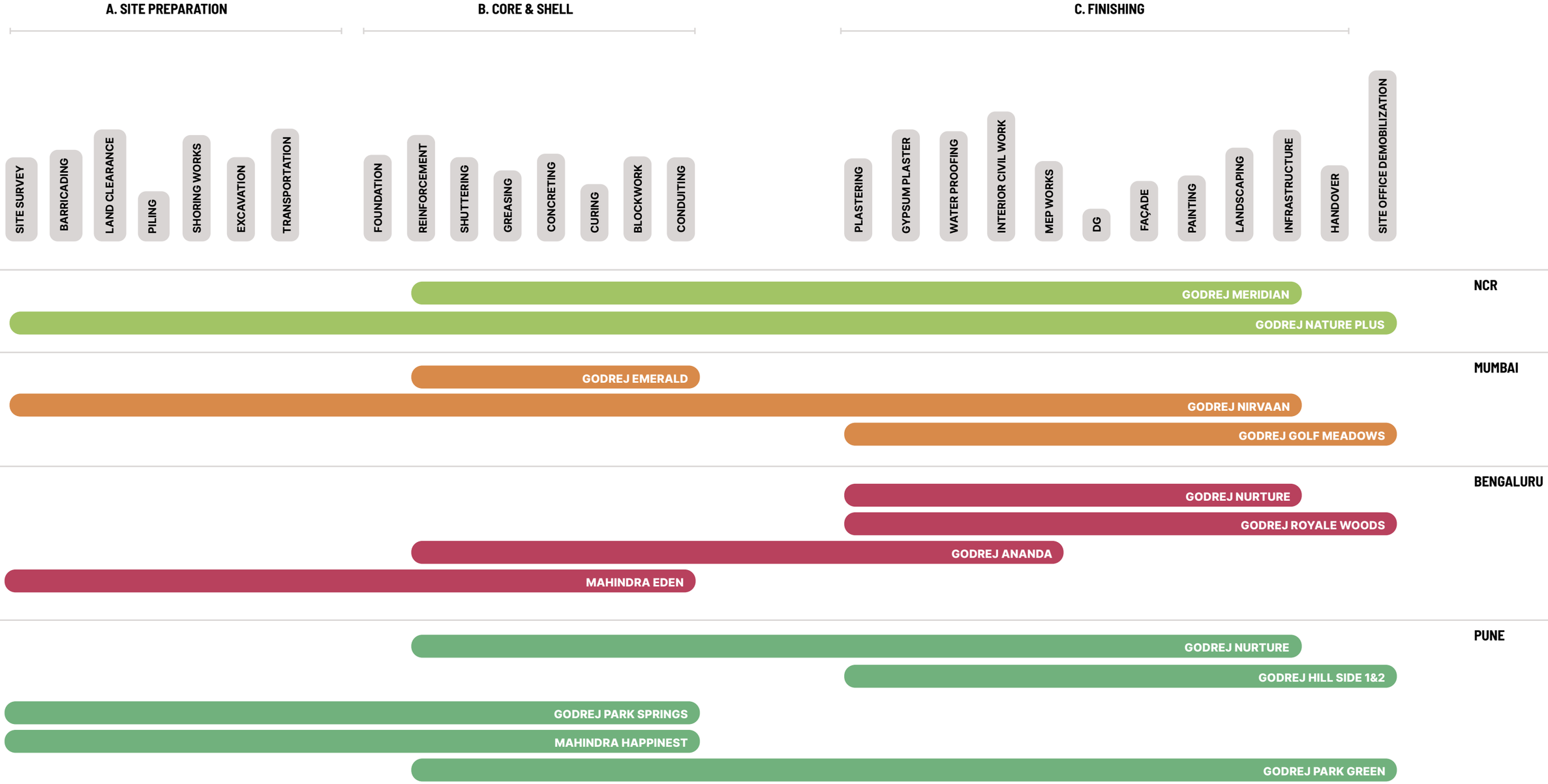
Completing the construction work, including all necessary testing and commissioning, and a final inspection to ensure that the building meets all relevant codes and regulations.

**C12. SITE OFFICE DEMOBILIZATION**

Removing all site offices, facilities, equipments, machinery and manpower from site.

# Construction schedule of selected projects

The construction stages were studied across the 14 selected sites and each of the 27 sub-stages was observed at least once in every region.



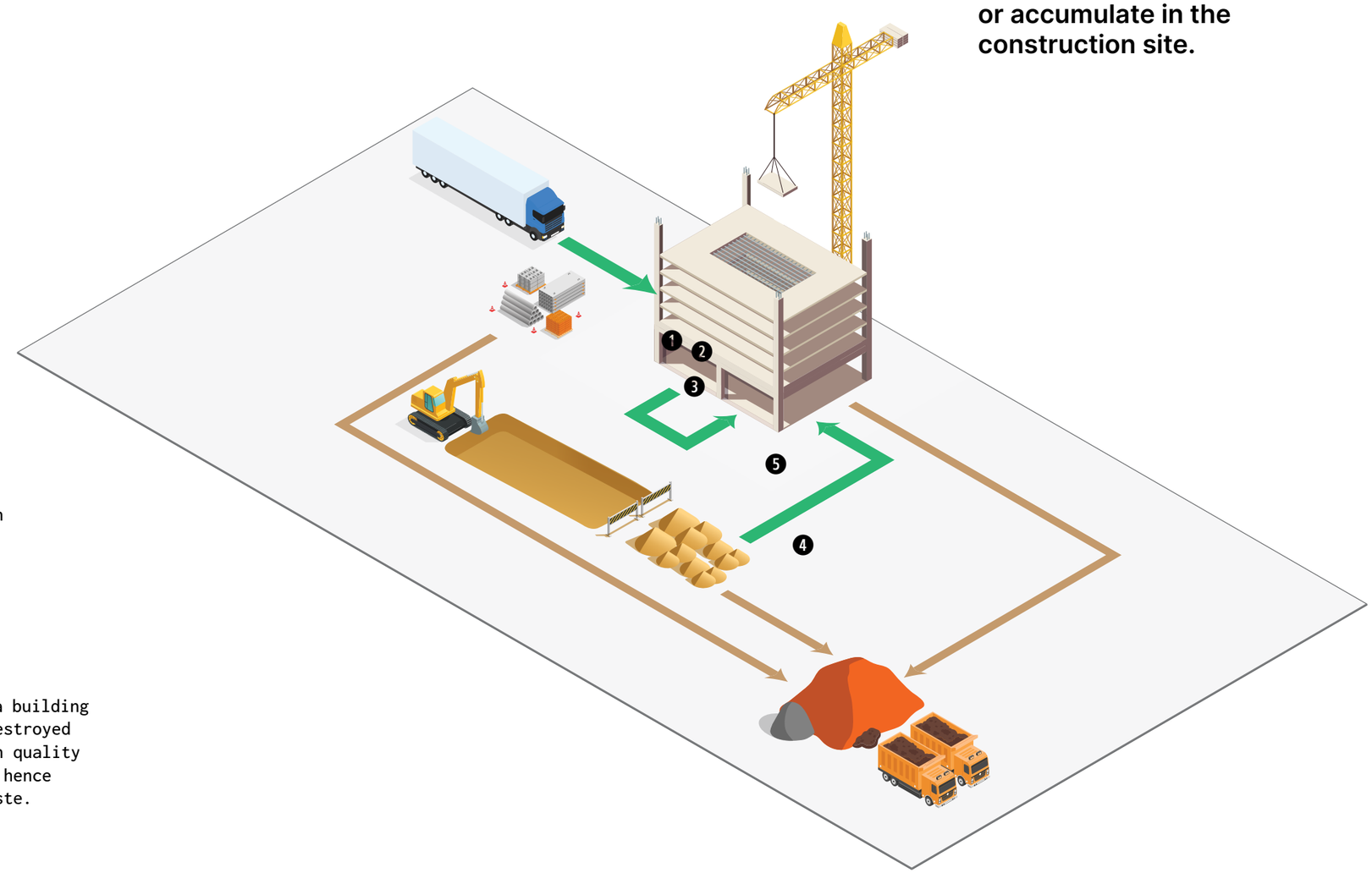
# Defining waste material

Waste material in this study are defined as the material that could not be utilized in the process of building on the same site and had to be transported outside for further processing.

In general, there are five types of material waste: construction material waste, packaging material waste, extracted material waste, safety material waste and target material waste.

Mass Balance Principle

**As a physical process, each construction step follows the mass balance principle - construction materials entering a construction site must either leave or accumulate in the construction site.**




❶

### CONSTRUCTION MATERIAL

is used to form the building. Most of this material once it enters a site is utilized completely to form building elements and only a small portion is discarded as construction waste.

❷

### PACKAGING MATERIAL

is used to package and protect construction materials. All of it ends up as construction waste.

❸

### SAFETY MATERIAL

is used to prioritize the safety of workers on construction sites.

❹

### EXTRACTED MATERIAL

are the soil excavated in the construction process. They usually turn into construction waste unless utilized in building or backfilling.

❺

### TARGET MATERIAL

are a part or whole of a building element that has been destroyed due to poor construction quality or change of design and hence becomes construction waste.

# Measuring Material Waste

We mapped more than 141 materials on site. For ease of quantification, materials with similar properties were clubbed together under a common core material.

# Computing area-based waste

The waste generated at a construction site is correlated to the size of the development under construction. Therefore, we explored total waste generated (kg) not in isolation, but in relation to the area of development (kg/sqft).

To compute total waste generated, we applied a part-to-whole strategy that involved observing things starting with the most basic unit and working up to a more complex system. Since the most basic unit in a construction site is an apartment, that became our starting point for waste calculation. We took the typical 1/2/3/4 BHKs on a floor and calculated the waste generation for different activities in that unit.

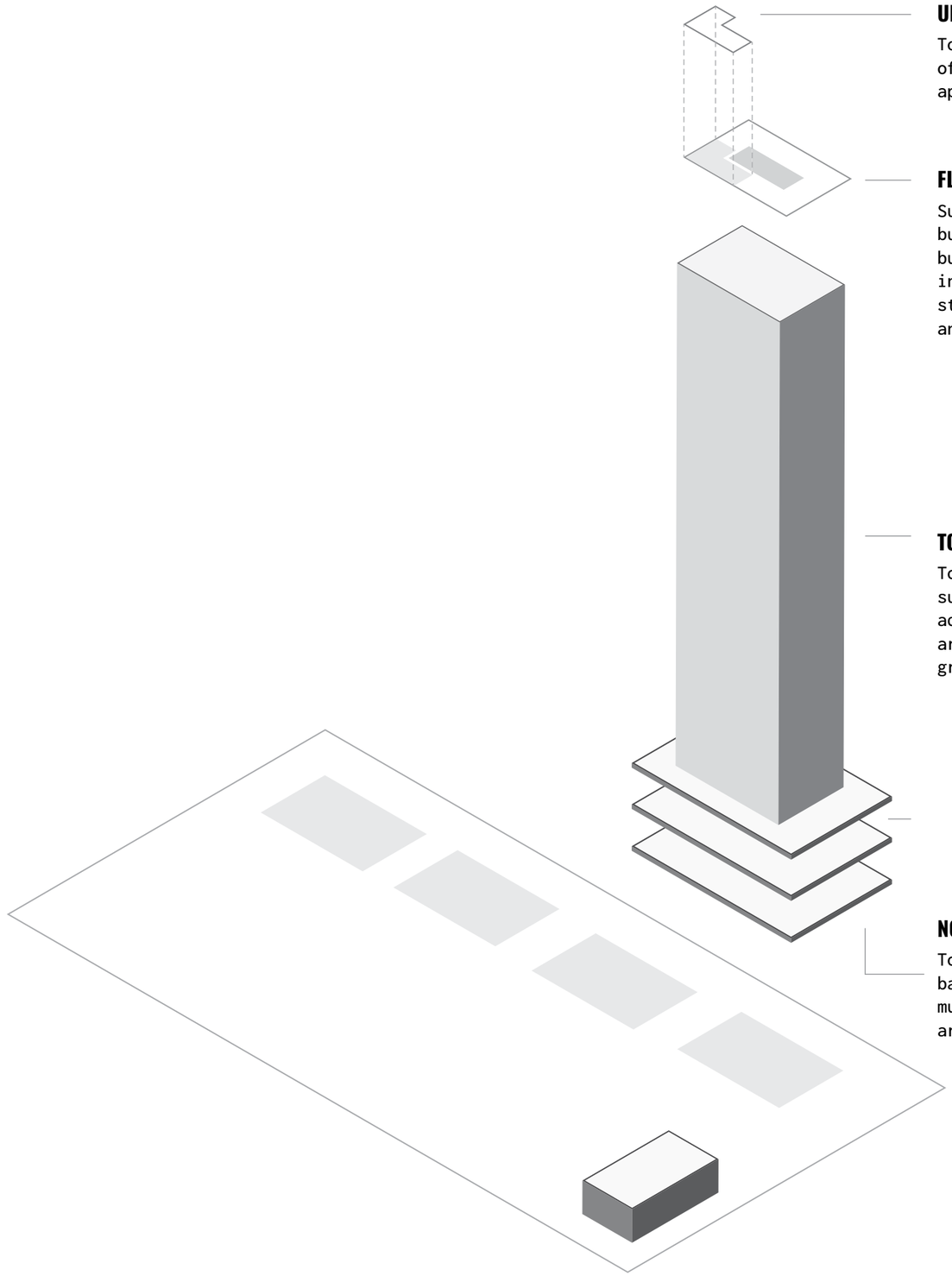
Next, we observed the waste generation in the utility areas of a floor such as the lobby, staircase and ducts. We then added that to the waste generated on all the units on a floor.

Once we had the total waste generated on a floor, we extrapolated that to the entire building. We multiplied the waste generated on a typical floor to the total number of floors and then to total number of towers. With this we arrived at the waste generated across all the towers in the project.

The waste generated in non-tower areas such as the basement, stilts, and multilevel car parking, and infra development (or site) area such as the hardscape, softscape, and boundary wall were individually observed.

Adding this to the waste generated in tower area, we computed the total waste generated at a construction site.

**To compute total waste generated, we applied a part-to-whole strategy that involved observing things starting with the most basic unit and working up to a more complex system.**



### UNIT AREA
Total built-up area of one typical apartment on a floor.

### FLOOR BUILT-UP AREA
Sum of all the units' built-up area and core built-up area which includes the lobby area, staircase area, duct area and other utility areas.

### TOWER AREA
Total area of the tower superstructure, or addition of built-up areas of all floors from ground till the top.

### NON-TOWER AREA
Total area of the podium, basements, stilts, multilevel car park and any area other than the tower.

### INFRASTRUCTURE DEVELOPMENT AREA OR SITE AREA
Total of hardscape area, softscape area, boundary wall and Mechanical, Electrical & Plumbing (MEP) area on ground.

### CONSTRUCTION AREA
Total of project built-up area, and infra development area or the site area.

# Defining site measured waste

For each stage and sub-stage, we measured the amount of material waste generated individually.

**1**

### OBSERVATION AREA

Measuring the amount of waste generated in smaller area such as one typical residential unit.

**2**

### TOWER AREA

Extrapolating the findings from a typical unit to the entire floor and then to the entire tower.

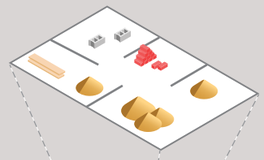
**Tower Area** = Observation Area x Total no. of units on a floor x Total no. of floors in a tower

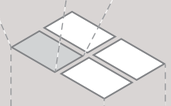
**3**

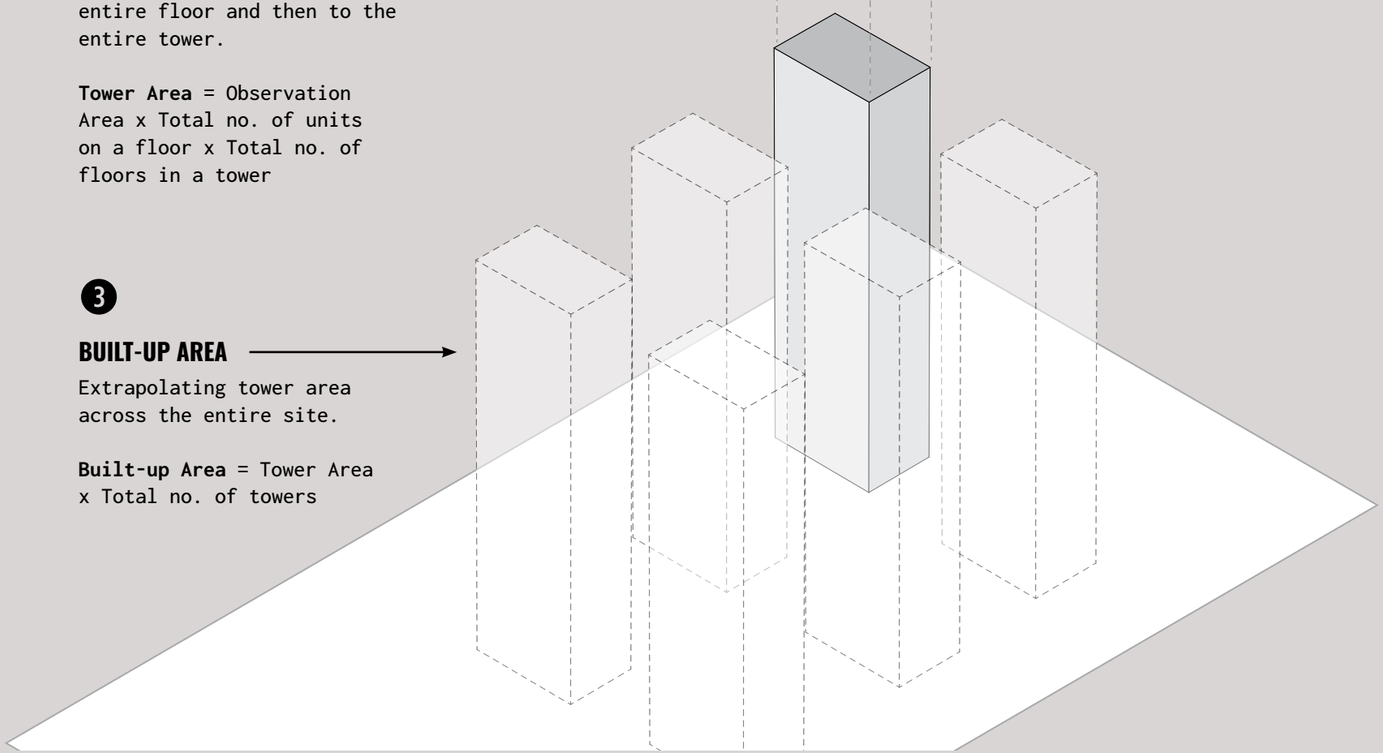
### BUILT-UP AREA

Extrapolating tower area across the entire site.

**Built-up Area** = Tower Area x Total no. of towers







We tabulated the findings on waste generation for each sub-stage.

**Assumption 1:** Percentage of waste generated for a small area is indicative of waste generated for the same activity in the entire site.

**Assumption 2**: All the by-products generated in the construction activity do not get primary recycled on the same site.

**Data from Godrej Nirvaan, Kalyan, Mumbai**

Name of Stage → **CORE AND SHELL**

Name of Sub-stage → **B8 - CONDUITING**

Core Material → **METAL**

| | Quantity (kg) | Area | Kg/sft |
|---|---|---|---|
| Metal box and coins | 2 | 5163 | 0.00038 |
| Metal solvent container | 3.15 | 5163 | 0.0006 |

Sub Material →

Core Material → **HARD PLASTIC**

| | Quantity (kg) | Area | Kg/sft |
|---|---|---|---|
| UPVC pipes | 3.66 | 5163 | 0.0007 |

Sub Material →

Total Construction Waste Generated per Sub-stage → **TOTAL (KG/SFT)** **0.0017**

# Collecting site measured waste data

**4,536**
data points

**378**
data sheets

03

# Key Findings

IN THIS SECTION


What is the quantum of construction waste generated in a mid-scale residential project in India? 74

What are the constituents of construction waste, by stage and material? 76

Which stages generate the most construction waste? 86

Where does the waste go? 90

How much of this waste is recycled? 100

KEY FINDINGS

# How have we contributed to expanding the study of construction waste?

Our research and analyses helped us in estimating the quantum of waste that a typical mid-scale residential real estate project in India generates per square feet of built area. This allows for a more precise estimate of construction waste in the country, directing a more informed approach to waste management.

Our research also identifies the different constituents of construction waste, including such materials that have not yet been accounted for.

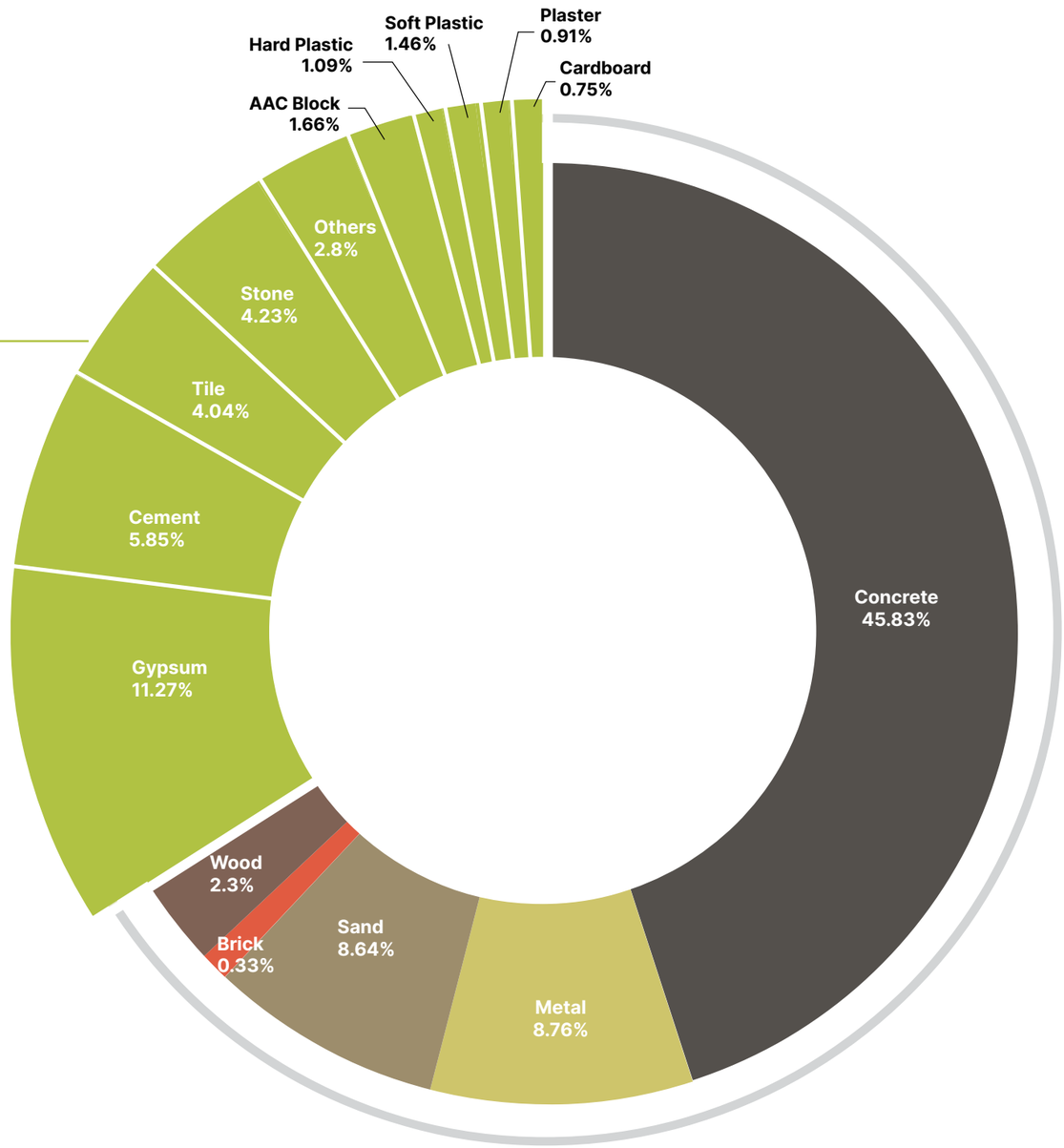
The detailed bottom-up approach adopted in this study opens doors for more industry-oriented research and profound understanding on the issue of construction waste.

It also enriches suggested techniques of waste management with generally applicable and actionable inputs that, if adopted, can measurably reduce the adverse effects of construction waste.

**Having a feet-on-ground approach allowed us to include several waste categories that were previously not a part of construction waste research**

Figure

**Additional Constituents of Construction Waste Identified in adopting Site Measured Approach**



KEY FINDINGS

# What is the quantum of construction waste generated in a mid-scale residential project in India?

**3.64 kg/sft**

The quantum of waste measured in a mid-scale residential Mivan construction project in India.

The maximum amount of waste generated is during the Finishing Stage

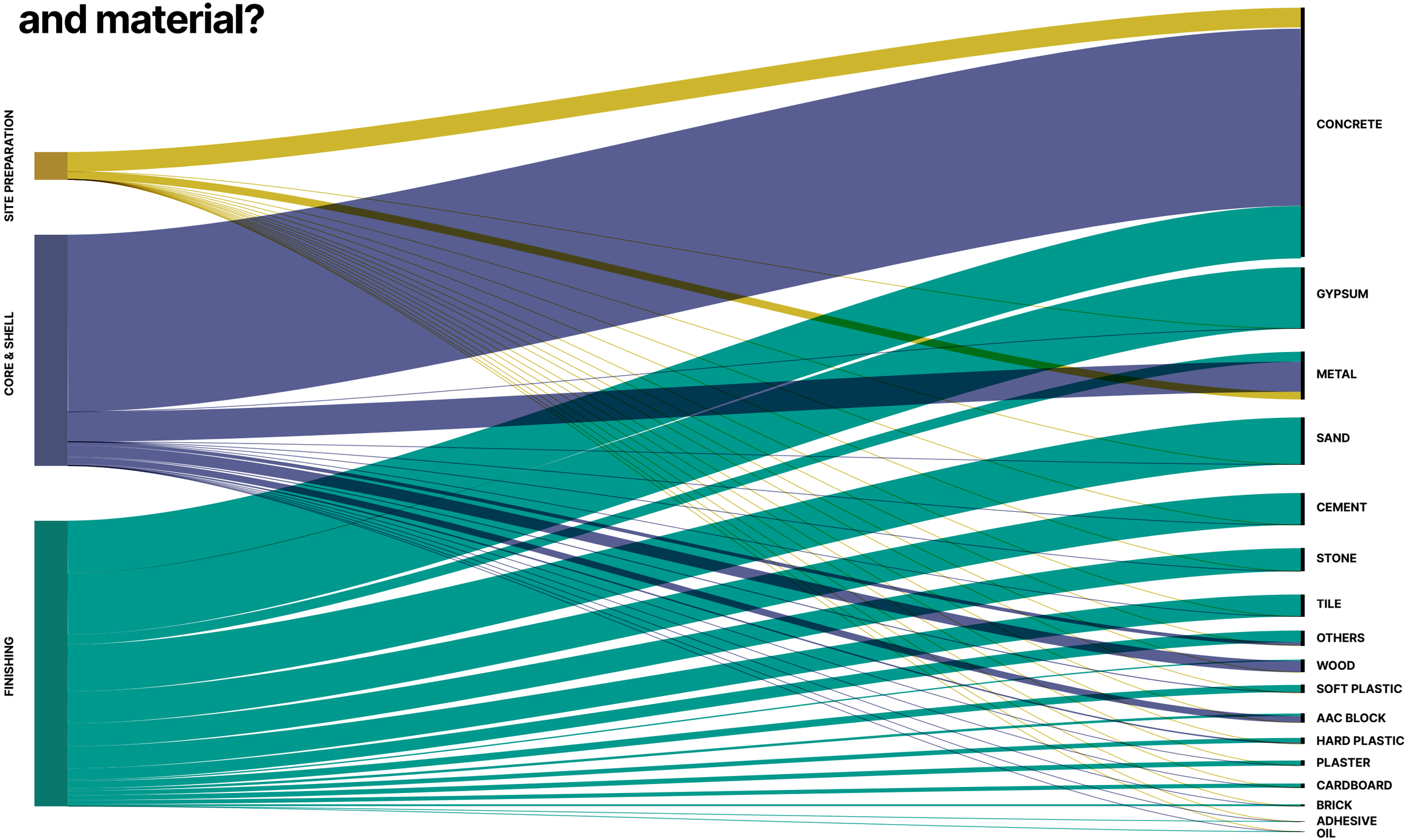
**SITE PREPARATION**

**CORE AND SHELL**

**FINISHING**

# What are the constituents of construction waste, by stage and material?

**3.64** kg/sft



KEY FINDINGS

# What is the distribution of construction waste material?

**19**

Core Materials

**141**

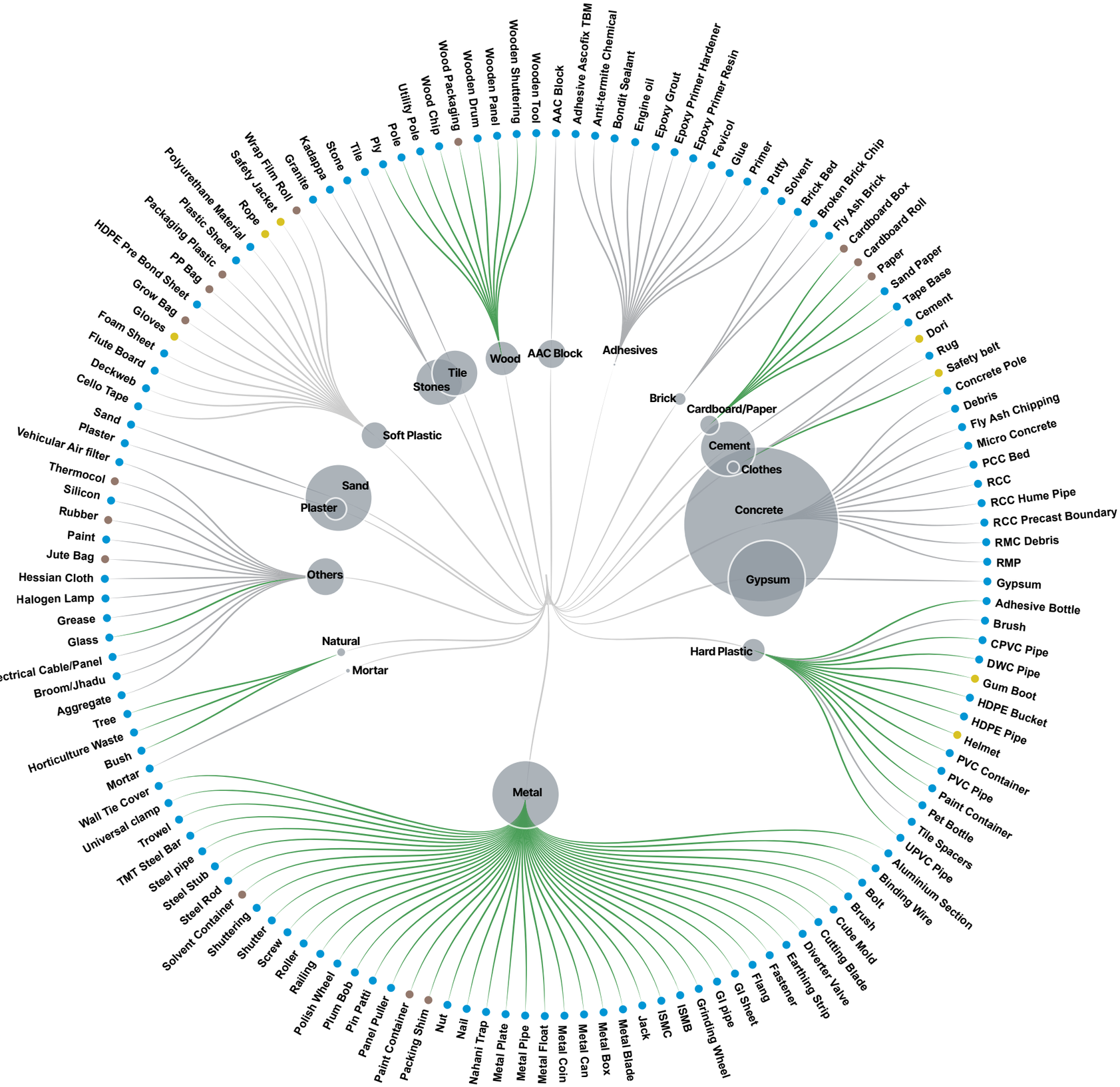
Materials identified across 19 Core Materials

**95**

Materials are currently recycled

**46**

Materials have the potential to be recycled




How to Read this chart

Quantum of Waste Generated (kg/sft)

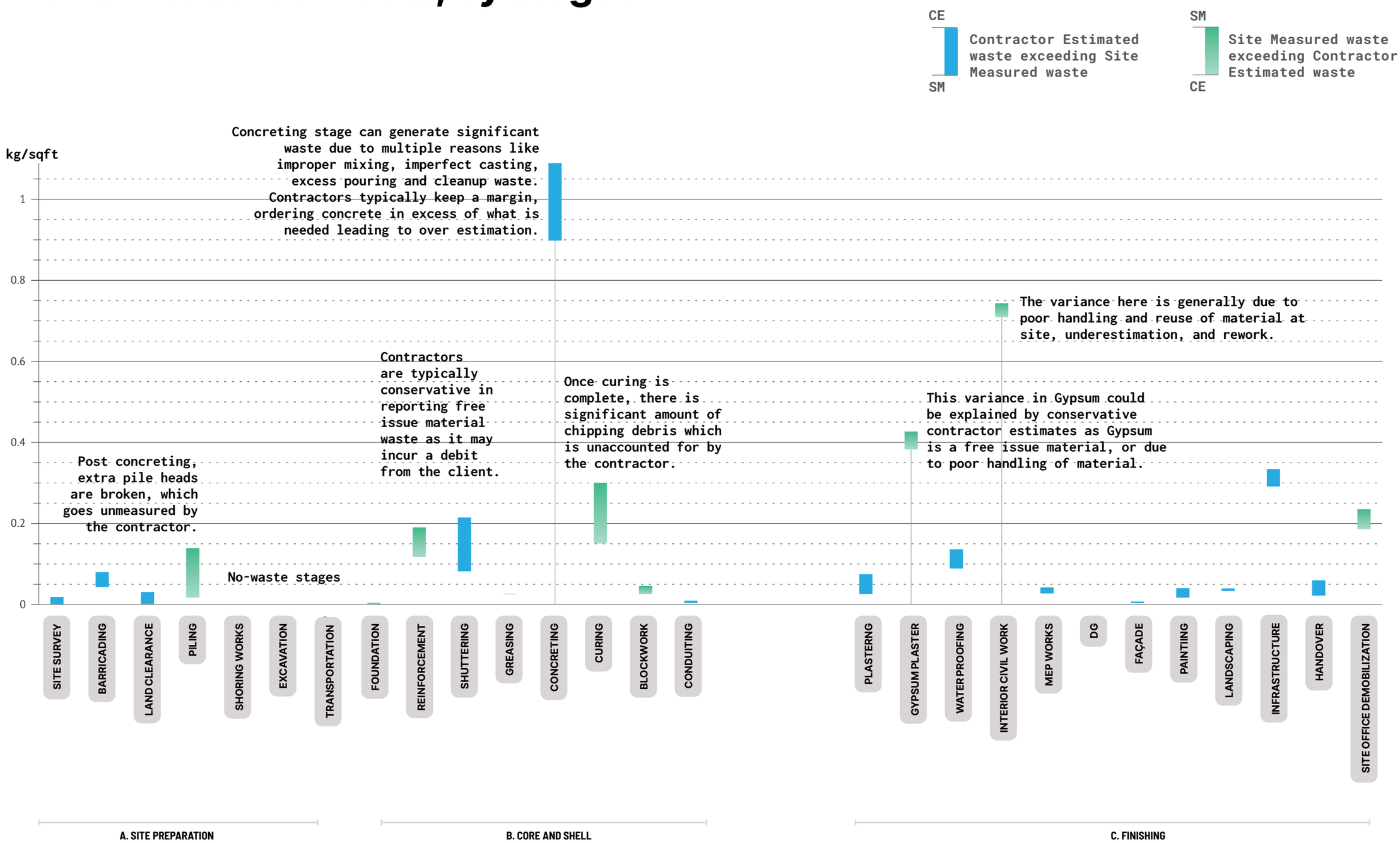
Currently recyled

Potential to be recycled

- Safety Material Waste
- Packaging Material Waste
- Construction Material Waste

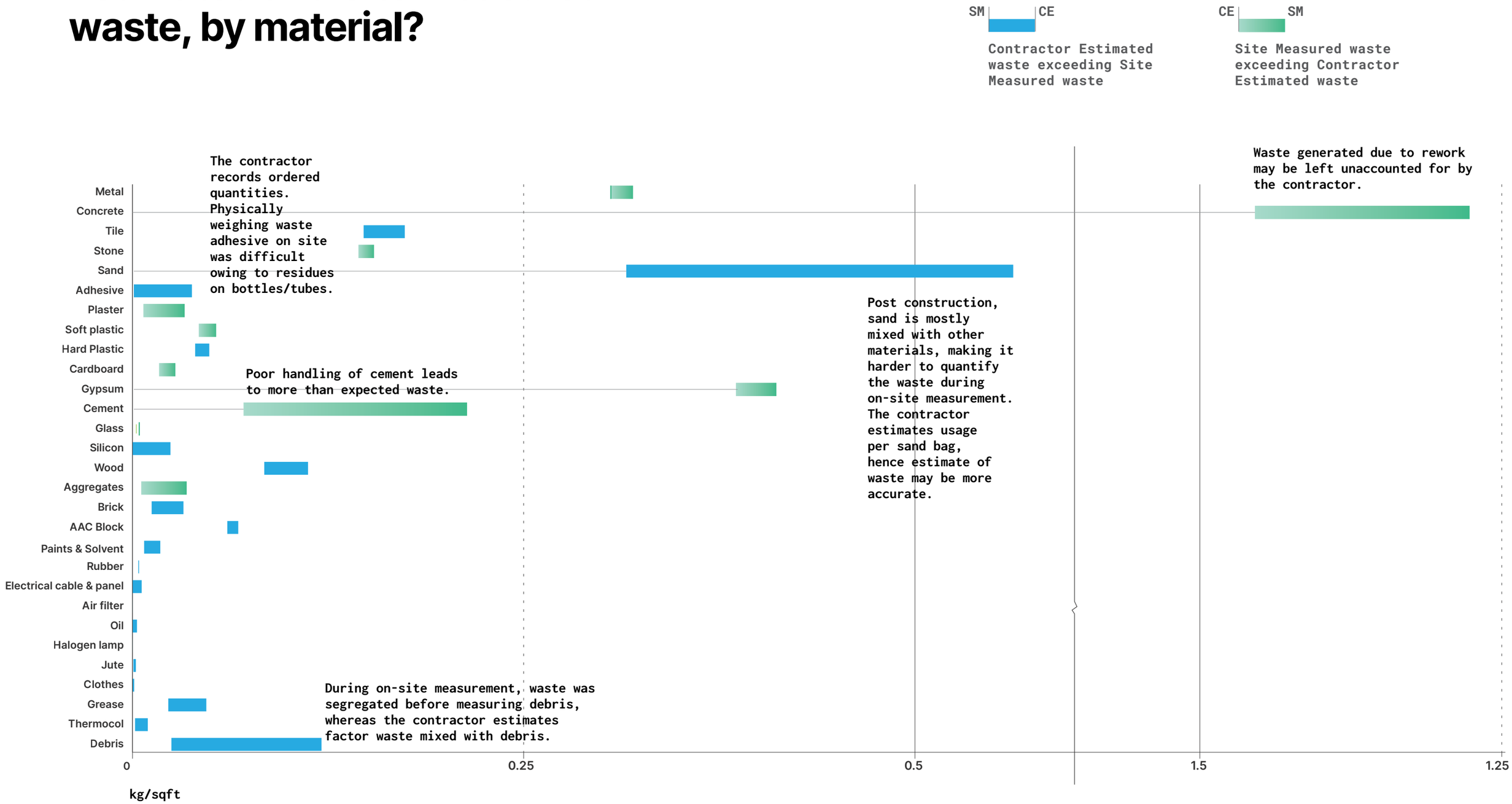
KEY FINDINGS

# What could explain the difference between Contractor Estimated and Site Measured waste, by stage?



KEY FINDINGS

# What could explain the difference between Contractor Estimated and Site Measured waste, by material?



KEY FINDINGS

# What are the top ten construction waste materials generated, by quantum?

Concrete and gypsum are basic building materials that are used in large quantities, and once broken, chipped or demolished are difficult to reuse. These two materials are, therefore significant contributors to construction waste.

| RANK | CORE MATERIAL | Site Measured value (kg/sft) |
|---|---|---|
| 1 | Concrete | 1.672 |
| 2 | Gypsum | 0.411 |
| 3 | Metal | 0.320 |
| 4 | Sand | 0.316 |
| 5 | Cement | 0.214 |
| 6 | Stone | 0.154 |
| 7 | Tile | 0.148 |
| 8 | Wood | 0.084 |
| 9 | AAC Block | 0.061 |
| 10 | Soft plastic | 0.053 |
| 11 | Hard Plastic | 0.040 |
| 12 | Plaster | 0.033 |
| 13 | Cardboard | 0.027 |
| 14 | Brick | 0.012 |
| 16 | Aggregates | 0.035 |
| 17 | Grease | 0.023 |
| 18 | Debris | 0.025 |
| 19 | Paints & Solvent | 0.007 |
| 20 | Glass | 0.005 |
| 21 | Rubber | 0.004 |
| 22 | Clothes | 0.000127 |
| 23 | Oil | 0.000112 |
| 24 | Jute | 0.001 |
| 25 | Thermocol | 0.002 |
| 26 | Adhesive | 0.001 |
| | TOTAL | 3.648 |

3 METAL

8 WOOD

9 AAC BLOCK

10 SOFT PLASTIC

1 CONCRETE

2 GYPSUM

4 SAND

5 CEMENT

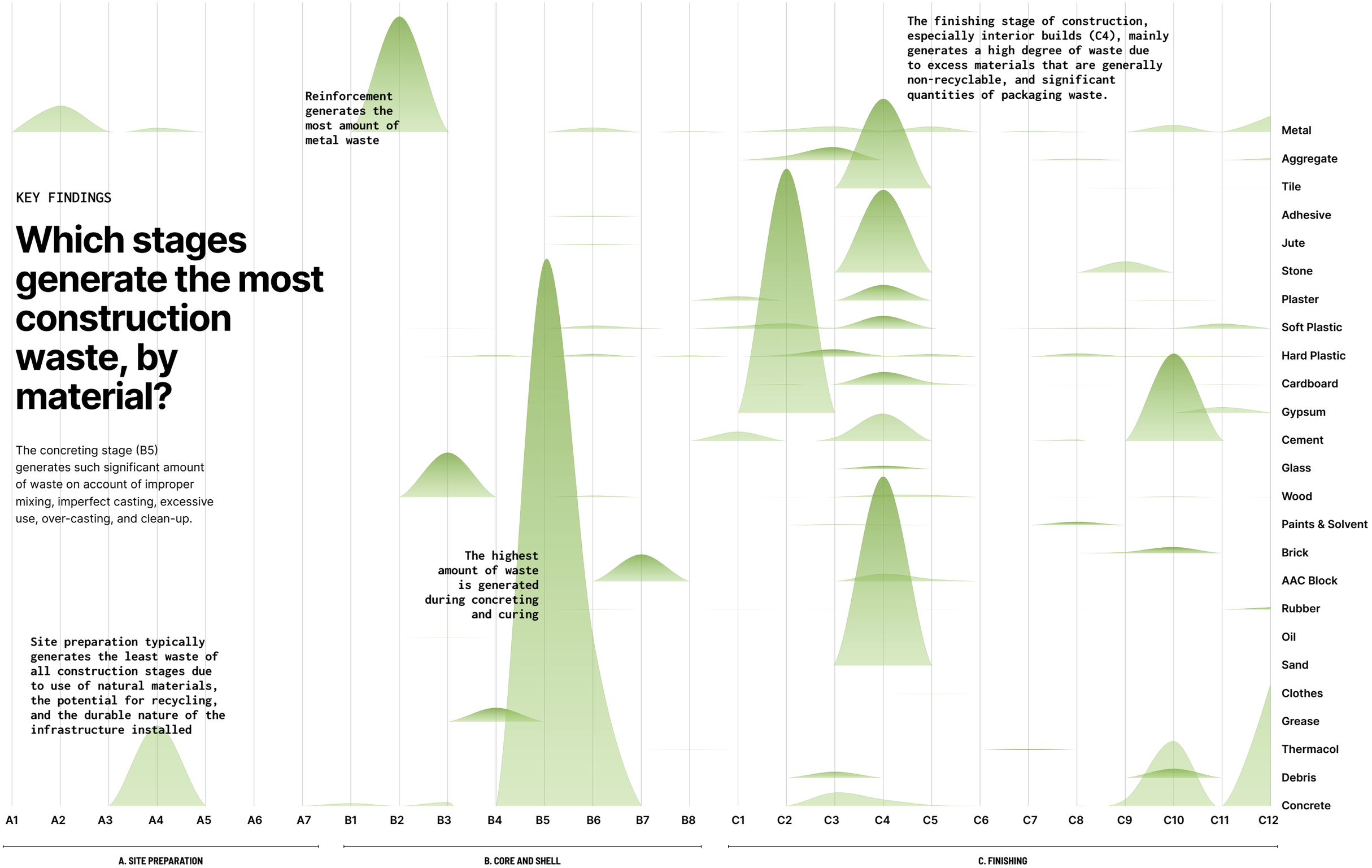
7 TILE

6 STONE

KEY FINDINGS

# Which stages generate the most construction waste, by material?

The concreting stage (B5) generates such significant amount of waste on account of improper mixing, imperfect casting, excessive use, over-casting, and clean-up.



KEY FINDINGS

# How much waste does 1 million square feet of residential construction* produce?

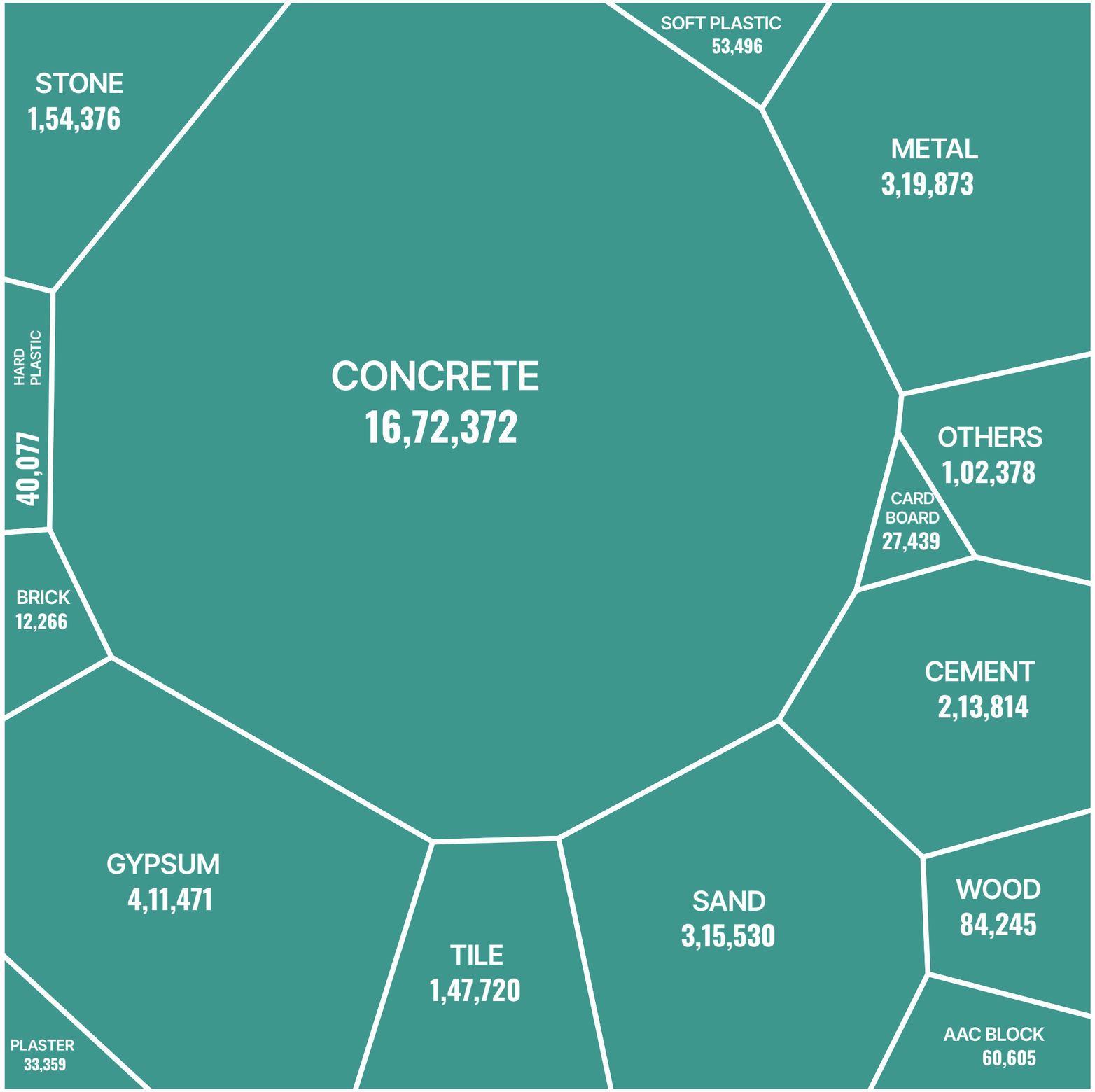
Site Measured approach has allowed us to understand construction waste material quantities and distribution for a typical mid-scale residential development using Mivan construction. These numbers may vary based on the materials used, and the level of waste reduction efforts employed during construction.

There is an immense scope to reduce waste generated during construction by using various methods including careful material selection at the design level, lean construction methods during execution, and recycling and reusing waste material post execution.

**36,48,900 kg**

**of construction waste is generated in a built-up area of 1 million square feet.**

* Using Mivan construction



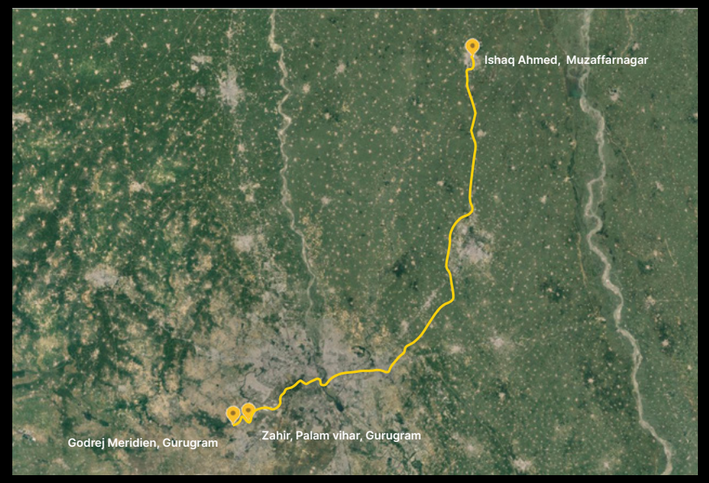
# Where does the waste go?

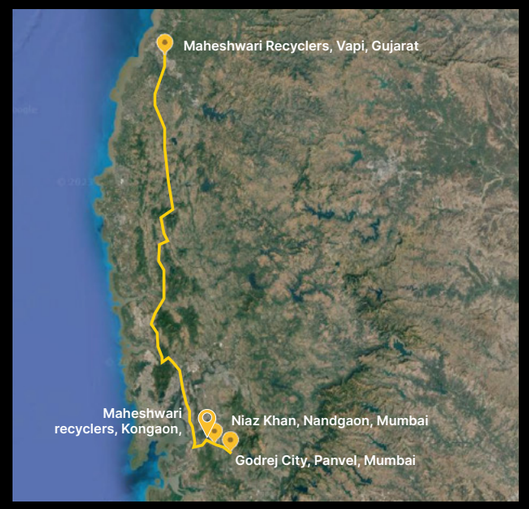
TRACING THE VALUE CHAIN OF

## Cardboard

Pune, 306.2 Km

NCR, 178.9 Km




Mumbai, 224.5 km

Bengaluru, 387 Km

**CONSTRUCTION SITE**

Rs 10-12/kg

**AGGREGATOR**

Rs 15-16/kg

**RECYCLER**

Rs 18-55/kg

For recycling, cardboard goes through shredding, pulping, screening, cleaning, bleaching and re-pulping to create a new cardboard material that can be used to make products like boxes, tubes, cups, file folders etc.

TRACING THE VALUE CHAIN OF

# Metal Containers

NCR, 32.4km

Mumbai, 87.9km

Hard Plastic

NCR, 39km

Pune, 80km

**CONSTRUCTION SITE**

Rs 25-35/kg

**AGGREGATOR**

Rs 40-60/kg

**RECYCLER**

Rs 70/kg

Metal containers are melted, refined and reformed into new products like cans,containers, foil, packaging, automotive parts, electronics etc.

TRACING THE VALUE CHAIN OF

# Steel

Bengaluru, 1024km

NCR, 397km

Pune, 320km

Mumbai, 40.4km

**CONSTRUCTION SITE**

Rs 22-60/kg

**AGGREGATOR**

Rs 35-65/kg

**RECYCLER**

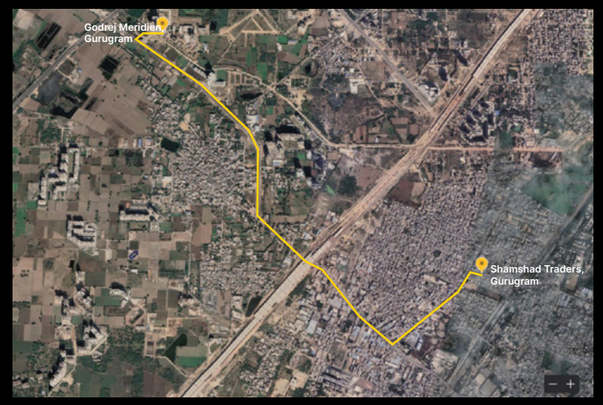
Rs 40-200/kg

After melting, refining, casting new Steel products are rolled into desired shapes like sheets, pipes, drums,appliances, automotive parts, railway tracks etc.

TRACING THE VALUE CHAIN OF

# Hard and Soft Plastic

PVC Pipe

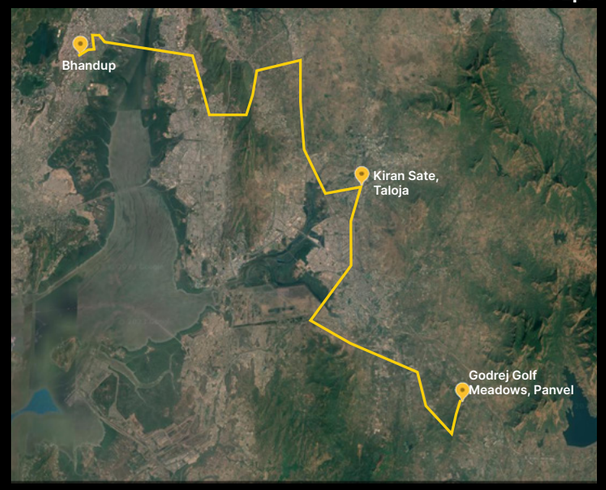



NCR, 3.5km

HDPE

Mumbai, 35km

PVC Pipe




Mumbai, 60km

PP Bag

Mumbai, 16km

**CONSTRUCTION SITE**

Rs 18-35/kg

**AGGREGATOR**

Rs 25-40/kg

**RECYCLER**

Rs 60-80/kg

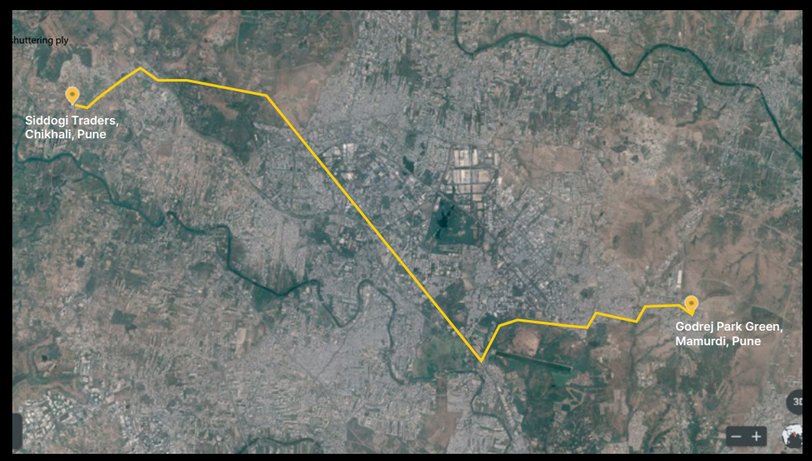
Hard and Soft plastic are melted and recycled into new products like Bottles, kitchenware, traffic cones, packaging material, trash bags, film and sheeting etc

TRACING THE VALUE CHAIN OF

# Wood

Shuttering Ply

NCR, 7km




Pune, 14.6km

**CONSTRUCTION SITE**

Rs 2-8/kg

**AGGREGATOR**

Rs 10-12/kg

TRACING THE VALUE CHAIN OF

# Aluminium

Alumnium Shuttering

NCR, 43km

Pune, 10km

**CONSTRUCTION SITE**

Rs 180-182/kg

**AGGREGATOR**

Rs 200-210/kg

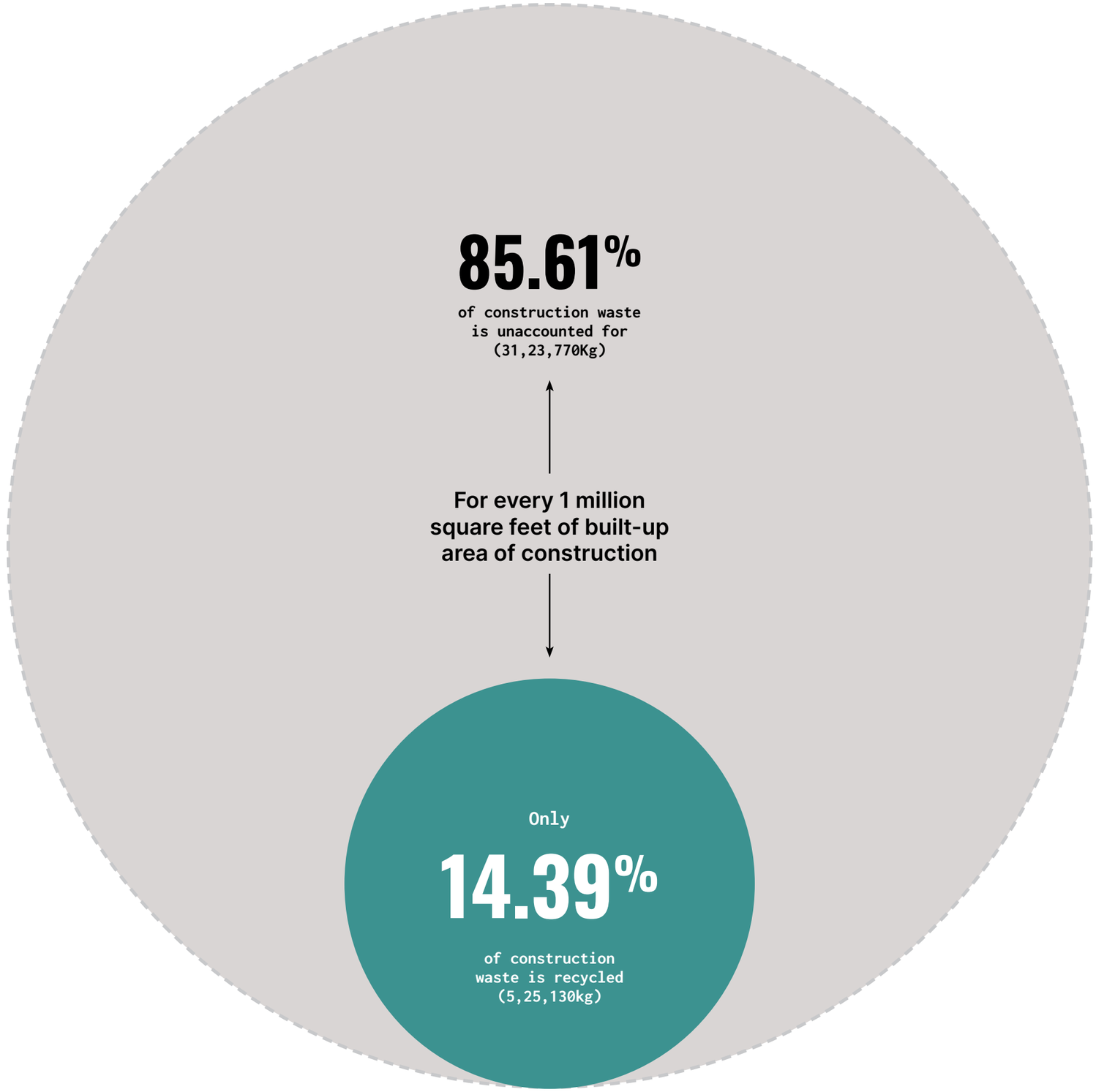
# How much of this waste is recycled?

For every million square feet of residential development, approximately 3,648 tonnes of construction waste is generated. Based on our assessment on site, only 14.39% (525 tonnes) of this waste is entering the recycling value chain. This includes materials such as metal, soft plastic, hard plastic, cardboard, and wood.

The remaining constituents of waste that amount to 85.61% (3,123 tonnes), most of which is concrete and gypsum, offer a tremendous opportunity for developing a suitable recycling ecosystem.

**3,648**

tonnes of construction waste is generated



# If trucks carried all the construction waste generated in building residential projects in India over the past decade, they will line up longer than our entire coastline.*

(or about one-fourth the length of the Earth's equator)

The responsibility of all stakeholders within the real estate sector goes beyond delivering buildings. The problem of construction waste needs commitment to urgent and effective action.

This handbook recommends practical steps and shares guidance for adoption of practices for developers to manage and control waste generated at their sites. We implore the sector to collectively pledge to a zero-waste approach to construction.

**25 MILLION**

tonnes of construction waste was generated in the past ten years*

*Authors' calculations based on data on Ready Supply of BuiltUp Residential Area of completed projects from PropEquity[28] (updated as of March 2023, covering 44 cities) and specifications of a loading truck used at a typical construction site. The above numeric values are approximations.

04

# Getting Started

IN THIS SECTION


How can developers get started? 109

Case for an On-site Material Recovery Facility 118

Operating models for construction waste management 126

# Collaborative and Co-ordinated Action to Manage Construction Waste

Addressing the challenges of Construction Waste (CW) management in India requires both incentive and disincentive mechanisms that can encourage the entire ecosystem to re-look at established processes, innovate and evolve. CW management plans need to be developed as a win-win scenarios for cities, real estate developers and contractors.

Key recommendations for stakeholders to collectively bring about change in addressing the sector's approach to construction waste

| | Waste Planning / Management | Production & Transportation | Reuse / Recycle / Processing | Disposal |
|---|---|---|---|---|
| **Central/ State Governments** | Mandate government project contractors to plan for and report on construction waste management<br>Institute wide range of policies and conduct regular consultations with regional stakeholders | Mandate full traceability and accountability for transporters of construction waste<br>Provide tax rebates for construction waste facilities | Mandate minimum use of a certain proportion of recycled materials<br>Review taxes on primary and recycled construction material and incentivize the latter | Strengthen surveillance and levy suitable stringent penalties on illegal dumping of waste<br>Raise cost of waste disposal to landfills<br>Institute differential pricing for disposal of inert and non-inert waste |
| **Urban Local Bodies** | Mandate allocation of a specified percentage of project site area for C&D waste storage/segregation as part of building design approval requirements | Designate appropriate C&D waste collection points<br>Facilitate door-to-door collection for a fee | Develop a system to manage the demand and supply of C&D waste<br>Set up recycling facilities within the city limits | Train waste management workers in efficient waste segregation techniques after disposal |
| **Thinktanks, Standard/ Regulatory setting institutes** | Develop awareness among industry players regarding use of construction waste in material production (eg: painted concrete in cement) | Develop reliable data collection techniques to accurately assess the quantity and type of construction waste<br>Promote research and knowledge sharing | Develop quality standard certification and protocols for use of recycled material for construction | Invest in research and development of environmentally sustainable techniques for disposal of non-recyclable waste |
| **Developers** | Assign a waste management team at each project site<br>Assess and incorporate the cost for construction waste management within project budgets<br>Initiate and promote collaboration to build industry standards for effective waste management | Leverage technology and management information systems to maintain and track data on production of waste | Process and treat the waste generated to reduce Scope 3 emissions<br>Reduce, reuse and recycle construction waste to improve profitability without compromising on quality | Divert waste away from landfills (improve ESG ratings) |

HOW CAN DEVELOPERS GET STARTED

# Setting up construction waste management in real estate companies

**Developers can set up systems and processes to manage construction waste at their sites by following four actionable steps outlined below:**

### 1 SETUP AN ASPECT-IMPACT REGISTER

Companies initiating work on their CW management plans would benefit from adopting a risk assessment and management approach. An aspect impact register for risks and opportunities will aid in setting up systems to address challenges at each stage of construction.

### 2 INSTITUTE CONSTRUCTION WASTE MANAGEMENT PLAN

A detailed Construction Waste Management Plan listing stage-wise requirements for both internal teams and external partners allows all teams to work towards a shared purpose.

### 3 BUILD AWARENESS AND CAPACITIES OF ALL TEAMS

Awareness and capacity building programs are essential to harness the collective potential of internal teams and external partners towards achieving goals.

### 4 UPDATE THE GCC TO INCLUDE WASTE MANAGEMENT MANDATE

Updating General Conditions of Contract (GCC) with a specific section addressing waste management is essential to provide a clear contractual framework for all parties.

HOW TO

# Setup an aspect-impact register

## SITE PREPARATION

EXCAVATION

| Aspects | Impacts | Control or Influence | Risks | Opportunities | Operation Control |
|---|---|---|---|---|---|
| » Vegetation clearance, fuel consumption, dust/air-borne substances/ pollutants generated<br>» Generation of debris, metal scrap, soil, and rock waste<br>» Noise generation | » Impact on habitats and species<br>» Natural resource depletion<br>» Breach of conditions of local noise limits<br>» Air pollution | » Awareness on suspected species / habitats<br>» Maximum EC compliances followed<br>» Regular maintenance of machinery, tools, and tackles for noise inspection<br>» Training and monitoring of waste collection, segregation, and disposal methods for the site workers, approved by National Green Tribunal (NGT) and Pollution Control Board (PCB).<br>» Ambient air and dust emission monitoring system<br>» Covering debris/soil with tarpaulin during transportation<br>» Anti-smog gun used for controlling PM level | » Increase in PM level due to soil/debris movement<br>» Health issues<br>» Disturbance to neighbourhoods<br>» Legal issue with residents and government authorities<br>» Delay in project deliverables and achievement of business goals<br>» Depletion of natural resources | » Secure certifications<br>» Strengthen contractors' agreement clauses for waste management<br>» Reinforce companies' sustainability polices<br>» Understand the value chain and create new business prospects with waste management | » Safety officers should ensure the training of waste collection, segregation, and storage as per guidelines to all safety officers and labourers<br>» Document controller should collect weekly data on waste generation and disposal<br>» Environment managers must establish protocol for waste handling and disposal<br>» Contract Officer should ensure inclusion of waste management guidelines in the contract<br>» Planning officer should ensure implementation of debris management plan<br>» Internal audits should be conducted quarterly |

HOW TO

# Setup an aspect-impact register

## CORE AND SHELL

FOUNDATION

| Aspects | Impacts | Control or Influence | Risks | Opportunities | Operation Control |
|---|---|---|---|---|---|
| » Cement, aggregate and sand consumption<br>» Fuel consumption<br>» Generation of debris<br>» Water consumption<br>» Consumption of wood, metal and adhesives<br>» Oil spillage<br>» Noise generation | » Impact on the health of construction workers due to lifting heavy weights, exposure to hazardous substances, noise, and vibration<br>» Land pollution<br>» Air pollution<br>» Noise pollution<br>» Natural resource depletion | » Using anti-smog gun to control PM level<br>» Following maximum EC compliances<br>» Implementing ambient air and dust emission monitoring system<br>» Providing a secondary containment tray while refilling/draining oil<br>» Regularly maintaining machinery, tools, and tackles for noise inspection<br>» Using boom placer instead of concrete pump, where applicable, to reduce noise and debris<br>» Covering debris/soil with tarpaulin during transportation<br>» Proposing curing compound instead of water sprinkling<br>» Using Ground Granulated Blast-furnace Slag (GGBS) and fly ash to reduce consumption of cement | » Increase in PM level<br>» Land contamination due to accumulation of debris<br>» Legal issue with residents and government authorities<br>» Health issues<br>» Depletion of natural resources | » Explore use of recycled components<br>» Explore alternate ways to reuse scraps<br>» Use concrete debris for backfilling<br>» Understand the value chain and create new business prospects with waste management<br>» Incorporate ‘zero waste to landfill” as a part of company’s brand promise | » Safety officers should ensure the training of the waste collection, segregation, and storage as per guidelines to other safety officers and labourers<br>» Document controller should collect data weekly for waste generation and disposal.<br>» Environment managers to establish protocol for waste handling and disposal.<br>» Contract Officer should ensure inclusion of waste management guidelines.<br>» Planning officer should ensure implementation of debris management plan.<br>» Internal Audits should be conducted quarterly. |

HOW TO

# Setup an aspect-impact register

## FINISHING

MEP WORKS

| Aspects | Impacts | Control or Influence | Risks | Opportunities | Operation Control |
|---|---|---|---|---|---|
| » Metal consumption<br>» Generation of electrical, hard plastic, soft plastic and metal waste<br>» Oil spillage<br>» Noise generation | » Impact on the health of construction workers due to lifting heavy weight, exposure to hazardous substances, noise, and vibration<br>» Waste accumulation<br>» Health hazards<br>» Noise pollution<br>» Natural resource depletion | » Following maximum EC compliances<br>» Implementing ambient air and & dust emission monitoring system<br>» Collecting, segregating, and appropriately storing the waste generated<br>» Using appropriate, certified and approved equipment<br>» Covering debris/soil with tarpaulin during transportation<br>» Using electric equipment that can reduce depletion of natural resources<br>» Disposing the waste generated through authorized vendors | » Land contamination<br>» HVAC installation leading to gas leakage causing air pollution<br>» Delay in project deliverables and achievement of business goals | » Reduce cost by using recycled materials<br>» Reduce cost by reusing waste on site<br>» Understand the value chain and create new business prospects with waste management<br>» Incorporate ‘zero waste to landfill” as a part of company’s brand promise | » Safety officers should ensure the training of the waste collection, segregation, and storage as per guidelines to other safety officers and labourers.<br>» Document controller should collect data weekly for waste generation and disposal.<br>» Environment managers to establish protocol for waste handling and disposal.<br>» Contract Officer should ensure inclusion of waste management guidelines.<br>» Planning officer should ensure implementation of debris management plan.<br>» Internal Audits should be conducted quarterly. |

HOW TO

# Institute a Construction Waste Management Plan

## Onset of Construction activity

- ☐ As part of compliance, submit a construction waste generation and management plan and apply for authorization letter from the State Pollution Control Board (SPCB)
- ☐ As best practice, setup a dedicated Material Recovery Facility (MRF) space at the construction site
- ☐ For efficient management, every site to have a clear accountability for construction waste management There are various models through which this can be done. Between the developer, contractor and any assigned third-party vendor.

## During Construction activity

### PROJECT OPERATIONS TEAM

- ☐ Assess construction waste by categories and quantum
- ☐ Ensure provision and creation construction of Material Recovery Facility (MRF)
- ☐ Ensure no waste is mixed, dumped on site, or taken out of site without approval
- ☐ Ensure that hazardous and other non-recyclable waste is handled as per local and central guidelines

### PROJECT ENVIRONMENT MANAGER

- ☐ Ensure all contractors understand and adhere to assigned construction waste management responsibilities and assist as required
- ☐ Submit monthly reports on a centralized MIS to allow developers to analyse data across portfolios for insights and action
- ☐ Ensure overall monitoring, quality assurance and compliance
- ☐ Monitor, audit and sign off on weekly reports from MRF supervisor/contractors.
- ☐ Conduct knowledge workshops, best practices training and capacity building of site team, contractors, workers and other stakeholders.

### PROJECT LIAISON MANAGER

- ☐ Report any case of on-site incidents to SPCB
- ☐ Submit Annual Report to SPCB demonstrating reduction in waste

### MRF FACILITY IN-CHARGE

- ☐ Survey the market for available recyclers
- ☐ Ensure aggregation, sorting and storage of waste at MRF
- ☐ Create inventory of waste aggregates and document the same
- ☐ Connect with the vendors and recyclers to confirm pick up frequency

### CONTRACTOR & THEIR STAFF

- ☐ Collect and segregate waste generated at-source including concrete, soil, debris, plastic, paper, metal, cardboard, tile, and others. (Refer to annexure 1 for waste types)
- ☐ Transport all waste from site to MRF as guided by project plan. Maintain detailed record of waste deposited
- ☐ Regular transfer of waste from site for disposal or recycling must happen for proper utilization of MRF space and avoid pile up/ backlogs
- ☐ Maintain certificate of transport, disposal, or recycling along with appropriate documentation and proof for traceability and accounting

## Post Construction activity

- ☐ Contractor to ensure and sign-off clearance of the site and MRF.
- ☐ Developer to ensure not more than 10% waste is sent to landfill sites or any authorized place for final disposal.

# Case for an On-site Material Recovery Facility

**What is an MRF?**

A Material Recovery Facility (MRF) is a specialized facility used in waste management to sort and process mixed waste materials. An MRF for construction waste uses mechanical and manual processes to separate recyclable materials from non-recyclable ones.

An MRF typically receives mixed waste materials, such as cement, plaster, gypsum, wood, metals, plastics etc. generated during construction activities. The waste is then sorted, processed, and shipped to be recycled into new products or materials that can be reused in construction or other industries.

The sorting process in an MRF typically involves a series of conveyor belts, screens, and other equipment that separate materials based on their size, weight, density, and composition. Workers may also manually sort through the waste to remove any contaminants or hazardous materials.

Once the materials are sorted and separated, they are sent to various recycling facilities or reused in construction projects. What is key to note is that an MRF at a construction site can significantly help to reduce the amount of construction waste that is sent to landfill by ensuring source segregation that is the first step towards recycling and reuse of materials.

**How to set up an MRF at construction sites**

A typical residential construction project of 1 million square feet typically that takes 3 and half years to deliver with the quantum of waste generated becoming significant at core and shell and peaking during finishing stage. To best rationalize costs, an MRF can be built on site once the core and shell stage of construction starts.

Our research has helped determine the quantity and percentage of waste by material allowing us to recommend a modular system to accommodate each waste stream. The sizes provided below have been allocated to accommodate the maximum amount of any waste material generated at site. We believe that modular space planning may provide greater flexibility in terms of adapting to changing waste streams, site conditions, or operational requirements.

A Material Recovery Facility at Bhubaneshwar, Odisha

To further optimize costs, we recommend building the MRF with three components to address key waste types.

**Bulk inert waste - Semi open space with a roof accessible from all sides**

Bulk inert construction waste refers to large quantities of non-hazardous waste materials that do not decompose or biodegrade over time. These materials are generally composed of inert, non-reactive substances that are considered stable and environmentally safe and are not likely to pose a risk to human health or the environment. These include plaster, sand, gypsum, stones, tiles, and ceramics. These materials are typically collected and transported out of site in large quantities. The semi open nature of the facility helps in parking and loading trucks with ease.

**High value waste - covered space with roof with one entry point**

High-value waste materials, such as Steel reinforcements, GI, copper, aluminium, and other metal are best segregated in an enclosed fully covered and secured space. These waste materials are often targeted by thieves or vandals and securing these materials locked in a secure MRF reduces the risk of theft or damage.

**Remaining waste materials - covered space with one entry point**

Removing bulk inert and high value metal waste leaves us with all residual waste categories including hard and soft plastic, cardboard etc. This waste can be secured in a covered space will one entry points and a dedicated space within for hazardous substances that could be flammable, explosive or decompose and release harmful gases/ toxins over time. These include asbestos, lead-based paints, chemical solvents, batteries, fluorescent bulbs, pesticides, oils, etc. These materials require special handling and disposal procedures to prevent contamination and minimize the risk of exposure to workers and the public.

Concrete is not included in the MRF as it does not need further sorting. Concrete waste is best thrown down the refuse chute, and once the pile on the ground is big enough, it can be directly loaded in trucks and transported out of site for further processing.

**Deriving the capacity and configuration of an MRF serving 1 Mn SFT**

The total waste generated in a 1 Mn sft development using our estimate of 3.64 sft /sft of built area translates to 3640 tonnes over 3.5 years i.e., 2.85 tonnes a day giving us the required capacity.

Material segregated in the MRF needs to be transported out of the site for further recycling necessitating constant use of loading vehicles. The space planning module is predicated on the size of a typical loading vehicle together with circulation space giving us a typical bay size = 2.5m x 5m

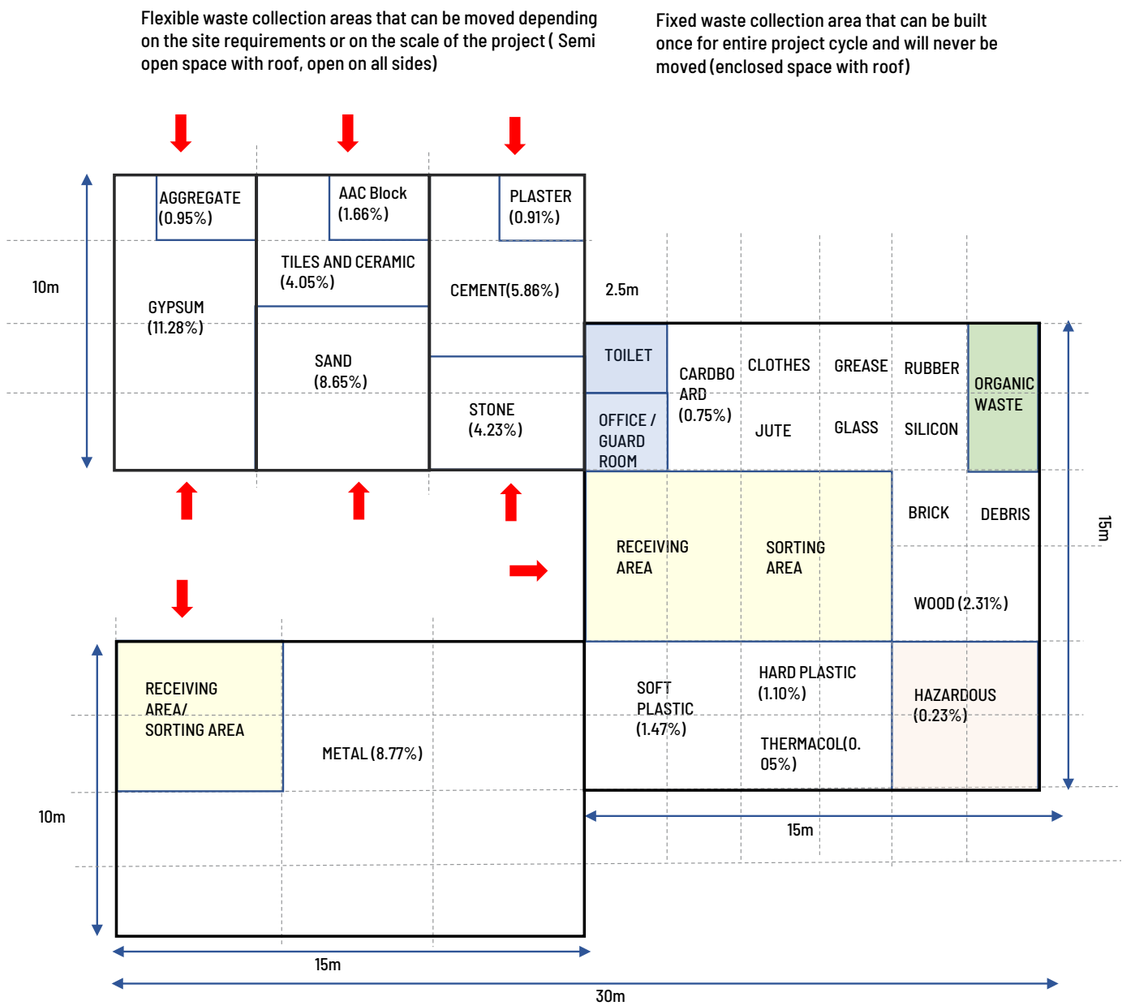
**The indicative costing of such a structure is INR 7.66 Lakhs with the assumptions below:**

### COVERED SPACE WITH ROOF

(15 × 15m and 15 × 10m) at INR 150/Sqft = INR 6,05,475

### SEMI OPEN SPACE WITH ROOF

(15×10m) at INR 100/Sqft = INR 1,61,460






### TOTAL REVENUE GENERATED FROM A MRF (INR)

**55.58** LAKHS

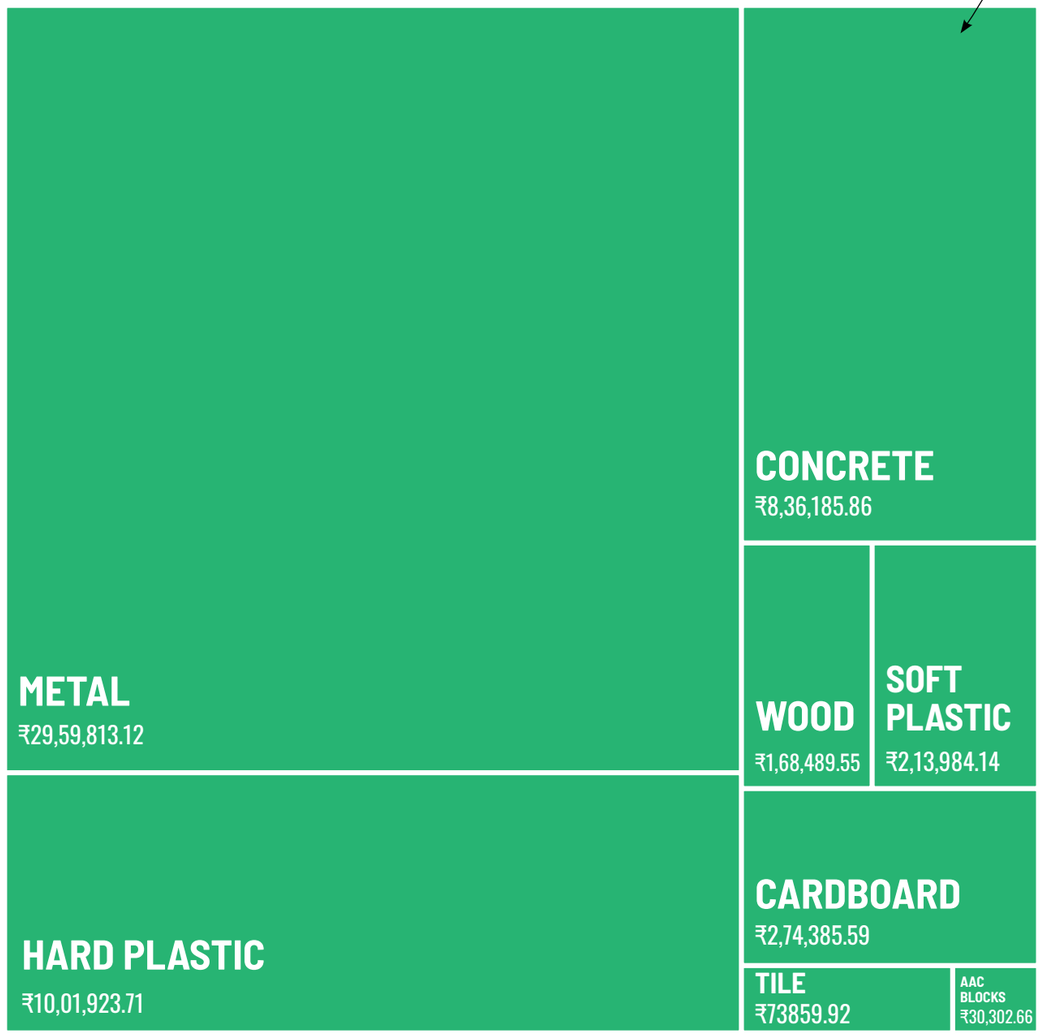
Note: The potential revenue generated will increase if we add reinforcement steel and Aluminium shuttering. However, in GPL and MLDL the waste from reinforcement steel and aluminium shuttering is in their respective vendors scope and hence we have not added it here.

### COST OF BUILDING A MRF (INR)

**7.66** LAKHS

The cost of constructing an MRF breaks even within the revenue generated from recycling Concrete

**Total revenue generated from recycling materials using an MRF**



HOW TO

# Build awareness and capacities of internal teams and external partners

Project Environment Manager, under supervision and monitoring of the Operations Head, will lead Construction Waste Management (CWM) trainings for site teams, Project Management Consultants (PMCs), contractors and workers.

| FOR PROJECT TEAMS | FOR PROJECT MANAGEMENT CONSULTANTS (PMC) & CONTRACTORS' WORKFORCE |
|---|---|
| ☐ Initiate CWM training for all site employees at the time of their joining and ensure consistent (minimum half yearly) refresher training | ☐ Ensure PMC and contractors' staff deployed at the site are provided necessary training<br>☐ Identify training needs based on<br>☐ Past investigations: Investigations of past incidents where waste was not segregated properly<br>☐ Observations of workforce behaviour<br>☐ Upcoming activities: nature of construction activities to be carrier out at the project site<br>☐ CWM updates: points highlighted in previous month's CWM updates and audit summary<br>☐ CWM campaigns: recommended CWM campaigns or other awareness programs<br>☐ Internal demand: any training needs identified by senior management or individual functions<br>☐ Change management: introduction of new process, equipment, machinery, or group of workmen<br>☐ General awareness: general CWM topics such as Policy and Regulations |
| ☐ Ensure monthly updates on waste generation based on construction progress | ☐ Prepare a monthly training calendar and get it signed off by the Operations Head |
| ☐ Furnish all required data related to CWM | |
| ☐ Assess and record training effectiveness at various levels through feedback from the participants at the end of each training session | |
| ☐ Review and analyse the feedback provided by the participants to improve training quality with focus on reaching all stakeholders, including non-native speakers via multilingual or pictorial communication | |

**Additionally contractors must be responsible for:**

Preparing and submitting a monthly training calendar to PMC safety in- charge for consolidation. PMC will provide it to Project Manager (PM) for monitoring.

Including CWM mandates in induction training and toolbox talk with their workers

HOW TO

# Update the GCC to include waste management mandate

The general conditions of contract (GCC) require a specific section to address waste management plans and related reporting mechanisms. In case waste management is referenced in any other clause or section, it is better referenced back to the waste management section.

Key aspects include:

1. Contractors, subcontractors, and their employees are responsible for the proper collection, handling, and storage of waste generated during construction and/or demolition.
2. As generator of waste the contractor shall prepare, execute, and maintain all licenses, registrations, approvals, authorizations, notices, shipping documents, and waste documentation required under local Law.
3. All waste disposed should be recorded (weight and end location) and gate passes, invoice/receipts should be maintained.
4. Debris disposal should be done according to local laws.
5. The contractor shall be responsible to secure all required approvals for waste disposal from the local authority before commencement of construction.
6. Construction waste to be kept within the site premises in segregated form as directed in the Material Recovery Facility (MRF) plan.
7. The generation, collection, storage, handling, transportation of all CWM waste including hazardous materials to the MRF, or designated collection sites should be in line with the project plan.
8. Only concrete to be disposed of through refuse chute exclusively to avoid mixing of waste.
9. Sand, gypsum and tile and stone waste to be segregated, filled in PP bags and brought to the designated stacking area (in MRF) using a service lift.
10. Half an hour to be dedicated in housekeeping in which segregation of each category of waste to be done and stored separately.
11. Weekly submission of waste generated, stored, and disposed should be submitted by Tuesday of every week (day range to be specified eg. Monday to Saturday each week).
12. Photo documentation of waste collected and disposed to be shared weekly.
13. Contractors to ensure all the outgoing waste to be quantified and documentation proof of the same to be submitted.
14. Contractors should ensure suitable site induction, information, and training of personnel to ensure that the plan is implemented. This is in compliance with "Construction and Demolition Waste Management rules" sub-rule (10) stating waste generators shall create a sustained system of information, education and communication (IEC) for construction and demolition waste through collaboration with expert institutions and civil societies and also disseminate through their own website.
15. Contractor should ensure that the full requirements of the site waste management plan are included in sub-contracts.

HOW TO

# Update the GCC to include waste management mandate

16. Within 15 (fifteen) days of the Notice to Proceed and in any case before commencement of major activities, the Contractor shall submit Debris Disposal/ Management Plan showing proposed locations at site for disposing debris generated at the site in line with the “Waste Management Section”.

17. Proper housekeeping shall be considered as a mandatory requirement. The Contractor shall be required to maintain the Site, Works and surroundings in a neat and orderly manner, free of accumulating debris, haphazard stacking of materials, unhygienic and unsafe environment, cleaning of the Site at all levels inside and outside, removal of unwanted materials, packing cases etc., shall be undertaken at least once on a daily basis. For the purpose of collecting debris, the Contractor shall provide at required locations as approved by the Company, debris chutes at his own Cost. The Contractor shall promptly inform the Company in the event that any other Contractors on the Site cause debris, etc. on the Site and Company will direct the other Contractors to remove the debris, etc. from the Site. The Contractor shall nominate the safety officer to be responsible for the housekeeping. Unwanted material and debris shall be carted away from the Site and disposed off, on a daily basis in accordance with the “Waste Management Section”.

18. The Contractor shall at all times during the Work ensure that from the moment the waste comes out from the internal working area to the external area at ground level via the chute/lift/other, it must then be taken to the MRF daily. Contractor must keep the site and premises, adjoining property and public property free from accumulations of waste materials, rubbish and other debris resulting from the Works and at the completion of the Work in compliance with “Construction and Demolition Waste Management Rules, 2016” as notified by Ministry of Environment, Forest and Climate Change. The Contractor shall periodically remove all waste materials, rubbish and debris from the site and premises and dispose at the designated location. The Contractor shall demobilize construction equipment, machinery, surplus materials, tools and shall leave the site not designated for alteration by the Contract Documents. Paved walkways, parking areas and roadways shall be swept and broom clean. Cleaning up operations shall include the removal and disposal of earth that is contaminated and the filling of resulting excavations with sound compacted earth as directed and approved by the Company. No waste material shall be buried or disposed off on the Company’s property unless so approved in writing by the Company.

19. The Contractor shall indemnify the Company and keep it indemnified for such a period as appropriate according to tax laws against any defaults on his part, such as but not limited to a delay or denial of amount of credit, refund of GST or any other benefit to the Company or any penal charge imposed on the Company under GST Laws, failure to upload the returns, incorrect disclosure of details on the GSTN portal, delay/failure to deposit tax, due to furnishing of incorrect/ incomplete documents by the Contractor or non-furnishing of the same and wrong determination of nature of supply. Further, the Company reserves the right to recover at its sole discretion such amounts from the Contractor by way of deduction from subsequent payments or from the performance Deposits or any other amount due to the Contractor. Alternatively, the Company shall also be entitled to withhold the payments of all the subsequent bills issued by the Contractor at its sole discretion. All the liabilities with regard to such default such as additional tax, penalty, interest, loss, damages, expenses and Costs shall remain with the Contractor till the expiry of the above-mentioned period.

    The Contractor shall indemnify and keep the Company indemnified in case of any penalty imposed by any competent authority due to non-compliance with the regulations for “Construction and Demolition Waste Management rules”.

20. The Contractor shall record, collate and share with the developer, project specific data monthly, including environmental metrics for his area of work to the Company in the first week of subsequent month. The data required includes but is not limited to the following:

    - Energy sources and consumption
    - Energy reduction initiatives and quantity
    - Renewable energy interventions by type and energy consumption
    - Water sources and consumption
    - Water capture, recycling, and reuse in-situ
    - Waste produced on site by type and quantity
    - Waste removed from site by type, quantity and disposal method
    - Ambient air emissions on at least a half yearly basis
    - Air emission tests for DG sets on at least a half yearly basis
    - Material use by type and weight

# Suggested operating models for construction waste management

Given their internal organization structures, scale of operations and growth plans, developers can adopt any one of the following three suggested models to operationalize their construction waste management plan.

### MODEL 1

Involves a comprehensive CWM plan led and implemented by the developer with total accountability of waste generated on-site. This includes identifying location and setting up a Material Recovery Facility (MRF) with a dedicated CWM team.

The responsibility of training and awareness of the team will also be with the developer. In this model the total cost of disposal as well as all proceeds from sale of waste accrue to the developer.

### MODEL 2

In this model the accountability of construction waste, construction of MRF and training on-site workers will be contractor's responsibility. Providing space for MRF on site as per proposed layout plan, training and awareness of the developer's team and project management team will be under developer's purview. The revenue generated from the sale of waste will go to the contractor.

### MODEL 3

Involves a combined approach where the developer is accountable for construction waste from free issue material and contractor for the rest of the materials that are not free issue.

The developer will be responsible for demarcating a site for MRF and hiring dedicated staff and conducting training and awareness sessions for them to manage waste.

The responsibility of source separation of waste, training and awareness of on-site workers and revenue generated will be jointly shared by both the contractor and developer.

Table

**Roles and responsibilities of each party**

| Types of Operating Waste management Model | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Ownership of waste | Developer | Contractor | Developer – for only free issue material like steel & cement<br><br>Contractor – other material |
| Project staff | Deployed by Developer | Deployed by Contractor | Deployed by Developer |
| MRF in - charge | To be deployed by Developer | To be deployed by Contractor | Can be deployed by Contractor |
| MRF site | To be given by / demarcated by developer | To be given by / demarcated by developer | To be given by / demarcated by developer |
| MRF Construction | To be developed by developer | To be developed by contractor | To be developed by developer or contractor |
| Training & awareness session to developers' employees | By Developer | By Developer | By Developer |
| Training & awareness session to Project Management Team | By Developer | By Developer | By Developer |
| Training & awareness session to workers | By Developer | By Contractor | Both |
| Responsibility of source separation | By Developer | By Contractor | By Developer/ By Contractor |
| Revenue from sale of waste | Developer | Contractor | Have to agree upon on split percentage as usually high value/ high market rate flux material is sourced directly by the developer |

# A change in perspective

When it comes to greenhouse gas emissions, the aviation sector draws a lot of attention, even though energy use and emissions from the construction sector are much higher. With the world rapidly urbanizing, the building construction sector will continue to generate more waste which will compound the climate change problem further unless we take a serious view to mitigate the problem.

Waste matters and the matter of waste could easily be turned into a recycling opportunity for a sustainable future.

**37%**

of $CO_2$ emissions arise from construction related activities[29]

**3%**

of $CO_2$ emissions arise from aviation[30]

# Endnotes


1. United Nations. (n.d.). *Day of 8 Billion | United Nations*. Accessed from: https://www.un.org/en/dayof8billion

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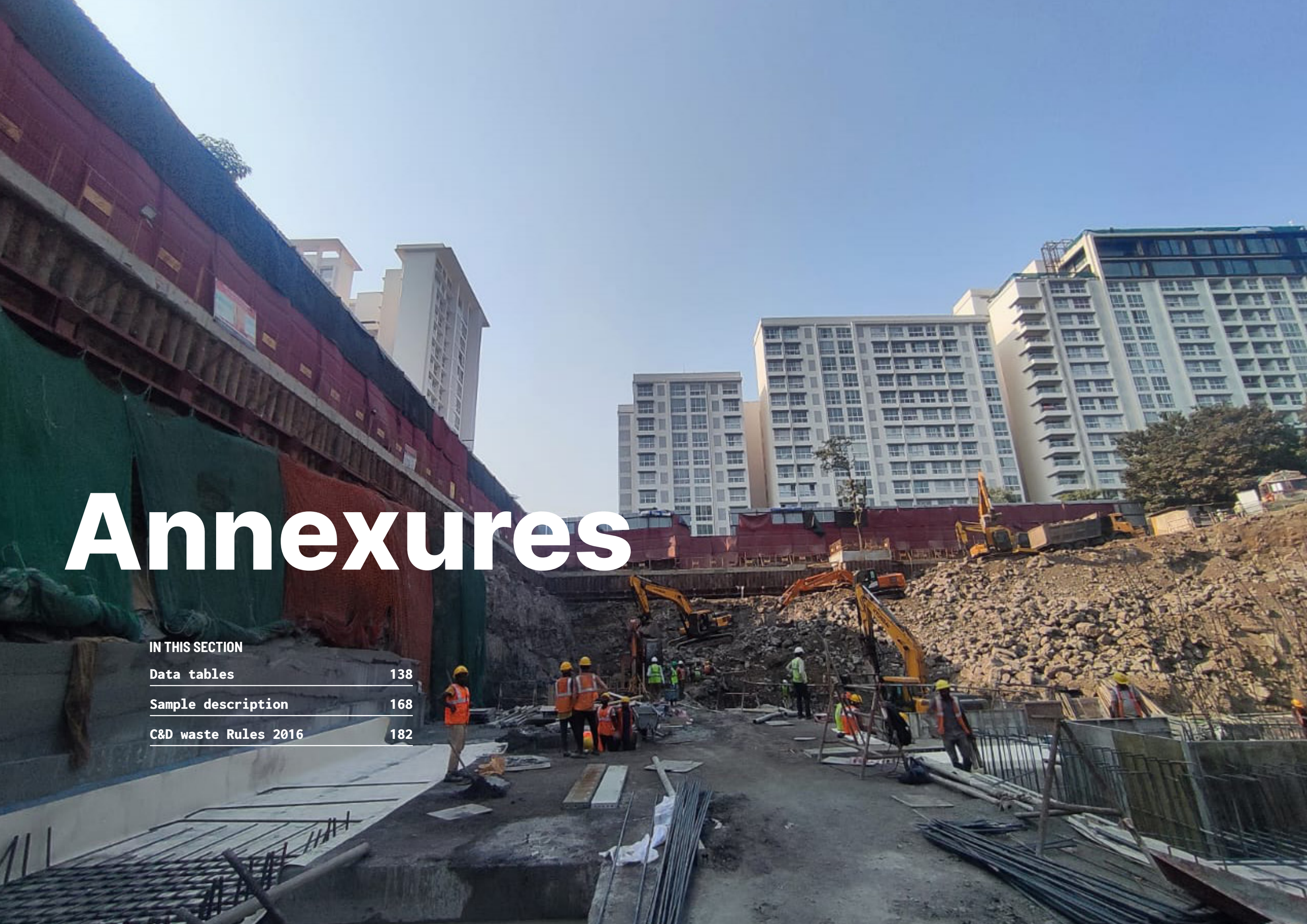

# Annexures

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# Data tables

Table 1

**C&D waste estimates for India**

| YEAR | AUTHORITY/INSTITUTE | ESTIMATE (MILLION TONNES) |
|---|---|---|
| 2000 | Ministry of Urban Development | 10–12 |
| 2001 | Technology Information, Forecasting and Assessment Council, Department of Science and Technology | 12–15 |
| 2010 | Ministry of Environment and Forest | 10–12 |
| 2013 | Centre for Science and Environment | 530 |
| 2014 | Ministry of Urban Development | No estimates |
| 2015 | Ministry of Urban Development | 10–12 |
| 2015 | Development Alternative and GIZ | 750 |
| 2016 | Ministry of Environment, Forest and Climate Change | 530 |
| 2017 | Building Material and Technology Promotion Council | 130 |

Source: Another brick off the wall' by Centre for Science and Environment (CSE), 2020.

Table 2

**The quantum of waste generated in a residential construction project in India**

| X KG/SQFT | SITE PREPARATION | | CORE AND SHELL | | FINISHING | | FINAL | |
|---|---|---|---|---|---|---|---|---|
| TRADITIONAL CONSTRUCTION | 0.06 | 1% | 1.85 | 44% | 2.33 | 55% | 4.25 | 100% |
| MIVAN CONSTRUCTION | 0.18 | 4% | 1.55 | 43% | 1.91 | 53% | 3.64 | 100% |

Table 3

**List of project sites by region, areas, towers and number of units**

| Project Name | Site Area (acres) | Site Area (sqft) | Built up area (sqft) | No. of Towers | No. of Units |
|---|---|---|---|---|---|
| NCR | | | | | |
| Godrej Meridien | 14.79 | 644383.08 | 2008116 | 7 | 754 |
| Godrej Nature Plus | 18.74 | 816314.40 | 2260582 | 12 | 1094 |
| MUMBAI | | | | | |
| Godrej Golf Meadows | 3.77 | 164221.20 | 677759 | 2 | 536 |
| Godrej Nirvaan | 8.01 | 349047.00 | 1124229 | 6 | 1176 |
| Godrej Emerald | 6.29 | 273992.40 | 1880000 | 7 | 1279 |
| BENGALURU | | | | | |
| Godrej Nurture | 5.91 | 257439.60 | 983517 | 7 | 684 |
| Godrej Ananda | 20.33 | 885574.80 | 1029317 | 3 | 806 |
| Godrej Royale Woods | 13 | 566280.00 | 1319439 | 6 | 1178 |
| Mahindra Eden | 7.75 | 337590.00 | 1053000 | 4 | 527 |
| PUNE | | | | | |
| Godrej Nurture | 16.9 | 736164.00 | 1087552 | 5 | 714 |
| Godrej Park Greens | 8.13 | 354142.80 | 3145795 | 7 | 1190 |
| Mahindra Happinest | 6.91 | 300999.60 | 517845 | 4 | 692 |
| Godrej Hillside | 4.3 | 187308.00 | 442885 | 3 | 588 |
| Godrej Park Springs | 4.9 | 213444.00 | 741000 | 4 | 752 |
| TOTAL | 139.73 | 6086900.88 | 18271036 | 77 | 11970 |

Table 4

**Stage-wise waste generation pan India for Mivan construction projects**

| CONSTRUCTION STAGE | | | AVERAGE | PERCENTAGE |
|---|---|---|---|---|
| 1 | A1 | Site Survey | 0 | 0.000 |
| 2 | A2 | Barricading | 0.0434 | 1.189 |
| 3 | A3 | Land Clearance | 0.0014 | 0.038 |
| 4 | A4 | Piling | 0.139 | 3.809 |
| 5 | A5 | Shoring works | 0 | 0.000 |
| 6 | A6 | Excavation | 0 | 0.000 |
| 7 | A7 | Transportation | 0 | 0.000 |
| **SITE PREPARATION TOTAL** | | | 0.1839 | 4% |
| 8 | B1 | Foundation | 0.0043 | 0.118 |
| 9 | B2 | Reinforcement | 0.1904 | 5.218 |
| 10 | B3 | Shuttering | 0.082 | 2.247 |
| 11 | B4 | Greasing | 0.0257 | 0.704 |
| 12 | B5 | Concreting | 0.8979 | 24.607 |
| 13 | B6 | Curing | 0.3005 | 8.235 |
| 14 | B7 | Blockwork | 0.0457 | 1.252 |
| 15 | B8 | Conduiting | 0.0036 | 0.099 |
| **CORE AND SHELL TOTAL** | | | 1.5500 | 43% |
| 16 | C1 | Plastering | 0.0261 | 0.715 |
| 17 | C2 | Gypsum Plaster | 0.427 | 11.702 |
| 18 | C3 | Water proofing | 0.0889 | 2.436 |
| 19 | C4 | Interior Civil work | 0.7435 | 20.376 |
| 20 | C5 | MEP | 0.0273 | 0.748 |
| 21 | C6 | DG | 0 | 0.000 |
| 22 | C7 | Façade | 0.0036 | 0.099 |
| 23 | C8 | Painting | 0.0171 | 0.469 |
| 24 | C9 | Landscaping | 0.0333 | 0.913 |
| 25 | C10 | Infrastructure | 0.2912 | 7.980 |
| 26 | C11 | Handover | 0.0221 | 0.606 |
| 27 | C12 | Site Office demobilization | 0.2349 | 6.438 |
| **FINISHING TOTAL** | | | 1.9642 | 53% |
| **TOTAL (kg/sqft)** | | | **3.6489** | **100%** |

Table 5

**The Composition of waste generated across material, as measured by Developer**

| RANK | CORE MATERIAL | SITE MEASURED VALUE (KG/SFT) | % COMPOSITION |
|---|---|---|---|
| 1 | Concrete | 1.672372 | 45.83% |
| 2 | Gypsum | 0.411471 | 11.28% |
| 3 | Metal | 0.319873 | 8.77% |
| 4 | Sand | 0.315530 | 8.65% |
| 5 | Cement | 0.213814 | 5.86% |
| 6 | Stone | 0.154376 | 4.23% |
| 7 | Tile | 0.147720 | 4.05% |
| 8 | Wood | 0.084245 | 2.31% |
| 9 | AAC Block | 0.060605 | 1.66% |
| 10 | Soft plastic | 0.053496 | 1.47% |
| 11 | Hard Plastic | 0.040077 | 1.10% |
| 12 | Aggregates | 0.034676 | 0.95% |
| 13 | Plaster | 0.033359 | 0.91% |
| 14 | Cardboard | 0.027439 | 0.75% |
| 15 | Debris | 0.024891 | 0.68% |
| 16 | Grease | 0.022908 | 0.63% |
| 17 | Brick | 0.012266 | 0.34% |
| 18 | Paints & Solvent | 0.007465 | 0.20% |
| 19 | Glass | 0.005296 | 0.15% |
| 20 | Rubber | 0.003747 | 0.10% |
| 21 | Thermocol | 0.001665 | 0.05% |
| 22 | Adhesive | 0.000902 | 0.02% |
| 23 | Jute | 0.000589 | 0.02% |
| 24 | Oil | 0.000112 | 0.00% |
| 25 | clothes | 0.000127 | 0.00% |
| 26 | Silicon | 0.000000 | 0.00% |
| 27 | Electrical cable & Panel | 0.000000 | 0.00% |
| 28 | Air filter | 0.000000 | 0.00% |
| 29 | Halogen lamp | 0.000000 | 0.00% |
| | TOTAL | 3.649021 | 100% |

Table 6

**List of core and sub materials by Recyclable (R), Non-Recyclable (NR) material**

| CORE AND SUB MATERIAL | TYPE OF WASTE | R / NR |
|---|---|---|
| METAL | | |
| Shuttering | Construction | R |
| Nail | Construction | R |
| Screw | Construction | R |
| Nut | Construction | R |
| Bolt | Construction | R |
| Metal Pipe | Construction | R |
| Binding Wire | Construction | R |
| Aluminium Section | Construction | R |
| ISMC | Construction | R |
| ISMB | Construction | R |
| Steel Rod | Construction | R |
| Steel pipe | Construction | R |
| Steel Stub | Construction | R |
| Cutting Blade | Construction | R |
| Grinding Wheel | Construction | R |
| Metal Box | Construction | R |
| Metal Coin | Construction | R |
| Roller | Construction | R |
| GI Sheet | Construction | R |
| Shutter | Construction | R |
| Trowel | Construction | R |
| Metal Float | Construction | R |
| Metal Blade | Construction | R |
| Metal Plate | Construction | R |
| Wall Tie Cover | Construction | R |
| Pin Patti | Construction | R |
| Brush | Construction | R |
| Cube Mold | Construction | R |
| Plum Bob | Construction | R |
| Jack | Construction | R |
| Panel Puller | Construction | R |
| Polish Wheel | Construction | R |
| Metal Can | Construction | R |
| Nahani Trap | Construction | R |
| Diverter Valve | Construction | R |
| Earthing Strip | Construction | R |
| Fastener | Construction | R |

| CORE AND SUB MATERIAL | TYPE OF WASTE | R / NR |
|---|---|---|
| Railing | Construction | R |
| Universal clamp | Construction | R |
| Flang | Construction | R |
| GI pipe | Construction | R |
| TMT Steel Bar | Construction | R |
| Paint Container | Packaging | R |
| Solvent Container | Packaging | R |
| Packing Shim | Packaging | R |
| HARD PLASTIC | | |
| Helmet | Safety | R |
| PVC Container | Construction | R |
| Adhesive Bottle | Construction | R |
| Pet Bottle | Construction | R |
| PVC Pipe | Construction | R |
| CPVC Pipe | Construction | R |
| UPVC Pipe | Construction | R |
| DWC Pipe | Construction | R |
| HDPE Pipe | Construction | R |
| Gum Boot | Safety | R |
| Paint Container | Construction | R |
| HDPE Bucket | Construction | R |
| Brush | Construction | NR |
| Tile Spacers | Construction | NR |
| WOOD | | |
| Utility Pole | Construction | R |
| Wooden Shuttering | Construction | R |
| Wooden Tool | Construction | R |
| Pole | Construction | R |
| Wood Chip | Construction | R |
| Wooden Drum | Construction | R |
| Wooden Panel | Construction | R |
| Ply | Construction | R |
| Wood Packaging | Packaging | R |
| SOFT PLASTIC | | |
| PP Bag | Packaging | R |
| Packaging Plastic | Packaging | R |
| Foam Sheet | Construction | R |
| Cello Tape | Construction | NR |



| CORE AND SUB MATERIAL | TYPE OF WASTE | R / NR |
|---|---|---|
| Deckweb | Construction | R |
| Plastic Sheet | Construction | R |
| Grow Bag | Packaging | R |
| Flute Board | Construction | R |
| Gloves | Safety | R |
| Polyurethane Material | Construction | R |
| Rope | Safety | R |
| HDPE Pre Bond Sheet | Construction | R |
| Safety Jacket | Safety | R |
| Wrap Film Roll | Packaging | R |
| CONCRETE | | |
| PCC Bed | Construction | NR |
| RCC | Construction | NR |
| Concrete Pole | Construction | NR |
| Fly Ash Chipping | Construction | NR |
| RMC Debris | Construction | NR |
| Debris | Construction | NR |
| RCC Precast Boundary | Construction | NR |
| RCC Hume Pipe | Construction | NR |
| RMP | Construction | NR |
| Micro Concrete | Construction | NR |
| NATURAL | | |
| Tree | Construction | R |
| Bush | Construction | R |
| Horticulture Waste | Construction | R |
| CARDBOARD/PAPER | | |
| Cardboard Box | Packaging | R |
| Sand Paper | Construction | R |
| Tape Base | Construction | R |
| Cardboard Roll | Packaging | R |
| Paper | Packaging | R |
| BRICK | | |
| Brick Bed | Construction | NR |
| Broken Brick Chip | Construction | NR |
| Fly Ash Brick | Construction | NR |
| CLOTHES | | |
| Rug | Construction | NR |
| Safety belt | Safety | R |
| Dori | Safety | NR |

| CORE AND SUB MATERIAL | TYPE OF WASTE | R / NR |
|---|---|---|
| STONES | | |
| Stone | Construction | NR |
| Granite | Construction | NR |
| Kadappa | Construction | NR |
| ADHESIVES/OIL/SEALANT | | |
| Engine oil | Construction | NR |
| Engine oil | Construction | NR |
| Fevicol | Construction | NR |
| Glue | Construction | NR |
| Solvent | Construction | NR |
| Primer | Construction | NR |
| Anti-termite Chemical | Construction | NR |
| Bondit Sealant | Construction | NR |
| Epoxy Primer Resin | Construction | NR |
| Epoxy Primer Hardener | Construction | NR |
| Epoxy Grout | Construction | NR |
| Adhesive Ascofix TBM | Construction | NR |
| Putty | Construction | NR |
| Sand | Construction | NR |
| GYPSUM | Construction | NR |
| TILE | Construction | NR |
| AAC BLOCK | Construction | NR |
| CEMENT | Construction | NR |
| MORTAR | Construction | NR |
| PLASTER | Construction | NR |
| OTHERS | | |
| Vehicular Air filter | Construction | NR |
| Hessian Cloth | Construction | NR |
| Broom/Jhadu | Construction | NR |
| Electrical Cable/Panel | Construction | NR |
| Halogen Lamp | Construction | NR |
| Rubber | Packaging | NR |
| Aggregate | Construction | NR |
| Jute Bag | Packaging | NR |
| Thermocol | Packaging | NR |
| Grease | Construction | NR |
| Silicon | Construction | NR |
| Glass | Construction | R |
| Paint | Construction | NR |

Table 7

**Comparison of Site Measured and Contractor Estimated Waste, by Stages**

| SITE STAGE NAME | SMW | SMW % | CEW | CE % | AVERAGE OF SM AND CE | PERCENTAGE OF TOTAL WASTE |
|---|---|---|---|---|---|---|
| Site Survey | 0 | 0.000 | 0.0187 | 0.49 | 0.00935 | 0% |
| Barricading | 0.0434 | 1.189 | 0.08 | 2.11 | 0.061735 | 2% |
| Land Clearance | 0.0014 | 0.038 | 0.031 | 0.82 | 0.016188 | 0% |
| Piling | 0.139 | 3.809 | 0.0172 | 0.45 | 0.078107 | 2% |
| Shoring works | 0 | 0.000 | 0 | 0.00 | 0 | 0% |
| Excavation | 0 | 0.000 | 0.0007 | 0.02 | 0.000359 | 0% |
| Transportation | 0 | 0.000 | 0 | 0.00 | 0 | 0% |
| Foundation | 0.0043 | 0.118 | 0.0014 | 0.04 | 0.00285 | 0% |
| Reinforcement | 0.1904 | 5.218 | 0.1172 | 3.09 | 0.153802 | 4% |
| Shuttering | 0.082 | 2.247 | 0.2148 | 5.66 | 0.14838 | 4% |
| Greasing | 0.0257 | 0.704 | 0.0266 | 0.70 | 0.026126 | 1% |
| Concreting | 0.8979 | 24.607 | 1.0893 | 28.69 | 0.993579 | 27% |
| Curing | 0.3005 | 8.235 | 0.1508 | 3.97 | 0.225632 | 6% |
| Blockwork | 0.0457 | 1.252 | 0.0257 | 0.68 | 0.035739 | 1% |
| Conduiting | 0.0036 | 0.099 | 0.0095 | 0.25 | 0.006544 | 0% |
| Plastering | 0.0261 | 0.715 | 0.0749 | 1.97 | 0.050524 | 1% |
| Gypsum Plaster | 0.427 | 11.702 | 0.3828 | 10.08 | 0.404885 | 11% |
| Water proofing | 0.0889 | 2.436 | 0.1364 | 3.59 | 0.112676 | 3% |
| Interior Civil work | 0.7435 | 20.376 | 0.709 | 18.68 | 0.726289 | 20% |
| MEP | 0.0273 | 0.748 | 0.0424 | 1.12 | 0.034836 | 1% |
| DG | 0 | 0.000 | 0.0001 | 0.00 | 9.01E-05 | 0% |
| Façade | 0.0036 | 0.099 | 0.0072 | 0.19 | 0.005399 | 0% |
| Painting | 0.0171 | 0.469 | 0.0403 | 1.06 | 0.028659 | 1% |
| Landscaping | 0.0333 | 0.913 | 0.0398 | 1.05 | 0.036545 | 1% |
| Infrastructure | 0.2912 | 7.980 | 0.3344 | 8.81 | 0.312818 | 8% |
| Handover | 0.0221 | 0.606 | 0.0599 | 1.58 | 0.040977 | 1% |
| Site Office demobilization | 0.2349 | 6.438 | 0.1862 | 4.90 | 0.210569 | 6% |
| TOTAL | 3.6489 | 100.000 | 3.7963 | 100.00 | 3.7226581 | 100% |

Table 8

**Comparison of Site Measured and Contractor Estimated Waste, by Materials**

| SITE STAGE NAME | SMW | SMW % | CEW | CE % | AVERAGE OF SM AND CE | AVG % |
|---|---|---|---|---|---|---|
| Metal | 0.319873 | 8.77% | 0.3052 | 8% | 0.313 | 8.41% |
| Concrete | 1.672372 | 45.83% | 1.5352 | 41% | 1.604 | 43.17% |
| Tile | 0.14772 | 4.05% | 0.174 | 5% | 0.161 | 4.32% |
| Stone | 0.154376 | 4.23% | 0.1444 | 4% | 0.149 | 4.02% |
| Sand | 0.31553 | 8.65% | 0.5628 | 15% | 0.439 | 11.75% |
| Adhesive | 0.000902 | 0.02% | 0.038 | 1% | 0.019 | 0.51% |
| Plaster | 0.033359 | 0.91% | 0.007 | 0% | 0.02 | 0.55% |
| Soft plastic | 0.053496 | 1.47% | 0.0424 | 1% | 0.048 | 1.29% |
| Hard Plastic | 0.040077 | 1.10% | 0.0491 | 1% | 0.045 | 1.20% |
| Cardboard | 0.027439 | 0.75% | 0.017 | 0% | 0.022 | 0.60% |
| Gypsum | 0.411471 | 11.28% | 0.3856 | 10% | 0.399 | 10.72% |
| Cement | 0.213814 | 5.86% | 0.071 | 2% | 0.142 | 3.87% |
| Glass | 0.005296 | 0.15% | 0.0039 | 0% | 0.005 | 0.12% |
| Silicon | 0 | 0.00% | 0.0243 | 1% | 0.012 | 0.32% |
| Wood | 0.084245 | 2.31% | 0.1122 | 3% | 0.098 | 2.63% |
| Aggregates | 0.034676 | 0.95% | 0.0056 | 0% | 0.02 | 0.55% |
| Brick | 0.012266 | 0.34% | 0.0326 | 1% | 0.022 | 0.60% |
| AAC Block | 0.060605 | 1.66% | 0.0676 | 2% | 0.064 | 1.72% |
| Paints & Solvent | 0.007465 | 0.20% | 0.0178 | 0% | 0.013 | 0.34% |
| Rubber | 0.003747 | 0.10% | 0.0042 | 0% | 0.004 | 0.11% |
| Electrical cable & Panel | 0 | 0.00% | 0.0059 | 0% | 0.003 | 0.08% |
| Air filter | 0 | 0.00% | 0.0001 | 0% | 0 | 0.00% |
| Oil | 0.000112 | 0.00% | 0.0029 | 0% | 0.001 | 0.04% |
| Halogen lamp | 0 | 0.00% | 0.0001 | 0% | 0 | 0.00% |
| Jute | 0.000589 | 0.02% | 0.0022 | 0% | 0.001 | 0.04% |
| Clothes | 0.000127 | 0.00% | 0.0011 | 0% | 0.001 | 0.02% |
| Grease | 0.022908 | 0.63% | 0.0472 | 1% | 0.035 | 0.94% |
| Thermocol | 0.001665 | 0.05% | 0.0098 | 0% | 0.006 | 0.15% |
| Debris | 0.024891 | 0.68% | 0.1208 | 3% | 0.073 | 1.93% |
| TOTAL | 3.649021 | 100% | 3.790086 | 100% | 3.719553 | 100% |

Table 9

**Comparison of Site Measured Waste by Materials and stages**

**Site Preparation Stage**

| CORE MATERIAL | SITE SURVEY | BARRICADING | LAND CLEARANCE | PILING | | SHORING WORKS | EXCAVATION | TRANSPORTATION | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| Metal | 0.000000 | 0.043436 | 0.001404 | 0.007027 | | 0.000000 | 0.000000 | 0.000000 | 0.051866 |
| Concrete | 0.000000 | 0.000000 | 0.000000 | 0.132002 | | 0.000000 | 0.000000 | 0.000000 | 0.132002 |
| Tile | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Stone | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Sand | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Adhesive | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Plaster | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Soft plastic | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Hard Plastic | 0.000000 | 0.000000 | 0.000000 | 0.000009 | | 0.000000 | 0.000000 | 0.000000 | 0.000009 |
| Cardboard | 0.000000 | 0.000000 | 0.000000 | 0.000004 | | 0.000000 | 0.000000 | 0.000000 | 0.000004 |
| Gypsum | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Cement | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Glass | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Silicon | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Wood | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Paints & Solvent | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Brick | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| ACC Block | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Rubber | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Electrical cable & Panel | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Air filter | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Oil | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Halogen lamp | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Jute | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Clothes | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Grease | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Thermocol | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Debris | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Aggregate | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Total | 0.000000 | 0.043436 | 0.001404 | 0.139042 | | 0.000000 | 0.000000 | 0.000000 | 0.183881 |

Table 9 (contd)

**Comparison of Site Measured Waste by Materials and stages**

**Core and Shell Stage**

| CORE MATERIAL | FOUNDATION | REINFORCEMENT | SHUTTERING | GREASING | | CONCRETING | CURING | BLOCKWORK | CONDUITING | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| Metal | 0.000003 | 0.190379 | 0.002012 | 0.000064 | | 0.000000 | 0.007416 | 0.000091 | 0.001516 | 0.201481 |
| Concrete | 0.004283 | 0.000000 | 0.006042 | 0.000000 | | 0.897915 | 0.279747 | 0.000000 | 0.000000 | 1.187988 |
| Tile | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Stone | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Sand | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Adhesive | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000747 | 0.000000 | 0.000000 | 0.000747 |
| Plaster | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Soft plastic | 0.000000 | 0.000000 | 0.000168 | 0.000028 | | 0.000000 | 0.004911 | 0.000999 | 0.000000 | 0.006106 |
| Hard Plastic | 0.000000 | 0.000000 | 0.000358 | 0.002680 | | 0.000000 | 0.004499 | 0.000000 | 0.001908 | 0.009445 |
| Cardboard | 0.000000 | 0.000000 | 0.000014 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000023 | 0.000037 |
| Gypsum | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Cement | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Glass | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Silicon | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Wood | 0.000013 | 0.000000 | 0.073275 | 0.000000 | | 0.000000 | 0.002366 | 0.000000 | 0.000000 | 0.075654 |
| Paints & Solvent | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Brick | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| ACC Block | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.044323 | 0.000000 | 0.044323 |
| Rubber | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000248 | 0.000000 | 0.000000 | 0.000248 |
| Electrical cable & Panel | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Air filter | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Oil | 0.000000 | 0.000000 | 0.000112 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000112 |
| Halogen lamp | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Jute | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000589 | 0.000000 | 0.000000 | 0.000589 |
| Clothes | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Grease | 0.000000 | 0.000000 | 0.000000 | 0.022908 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.022908 |
| Thermocol | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000155 | 0.000155 |
| Debris | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Aggregate | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Total | 0.004300 | 0.190379 | 0.081981 | 0.025680 | | 0.897915 | 0.300523 | 0.045413 | 0.003602 | 1.549793 |

Table 9 (contd)

**Comparison of Site Measured Waste by Materials and stages**

**Core and Shell Stage**

| CORE MATERIAL | PLASTERING | GYPSUM PLASTER | WATERPROOFING | | | INTERIOR CIVIL WORK | | | | MEP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Podium | Toilet | | Tiling & Stone | ACC Block / IPS Flooring | Wooden Doors | Window | Fire fighting | Plumbing | Electrical | Lift Installation |
| Metal | 0.000000 | 0.004449 | 0.005751 | 0.003550 | | 0.000607 | 0.000985 | 0.000209 | 0.000071 | 0.004561 | 0.002756 | 0.001396 | 0.000516 |
| Concrete | 0.000000 | 0.000000 | 0.010498 | 0.011468 | | 0.008093 | 0.002367 | 0.000000 | 0.000000 | 0.000333 | 0.000706 | 0.000000 | 0.000490 |
| Tile | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.147385 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Stone | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.136183 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Sand | 0.000000 | 0.000000 | 0.000000 | 0.004323 | | 0.294827 | 0.016360 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Adhesive | 0.000000 | 0.000000 | 0.000006 | 0.000000 | | 0.000000 | 0.000000 | 0.000148 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Plaster | 0.006905 | 0.000000 | 0.000000 | 0.000000 | | 0.015102 | 0.010640 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Soft plastic | 0.003894 | 0.008587 | 0.001251 | 0.000183 | | 0.019014 | 0.001086 | 0.000443 | 0.000566 | 0.000051 | 0.000162 | 0.000701 | 0.000081 |
| Hard Plastic | 0.000000 | 0.003550 | 0.003467 | 0.008746 | | 0.001074 | 0.000000 | 0.000108 | 0.000438 | 0.000964 | 0.001181 | 0.002094 | 0.000000 |
| Cardboard | 0.000000 | 0.000910 | 0.000886 | 0.000000 | | 0.011452 | 0.000000 | 0.009554 | 0.000063 | 0.000144 | 0.001078 | 0.001497 | 0.001133 |
| Gypsum | 0.000000 | 0.402021 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Cement | 0.015273 | 0.000000 | 0.001927 | 0.003783 | | 0.040819 | 0.004026 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Glass | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.005296 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Silicon | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Wood | 0.000000 | 0.000134 | 0.000266 | 0.000029 | | 0.000000 | 0.000000 | 0.003582 | 0.000000 | 0.000569 | 0.000000 | 0.000078 | 0.002763 |
| Paints & Solvent | 0.000000 | 0.000000 | 0.000894 | 0.000500 | | 0.000551 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Brick | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| AAC Block | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.012465 | 0.000000 | 0.000000 | 0.000000 | 0.003817 | 0.000000 | 0.000000 |
| Rubber | 0.000067 | 0.000000 | 0.000019 | 0.000020 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000046 | 0.000000 | 0.000000 | 0.000000 |
| Electrical cable & Panel | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Air filter | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Oil | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Halogen lamp | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Jute | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Clothes | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000110 | 0.000000 | 0.000000 | 0.000000 |
| Grease | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Thermocol | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Debris | 0.000000 | 0.000000 | 0.002370 | 0.007576 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Aggregate | 0.000000 | 0.007315 | 0.020908 | 0.000545 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| TOTAL (kg/sft) | 0.026139 | 0.426967 | 0.048244 | 0.040722 | | 0.675108 | 0.047930 | 0.014045 | 0.006435 | 0.006779 | 0.009699 | 0.005767 | 0.004982 |

Table 9 (contd)

**Comparison of Site Measured Waste by Materials and stages**

**Core and Shell Stage**

| CORE MATERIAL | DG | FAÇADE | PAINTING | LANDSCAPE | | INFRASTRUCTURE | | HANDOVER | SITE OFFICE DEMOBILIZATION |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Infra Civil | Infra MEP | | |
| Metal | 0.000011 | 0.001839 | 0.000366 | 0.000042 | | 0.011764 | 0.000028 | 0.000744 | 0.026880 |
| Concrete | 0.000000 | 0.000000 | 0.000000 | 0.010760 | | 0.090597 | 0.015973 | 0.000000 | 0.201096 |
| Tile | 0.000000 | 0.000000 | 0.000000 | 0.000232 | | 0.000000 | 0.000000 | 0.000050 | 0.000052 |
| Stone | 0.000000 | 0.000000 | 0.000000 | 0.018193 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Sand | 0.000000 | 0.000000 | 0.000000 | 0.000020 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Adhesive | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Plaster | 0.000000 | 0.000000 | 0.000000 | 0.000052 | | 0.000000 | 0.000661 | 0.000000 | 0.000000 |
| Soft plastic | 0.000001 | 0.000285 | 0.001061 | 0.001040 | | 0.000000 | 0.000783 | 0.008200 | 0.000000 |
| Hard Plastic | 0.000000 | 0.000054 | 0.005302 | 0.000924 | | 0.000160 | 0.001457 | 0.001078 | 0.000025 |
| Cardboard | 0.000005 | 0.000000 | 0.000076 | 0.000000 | | 0.000000 | 0.000000 | 0.000600 | 0.000000 |
| Gypsum | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.009450 | 0.000000 |
| Cement | 0.000000 | 0.000000 | 0.002108 | 0.000000 | | 0.000000 | 0.143852 | 0.002025 | 0.000000 |
| Glass | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Silicon | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Wood | 0.000000 | 0.000000 | 0.000118 | 0.000000 | | 0.000856 | 0.000000 | 0.000000 | 0.000196 |
| Paints & Solvent | 0.000000 | 0.000000 | 0.005520 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Brick | 0.000000 | 0.000000 | 0.000000 | 0.002059 | | 0.000000 | 0.010207 | 0.000000 | 0.000000 |
| AAC Block | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Rubber | 0.000000 | 0.000000 | 0.000013 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.003334 |
| Electrical cable & Panel | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Air filter | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Oil | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Halogen lamp | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Jute | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Clothes | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000017 |
| Grease | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Thermocol | 0.000000 | 0.001510 | 0.000000 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| Debris | 0.000000 | 0.000000 | 0.000000 | 0.000000 | | 0.000000 | 0.014945 | 0.000000 | 0.000000 |
| Aggregate | 0.000000 | 0.000000 | 0.002574 | 0.000000 | | 0.000000 | 0.000000 | 0.000000 | 0.003333 |
| TOTAL (kg/sft) | 0.000017 | 0.003688 | 0.017137 | 0.033322 | | 0.103377 | 0.187907 | 0.022147 | 0.234934 |

Table 10

**Comparison of Site Measured Waste by Projects and stages**

| REGION | | | NCR (2 PROJECTS) | | MUM (3 PROJECTS) | | | | BLR (4 PROJECTS) | | | | PUNE (5 PROJECTS) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PROJECTS | | | MERIDIEN | NATURE PLUS | NIRVAAN | GOLF MEADOWS | EMERALD | | ANANDA | EDEN | ROYAL WOODS | NURTURE | HILL SIDE | NURTURE | PARK GREENS | HAPPINEST | PARK SPRINGS | AVERAGE |
| CONSTRUCTION TYPE | | | MIVAN | TRADITIONAL | MIVAN | MIVAN | MIVAN | | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | |
| 1 | A1 | Site Survey | | 0.0008 | 0.0000 | | | | | 0.0000 | | | | | | 0.0000 | 0.0000 | 0.0000 |
| 2 | A2 | Barricading | | 0.0138 | 0.0002 | | | | | 0.0945 | | | | | | 0.025066 | 0.0540 | 0.0434 |
| 3 | A3 | Land Clearance | | 0.0452 | 0.0000 | | | | | 0.0000 | | | | | | 0.005615 | 0.0000 | 0.0014 |
| 4 | A4 | Piling | | 0.0000 | 0.3955 | | | | | 0.0000 | | | | | | 0.160632 | 0.0000 | 0.1390 |
| 5 | A5 | Shoring works | | 0.0000 | 0.0000 | | | | | 0.0000 | | | | | | 0.0000 | 0.0000 | 0.0000 |
| 6 | A6 | Excavation | | 0.0000 | 0.0000 | | | | | 0.0000 | | | | | | 0.0000 | 0.0000 | 0.0000 |
| 7 | A7 | Transportation | | 0.0000 | 0.0000 | | | | | 0.0000 | | | | | | 0.0000 | 0.0000 | 0.0000 |
| SITE PREP TOTAL | | | | 0.0598 | 0.3957 | | | | | 0.0945 | | | | | | 0.1913 | 0.0540 | 0.1839 |
| 8 | B1 | Foundation | 0.0041 | | 0.0055 | | | | | 0.0033 | | | | | | | | 0.0043 |
| 9 | B2 | Reinforcement | 0.1052 | 0.0861 | 0.1123 | | 0.115909 | | 0.7705 | 0.1244 | | | | 0.1239 | 0.071306 | 0.0810 | 0.208817 | 0.1904 |
| 10 | B3 | Shuttering | 0.0084 | 0.8998 | 0.0000 | | 0.613636 | | 0.0003 | 0.0000 | | | | 0.0032 | 0.003930 | 0.0873 | 0.021075 | 0.0820 |
| 11 | B4 | Greasing | 0.0685 | 0.0000 | 0.0199 | | 0.009091 | | 0.0242 | 0.0318 | | | | 0.053117 | 0.001547 | 0.0225 | 0.000264 | 0.0257 |
| 12 | B5 | Concreting | 0.7889 | 0.0669 | 0.7546 | | 0.4159 | | 0.0299 | 1.2442 | | | | 1.123790 | 1.390473 | 1.1133 | 1.220000 | 0.8979 |
| 13 | B6 | Curing | 0.1127 | 0.1172 | 0.8404 | | 0.340600 | | 0.0027 | 0.3242 | | | | 0.108111 | 0.328153 | 0.2794 | 0.368291 | 0.3005 |
| 14 | B7 | Blockwork | 0.0815 | 0.6863 | 0.0000 | | 0.0000 | | | 0.0000 | | | | | 0.009943 | 0.0000 | 0.0000 | 0.0457 |
| 15 | B8 | Conduiting | 0.0006 | 0.0002 | 0.0017 | | 0.007500 | | | | | | | 0.002013 | 0.001921 | 0.0051 | 0.006283 | 0.0036 |
| CORE AND SHELL TOTAL | | | 1.1700 | 1.8565 | 1.7344 | | 1.502636 | | 0.8276 | 1.7280 | | | | 1.4141 | 1.8073 | 1.5886 | 1.8247 | 1.5500 |
| 16 | C1 | Plastering | 0.0386 | 0.1122 | 0.0067 | 0.0871 | | | 0.0062 | | 0.0412 | 0.0343 | 0.0172 | 0.001078 | 0.00260 | | | 0.0261 |
| 17 | C2 | Gypsum Plaster | 0.2000 | 0.2017 | 0.7640 | 0.6189 | | | 0.5879 | | 0.3544 | 0.1774 | 0.5804 | 0.321045 | 0.23885 | | | 0.4270 |
| 18 | C3 | Water proofing | 0.0577 | 0.1479 | 0.0556 | 0.0615 | | | 0.0185 | | 0.3523 | 0.1346 | 0.0306 | 0.036704 | 0.05275 | 0.0155 | | 0.0889 |
| 19 | C4 | Interior Civil work | 0.2310 | 0.1819 | 1.5600 | 1.3510 | | | | | 0.6180 | 0.0744 | 1.0331 | 0.636789 | 0.44411 | | | 0.7435 |
| 20 | C5 | MEP | 0.0051 | 0.0331 | 0.0282 | 0.0227 | | | 0.0324 | | 0.0394 | 0.03536 | 0.0187 | 0.031137 | 0.03233 | | | 0.0273 |
| 21 | C6 | DG | | | | 0.000037 | | | | | 0.0000 | 0.00009 | 0.0000 | | | | | 0.0000 |
| 22 | C7 | Façade | 0.0105 | 0.0125 | 0.0019 | 0.0010 | | | | | | | 0.0005 | 0.004179 | | | | 0.0036 |
| 23 | C8 | Painting | | 0.0127 | 0.0126 | 0.0250 | | | | | 0.0103 | 0.0213 | | 0.012531 | 0.02057 | | | 0.0171 |
| 24 | C9 | Landscaping | 0.0100 | 0.0112 | | 0.0111 | | | | | 0.0047 | 0.0017 | 0.0003 | | 0.17200 | | | 0.0333 |
| 25 | C10 | Infrastructure | 1.7110 | 0.9183 | 0.2259 | 0.0573 | | | | | 0.2248 | 0.0055 | 0.0787 | 0.006319 | 0.02023 | | | 0.2912 |
| 26 | C11 | Handover | | | | 0.0070 | | | | | | | 0.0371 | | | | | 0.0221 |
| 27 | C12 | Site Office demobilization | | 0.7036 | | 0.0011 | | | | | | 0.0002 | | | | | | 0.2349 |
| FINISHING TOTAL | | | 2.2640 | 2.3351 | 2.6549 | 2.2436 | | | 0.6450 | | 1.6452 | 0.4848 | 1.7965 | 1.0498 | 0.9834 | 0.0155 | | 1.9150 |
| TOTAL (kg/sft) | | | 3.4340 | 4.2514 | 4.7850 | 2.2436 | 1.5026 | | 1.4726 | 1.8224 | 1.6452 | 0.4848 | 1.7965 | 2.4639 | 2.7907 | 1.7954 | 1.8787 | 3.6489 |

Table 11

**Comparison of Contractor Estimated Waste by Projects and stages**

| REGION | | | NCR (2 PROJECTS) | | MUM (3 PROJECTS) | | | | BLR (4 PROJECTS) | | | | PUNE (5 PROJECTS) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PROJECTS | | | MERIDIEN | NATURE PLUS | NIRVAAN | GOLF MEADOWS | EMERALD | | ANANDA | EDEN | ROYAL WOODS | NURTURE | HILL SIDE | NURTURE | PARK GREENS | HAPPINEST | PARK SPRINGS | AVG |
| CONSTRUCTION TYPE | | | MIVAN | TRADITIONAL | MIVAN | MIVAN | MIVAN | | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | MIVAN | |
| 1 | A1 | Site Survey | 0.0005 | 0.0003 | 0.0703 | 0.0000 | | | 0.0081 | 0.0000 | 0.0703 | | | | | 0.0000 | 0.000536 | 0.0187 |
| 2 | A2 | Barricading | 0.0428 | 0.0010 | 0.1471 | 0.1539 | | | 0.0013 | 0.0221 | 0.1471 | | | | | 0.060226 | 0.065661 | 0.0800 |
| 3 | A3 | Land Clearance | 0.0000 | 0.0901 | 0.1239 | 0.0000 | | | 0.0000 | 0.0000 | 0.1239 | | | | | 0.0000 | 0.0000 | 0.0310 |
| 4 | A4 | Piling | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | 0.0000 | 0.0000 | 0.0000 | | | | | 0.137451 | 0.0000 | 0.0172 |
| 5 | A5 | Shoring works | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | 0.0000 | 0.0000 | 0.0000 | | | | | 0.0000 | 0.0000 | 0.0000 |
| 6 | A6 | Excavation | 0.0000 | 0.0000 | 0.0021 | 0.0000 | | | 0.0007 | 0.0006 | 0.0021 | | | | | 0.000299 | 0.0000 | 0.0007 |
| 7 | A7 | Transportation | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | 0.0000 | 0.0000 | 0.0000 | | | | | 0.0000 | 0.0000 | 0.0000 |
| SITE PREP TOTAL | | | 0.0433 | 0.0914 | 0.3433 | 0.1539 | 0.0000 | | 0.0101 | 0.0227 | 0.3433 | | | | | 0.1980 | 0.0662 | 0.1476 |
| 8 | B1 | Foundation | | | 0.0070 | | | | | | | | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0014 |
| 9 | B2 | Reinforcement | 0.1052 | 0.0846 | 0.1453 | 0.1270 | 0.115909091 | | 0.1743 | 0.1105 | 0.0232 | | | 0.1269 | 0.0721 | 0.0787 | 0.2105 | 0.1172 |
| 10 | B3 | Shuttering | 0.0605 | 0.9379 | 0.0154 | 0.1416 | 0.643155 | | 0.0971 | 0.0153 | 0.0998 | | | 0.2074 | 0.6267 | 0.2419 | 0.2138 | 0.2148 |
| 11 | B4 | Greasing | 0.0002 | 0.0000 | 0.0194 | 0.1067 | 0.009090909 | | 0.0158 | 0.0040 | 0.0243 | | | 0.0572 | 0.0019 | 0.0225 | 0.0313 | 0.0266 |
| 12 | B5 | Concreting | 0.6574 | 0.3493 | 1.2611 | 1.0781 | 0.831818182 | | 0.5772 | 1.7154 | 1.0325 | | | 1.1761 | 1.0097 | 1.3727 | 1.2698 | 1.0893 |
| 13 | B6 | Curing | 0.0459 | 0.0027 | 0.3160 | 0.4753 | 0.005009 | | 0.0130 | 0.0008 | 0.4956 | | | 0.0000 | 0.0000 | 0.0787 | 0.2280 | 0.1508 |
| 14 | B7 | Blockwork | 0.0902 | 0.4573 | 0.0194 | 0.0000 | | | 0.0000 | 0.0141 | 0.0000 | | | 0.0000 | 0.1080 | 0.0000 | 0.0000 | 0.0257 |
| 15 | B8 | Conduiting | 0.0590 | 0.0000 | 0.0058 | 0.0000 | | | | | 0.0063 | | | 0.0029 | 0.0018 | 0.0088 | 0.0009 | 0.0095 |
| CORE AND SHELL TOTAL | | | 1.0184 | 1.8318 | 1.7894 | 1.9287 | 1.6050 | | 0.8774 | 1.8601 | 1.6817 | | | 1.570498 | 1.82027 | 1.8033 | 1.9543 | 1.6353 |
| 16 | C1 | Plastering | 0.1432 | 0.1784 | 0.0163 | 0.0418 | | | 0.0251 | | 0.0713 | 0.0366 | 0.3315 | 0.000962 | 0.00772 | | | 0.0749 |
| 17 | C2 | Gypsum Plaster | 0.2211 | 0.2418 | 0.5881 | 0.4420 | | | 0.5592 | | 0.4414 | 0.1821 | 0.4407 | 0.363407 | 0.20703 | | | 0.3828 |
| 18 | C3 | Water proofing | 0.0629 | 0.2007 | 0.08030217 | 0.0813 | | | 0.2240 | | 0.1909 | 0.1909 | 0.0760 | 0.049777 | 0.38846 | 0.0197 | | 0.1364 |
| 19 | C4 | Interior Civil work | 0.4996 | 0.2463 | 1.6911 | 1.1377 | | | | | 0.5456 | 0.0841 | 0.7997 | 0.518354 | 0.39604 | | | 0.7090 |
| 20 | C5 | MEP | 0.0081 | 0.0396 | 0.038579752 | 0.0598 | | | 0.0528 | | 0.0761 | 0.0354 | 0.0523 | 0.041028 | 0.01775 | | | 0.0424 |
| 21 | C6 | DG | | | | 0.0000 | | | | | 0.0006 | 0.0001 | 0.0000 | 0.0000 | | | | 0.0001 |
| 22 | C7 | Façade | 0.0175 | 0.0209 | 0.00003 | 0.0064 | | | | | | | 0.0000 | 0.004792 | | | | 0.0072 |
| 23 | C8 | Painting | | 0.0188 | 0.012325454 | 0.1362 | | | | | 0.0229 | 0.0229 | 0.0194 | 0.028953 | 0.03910 | | | 0.0403 |
| 24 | C9 | Landscaping | 0.0365 | 0.0131 | | 0.0030 | | | | | 0.0048 | 0.0024 | 0.0196 | | 0.17248 | | | 0.0398 |
| 25 | C10 | Infrastructure | 1.5386 | 0.9243 | 0.272603845 | 0.1153 | | | | | 0.4486 | 0.0100 | 0.2612 | 0.006944 | 0.02216 | | | 0.3344 |
| 26 | C11 | Handover | | | | | | | | | | | 0.0599 | | | | | 0.0599 |
| 27 | C12 | Site Office demobilization | | 0.7036 | | 0.3724 | | | | | | 0.0000 | | | | | | 0.1862 |
| FINISHING TOTAL | | | 2.5274 | 2.5875 | 2.6994 | 2.3959 | 0.0000 | | 0.8611 | | 1.8021 | 0.5647 | 2.0603 | 1.0142 | 1.2507 | 0.0197 | | 2.0135 |
| TOTAL (kg/sft) | | | 3.5891 | 4.5108 | 4.8321 | 4.4786 | 1.6050 | | 1.7486 | 1.8828 | 3.8271 | 0.5647 | 2.0603 | 2.5847 | 3.0710 | 2.0210 | 2.0205 | 3.7964 |

Table 12

**Contractor estimated waste - Core and shell stage of Godrej Nirvaan project, Kalyan, Mumbai**

| Sr.No. | Material/item | % theoretical waste/ floor | Quantity required per floor or unit area | Unit | Wastage in kg | Area | Stage | X kg/ sqft | Core material | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Steel | 3% | 25 | Tonne | 750 | 5163 | Reinforcement | 0.1453 | Metal | 25 Tonne required per floor |
| 2 | RMC Concrete | 0-1% | 644160 kg | kg | 6441 | 5163 | Concreting | 1.2475 | Concrete | RMC density 2440kg/m3 |
| 3 | Mivan shuttering (metal) | 0.04% | 49952.00 | kg | 19.98 | 5163 | Shuttering | 0.0039 | Metal | 18kg per sq. mt. |
| 4 | Mivan shuttering (wood) | - | - | RM | | 5163 | Shuttering | 0.0000 | Wood | |
| 5 | Diesel | 0% | 0 | RM | 0.00 | 5163 | Concreting | 0.0000 | Oil | No waste |
| 6 | 3m metal pipe for RMC pumping | 0.01% | 1 piece | Nos | 30 | 5163 | Concreting | 0.0058 | Metal | Pipe waste when pressure is more |
| 7 | PP bags (polypropylene/plastic) | 100% | 55 bags | Nos | 8.25 | 5163 | Concreting | 0.0016 | Soft Plastic | 150gm per bag |
| 8 | Concrete Cover block | 10% | 1200piece | Nos | 7.2 | 5163 | Shuttering | 0.0014 | Concrete | 50-60gm per block |
| 9 | Curing compound bucket (HDPE) | 100% | 7 buckets | Nos | 18.375 | 5163 | Curing | 0.0036 | Hard Plastic | Empty bucket weighs 2.6kg |
| 10 | Grease | 100% | 100kg | kg | 100 | 5163 | Greasing | 0.0194 | Silicon | Grease dries up and chips off |
| 11 | Crush sand | 100% | 40bag | Nos | 1000 | 5163 | Concreting | 0.1937 | Sand | Slurry used for leveling chips off |
| 12 | Cement | 100% | 15 bag | Nos | 600 | 5163 | Concreting | 0.1162 | Cement | Slurry used for leveling chips off |
| 13 | Wall tie cover | 100% | 3 rolls | Nos | 3 | 5163 | Shuttering | 0.0006 | Soft Plastic | Few are resued, eventually wasted |
| 14 | Flute board (plastic) | 100% | 3kg | kg | 3 | 5163 | Shuttering | 0.0006 | Soft Plastic | Few are resued, eventually wasted |
| 15 | Rubber gloves | 30% | 50piece | Nos | 1.95 | 5163 | Shuttering | 0.0004 | Rubber | Mostly waste during concreting |
| 16 | Gum boot | 1% | 100 piece | Nos | 1.6 | 5163 | Shuttering | 0.0003 | Rubber | Mostly waste during concreting |
| 17 | Safety Jacket (polyester) | 10% | 50 piece | Nos | 0.5 | 5163 | Shuttering | 0.0001 | Hard Plastic | every 12 slabs all jackets are changed |
| 18 | PVC pipe for curing | 4% | 100m | kg | 1.2 | 5163 | Curing | 0.0002 | Hard Plastic | Cuts due to rough usage |
| 19 | Pin Patti (MS) | 10% | 35000 nos | Nos | 42 | 5163 | Shuttering | 0.0081 | Metal | 120 gm per patti |
| 20 | Halogen lamp | 3% | 10nos | RM | 32 | 5163 | Concreting | 0.0062 | Metal | Breaks during early morning pouring |
| 21 | Blockwork | 10% | 1000kg | RM | 100 | 5163 | Blockwork | 0.0194 | AAC Block | Wasted during rework and handling |
| 22 | Safety belt (polyester) | 10% | 20 piece | RM | | 5163 | Shuttering | 0.0000 | Hard Plastic | |
| 23 | Binding wire (GI) | 6% | 200kg | RM | 12 | 5163 | Curing | 0.0023 | Metal | Most waste due to handling and pouring |
| 24 | Iron Nails | 20% | 12 | m2 | 1 | 5163 | Shuttering | 0.0002 | Metal | Nails stuck chips outs during deshuttering |
| 25 | Thermocol | 100% | 0.5 | RM | 0.5 | 5163 | Shuttering | 0.0001 | Soft Plastic | Filled in backbox to avoid concrete |
| 26 | backing box coin | 100% | 2 | kg | 2 | 5163 | Conduting | 0.0004 | Metal | Each box has atlead 8 coins waste |
| 27 | PVC conduit pipe | 10% | 3.5 | kg | 30 | 5163 | Conduting | 0.0058 | Hard Plastic | Wasted during electrical work in shuttering |
| | | | | Total | 9205.56 | 5163 | | 1.78299 | | |

Table 13

**List of operational C&D waste recycling facilities in India, as of 2023**

| City | Place | Capacity (TPD) |
|---|---|---|
| Delhi | Burari | 2,000 |
| | Mundka | 150 |
| | Shastri Park | 500 |
| | Bakkarwala | 1,000 |
| Noida | Sector 80 | 300 |
| Gurugram | Basai | 300 |
| Ghaziabad | Ghaziabad | 150 |
| Mumbai | Thane, Daighar | 300 |
| | Vikhroli | 100 |
| Indore | Devguradia | 100 |
| Hyderabad | Jeetimedla | 300 |
| Bengaluru | Chikkajala | 1,000 |
| | Kannur | 750 |
| Ahmedabad | Gyaspur Pirana | 1,000 |
| Tirupati | Tukivakam village | 150 |
| Vijayawada | Vijayawada | 200 |
| Chandigarh | Industrial Area Phase 1 | 150 |
| Surat | Surat | 300 |
| Pune | Pimpri Chichawad | 200 |
| Devas | | 8 |
| Kolkata | Rajarhat | 500 |

Table 14

**Potential Revenue Within Construction Life Cycle, for 1 million square feet of built-up area**

| | Material Name | Waste Generated (kg/sqft) | Waste Generated for 1 Million sqft (kg) | % composition | Unit Cost (Rs/kg) | Revenue Generation Potential (Rs) |
|---|---|---|---|---|---|---|
| 1 | Metal | 0.118393 | 1,18,392.52 | 3.3% | 25.00 | 29,59,813.12 |
| 2 | Hard Plastic | 0.040077 | 40,076.95 | 1.1% | 25.00 | 10,01,923.71 |
| 3 | Wood | 0.084245 | 84,244.78 | 2.3% | 2.00 | 1,68,489.55 |
| 4 | Soft Plastic | 0.053496 | 53,496.04 | 1.5% | 4.00 | 2,13,984.15 |
| 5 | Cardboard | 0.027439 | 27,438.56 | 0.8% | 10.00 | 2,74,385.59 |
| | | | | | | |
| 6 | Concrete | 1.672372 | 16,72,371.73 | 45.9% | 0.50 | 8,36,185.87 |
| 7 | Tile | 0.147720 | 1,47,719.83 | 4.1% | 0.50 | 73,859.92 |
| 8 | AAC blocks | 0.060605 | 60,605.32 | 1.7% | 0.50 | 30,302.66 |
| 9 | Gymsum | 0.411471 | 4,11,471.37 | 11.3% | 0.00 | - |
| 10 | Brick | 0.012266 | 12,266.05 | 0.3% | 0.00 | - |
| 11 | Sand | 0.315530 | 3,15,530.17 | 8.7% | 0.00 | - |
| 12 | Others | | 5,00,000.00 | 13.7% | 0.00 | - |
| | TOTAL REVENUE GENERATED | | | 100% | | 55,58,944.57 |

Note: The potential revenue generated will increase if we add reinforcement steel and Aluminium shuttering. However, in GPL and MLDL the waste from reinforcement steel and aluminium shuttering is in their respective vendors scope and hence we have not added it here.

Table 16

**Template for fortnightly reporting waste on Site**

| Contractors Name: _____ | | | | | | | | | | | | | | | | | | | | | | | | | | | | Date: ___ / ____ / _____ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Collection | | | | | | | | | | | Waste Disposal | | | | | | | | | | | | | | | |
| S.No | Material | Type of waste | Where was the waste stored | | | | | Construction stage | | | | | | | How was it disposed | | | | Transportation | | | | | Managed By | | | | |
| | | | Quantity | MRF | Designated space | Near building / Chute | Other | Site prep. | Excavation | Core-shell | Finishing | | Quantity | Selling cost | Reuse | Recycler | Aggregator | Dumping site | No transfer / Reuse | Truck/ Heavy Vehicle | Loader/ Tata Ace | Cart/ tempo | Cost of transportation | Godrej | Contractor | Consultant | Govern. / ULB | Others |
| 1 | Concrete | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Gypsum | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Metal | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Sand | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Cement | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Stone | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Tile | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Wood | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | AAC Block | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Soft plastic | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Hard Plastic | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Aggregates | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Plaster | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Cardboard | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | Debris | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | Grease | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | Brick | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | Paints & Solvent | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | Glass | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | Rubber | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | Thermocol | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | Adhesive | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | Jute | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | Oil | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | Clothes | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | Silicon | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | Electrical cable & Panel | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28 | Air filter | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29 | Halogen lamp | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 14

**Stagewise waste generated list**

| CONSTRUCTION STAGE | | | WASTE MATERIALS |
|---|---|---|---|
| SITE PREPARATION | | | |
| 1 | A1 | Site Survey | PCC Bed, Steel Rod, Brick Bed |
| 2 | A2 | Barricading | Welding Rod, Nut, GI Sheet, ISMC, ISMB, Screw, RCC, Precast Boundary, Bolt. |
| 3 | A3 | Land Clearance | Debris, Trees, Utility Pole, RCC Hume Pipe, Electrical Cable Gauge |
| 4 | A4 | Piling | Welding Rod, Concrete, Metal Plate |
| 5 | A5 | Shoring works | No Waste |
| 6 | A6 | Excavation | Air Filter, Engine Oil |
| 7 | A7 | Transportation | No Waste |
| CORE AND SHELL | | | |
| 8 | B1 | Foundation | Chipping Waste, Wood chip, Binding Wire, Steel |
| 9 | B2 | Reinforcement | TMT Steel Bar, Debris, Binding Wire, Metal Blade |
| 10 | B3 | Shuttering | Wood, Tape Base, Nail, Wall Tie Cover, Flute Board, PVC Pipe, Pin Patti, Binding Wire, Thermocol, Roller, Brush, Steel |
| 11 | B4 | Greasing | Grease, HDPE Bucket, Oil, Roller Brush, Brush |
| 12 | B5 | Concreting | RMC debris, Cube Mold |
| 13 | B6 | Curing | Chipping debris, Binding Wire, PVC pipe, Shuttering, Nail, Wall Tie Cover, Bucket, Testing Cube, Roller, PP Bag, Jute Bag, Anti-termite Chemical, Jack, Cement, Sand, Aggregate, Hessian Cloth, Panel Puller |
| 14 | B7 | Blockwork | AAC Block, Soft Plastic Packaging |
| 15 | B8 | Conduiting | PVC Pipe, Back Box Coin, Solvent, Soft Plastic Packaging, Back Box Filling |
| FINISHING | | | |
| 16 | C1 | Plastering | Mortar Debris, RMP, PP Bag, Sand, Metal Float |
| 17 | C2 | Gypsum Plaster | Gypsum, Aluminium Section, Trowel, Metal Plate, Plastic Bucket, Bondit, Plum Bob, PP Bag, Roller Brush |
| 18 | C3 | Water proofing | Debris, Micro Concrete, Hard Plastic Bucket, RMP, Roller, Polyurethane Material, Soft Plastic Packaging, Cardboard, SP 40 Grout Filling, Grinder Blade, Metal Bucket, Adhesive Can, Deckweb, PP Bag, HDPE Pre Bond Sheet, Epoxy Primer, Resin, Epoxy Primer Hardener, Brush |
| 19 | C4 | Interior Civil work | Debris, Tile, Sand, Cardboard, Rope, Metal blade, PP Bag, Foam Sheet, Stone, RMP, Plum Bob, AAC Block, Hinges, Foam Can, Soft Plastic Packaging, Silicon Bottle, Glass, Screw, Granite, Adhesive, Broom, Thapi, Glue, Epoxy Grout, Paint Brush, Gun Cleaner Can, Wrap Film Roll, Packing Shim, Solvent |
| 20 | C5 | MEP | CPVC, Solvent Can, Cutting Blade, Grinding Wheel, PP Bag, Cardboard, Welding Rod Stub, GI Pipe, Foam Sheet, Polish Wheel, Fly Ash Chipping, Cello Tape, Universal Clamp, Lubricant Can, Plastic Wire, Soft Plastic Packaging, Metal Wire, Rod, Electrical Wire, Nahani Trap, Diverter Valve, CPVC Pipe, Cutting Blade, Hexablade , Nut, Cutting Wheel, Earthing Strip, Wooden Drum, Jute Bag, |
| 21 | C6 | DG | Soft Plastic Packaging, Paper, Cardboard |
| 22 | C7 | Façade | Soft Plastic Packaging, Welding Rod, Fastener, Metal Tube, Metal Plate, Washer, Primer |
| 23 | C8 | Painting | PP Bag, Paint Bucket, Prime Drum, RMP Bag, Putty, Broom, Paint Brush, Roller Brush, Sand Paper, Trowel, Paint |
| 24 | C9 | Landscaping | Fly Ash Brick, Cement Mortar, PP Bag, Grow Bag, Horticulture Waste, Soil Waste, PP Green Sheet, Solvent Can, Concrete, Tile, Railing, Paint, Paint Container, Welding Rod, Kaddapa, Stone |
| 25 | C10 | Infra | Wood, RMC, RCC Pipe, Binding Wire, Brick, Cement, Sand, Aggregate, DWC Pipe, Hilti Rod, Metal Blade, Steel, Shuttering Ply, Shuttering Oil, RCC Precast Boundary, Stone |
| 26 | C11 | Handover | Dust, Metal, Plastic bucket/ Container, Thermocol, Cardboard, Debris, Soft Plastic Packaging |
| 27 | C12 | Site Office demobilization | GI sheet, PCC, Nail, Ply, Binding Wire, Cable, Cutting Blade |

Table 15

**Value Chain of waste materials**

| Region Name | Material | Point A Name | | Point A (Rs/Kg) | Distance (Km) | Point B Name | Point B (Rs/Kg) | Distance (Km) | Point C Name | Point C (Rs/Kg) | Distance C (km) | Point D Name | Point D (Rs/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NCR | Cardboard | Godrej Meridien | Gurugram | 12 | 8.9km | Zahir, Palam Vihar, Gurugram | 15 | 170 Km | Muzaffarnagar | 55 | | | |
| | Metal and Plastic Containers | Godrej Meridien | Gurugram | 35 | 32.4km | Nina Percept Pvt Ltd,Sarvapriya Vihar, New Delhi | 55-60 | | | | | | |
| | HDPE Hard Plastic Waste | Godrej Meridien | Gurugram | 35 | 12km | Sokat Ali, Kapasera border, Gurugram | 50 | 27 Km | Shams Plastic, Mundka, New Delhi | 70 | | | |
| | Steel (Scrap, Bars and Wire) | Godrej Meridien | Gurugram | 33 - 60 | 15km | Shri Ganesh Ji Traders, Hayatpura , Gurugram | 45 | 382 Km | Ishan Enterprises, Govind Garh, Punjab | 61 | | | |
| | Aluminium Shuttering | Godrej Meridien | Gurugram | 182-185 | 43km | Ziaur Rehman, Jasola Vihar, New Delhi | 210 | | | | | | |
| | PVC Pipe | Godrej Meridien | Gurugram | 30-35 | 3.5 km | Samshad Traders, Gurugram | 40 | | | | | | |
| | Shuttering Ply | Godrej Meridien | Gurugram | 2-8 | 7 km | Ishwar Lal, Bajghera, Gurugram | 10-12 | | | | | | |
| Mumbai | Cardboard | Godrej Golf Meadows | Panvel | 10 | 9 Km | Niaz Khan, Nandgaon, Panvel | 16 | 4.5 Km | Maheshwari Recyclers, Kongaon, Panvel | 18 | 211km | Vapi, Gujarat | 45 |
| | Metal and Plastic Containers | Godrej Golf Meadows | Panvel | 35 | 80 Km | KGN Enterprise, Nalasopara | 60 | 7.9 Km | Shama Plastic, Virar | 70 | | | |
| | HDPE Hard Plastic Waste | Godrej Nirvaan | Kalyan | 25-30 | 35 Km | Ruchi & Zoom Plastic, Andheri MIDC | 33-35 | | | | | | |
| | Steel (Scrap, Bars and Wire) | Godrej Golf Meadows | Panvel | 22-25 | 5 Km | Kalim Shah,Panvel | 35 | 35.4 Km | Kurla | 50 | | | |
| | PVC Pipe | Godrej Golf Meadows | Panvel | 21 | 23 Km | Kiran Sate, Taloja | 25 | 37km | Bhandup | 30-40 | | | |
| | PP Bag | Godrej Golf Meadows | Panvel | 18-20 | 16 Km | AK Enterprises, Kalamboli | 60-80 | | | | | | |
| | Glass | Godrej Golf Meadows | Panvel | 1 | 16.5 km | Siddiqui Scrap, Panvel | 3 | 80km | Nallasopara | 7 | 65.4km | Palghar | 10 |
| Pune | Cardboard | Godrej Park greens | Mamurdi | 10 | 9.2km | Eicher , Kudalwadi, Pune | 15 | 297Km | Eicher, Vapi, Gujarat | 45 | | | |
| | Metal and Plastic Containers | Godrej Nurture | Mamurdi | 25 | 15 Km | Deepak Enterprises,Bhosari | 40 | 65 Km | MIPL,Ranjangaon | | | | |
| | Steel (Scrap, Bars and Wire) | Godrej Park greens | Mamurdi | 30-35 | 10 km | Viraj, A S Traders, Pune | 35 | 310 km | Jalna,Maharashtra | 40 | | | |
| | Aluminium Shuttering | Godrej Park greens | Mamurdi | 180 | 10 km | Viraj, A S Traders, Pune | 200 | | | | | | |
| | Shuttering Ply | Godrej Park greens | Mamurdi | 2-6 | 14.6 Km | Siddogi Traders, Chikhali, Pune | 9 - 10 | | | | | | |
| Bengaluru | Cardboard | Godrej Royale woods | Devanahalli | 12 | 45km | Bharath Steel traders, Bommanhalli | 15 | 342km | Chennai | 50 | | | |
| | Steel (Scrap, Bars and Wire) | Godrej Royale woods | Devanahalli | 48 | 55km | Bharath Steel traders, Bommanhalli | 65 | 969km | Jalna | 200 | | | |

## Godrej Meridien

This project has 3 and 4 BHK apartments, with basements and 19, 23, 25 or 34 floors. Construction of 4 towers is almost complete, has started for 1 and pending for remaining 2.

LOCATION
**Gurugram, Haryana**

SITE AREA
**14.793 acres.**

BUILT UP AREA
**2008116 sqft.**

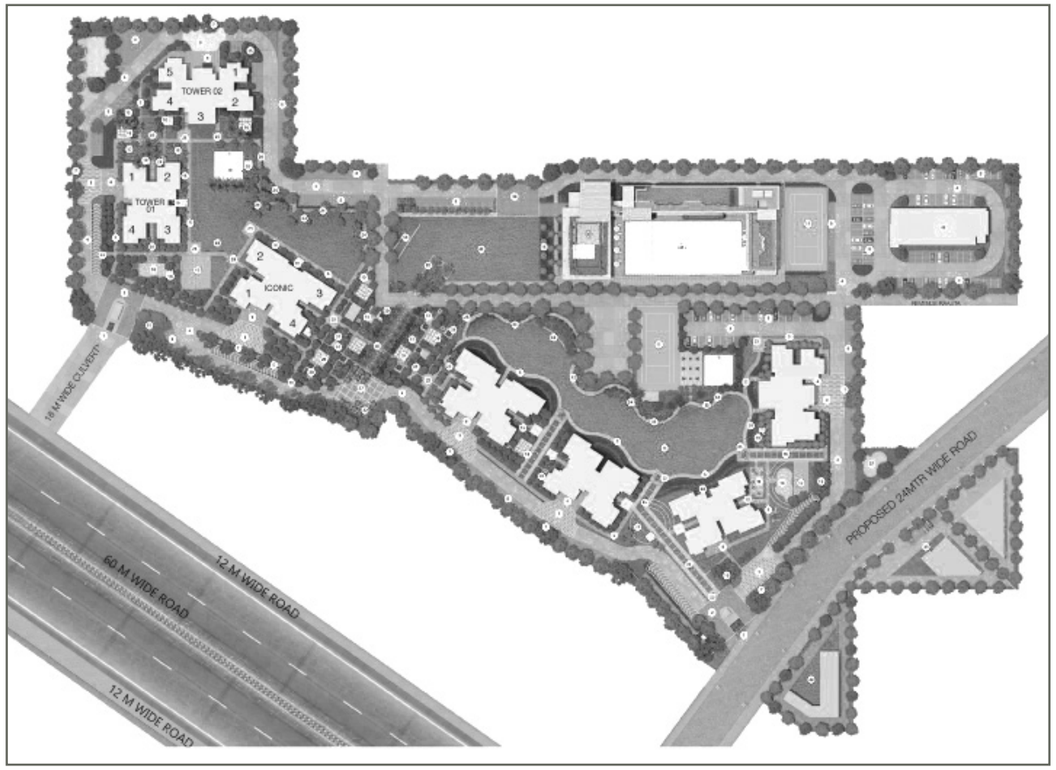
EXPECTED COMPLETION
**2026**

NUMBER OF TOWERS
**7**

NUMBER OF UNITS
**754**

Figure
**Tower Construction in progress**

Figure
**Master plan of Godrej Meridien**




Plan - Not to scale



## Godrej Nature Plus

This project has a combination of 2 and 3 BHK apartments. There is single basement in the project and each tower has either 18,22 or 24 floors. Project has a club area of 16,000 square feet.

LOCATION
**Gurugram, Haryana**

SITE AREA
**18.74 acres**

BUILT UP AREA
**22,60,582 Sqft**

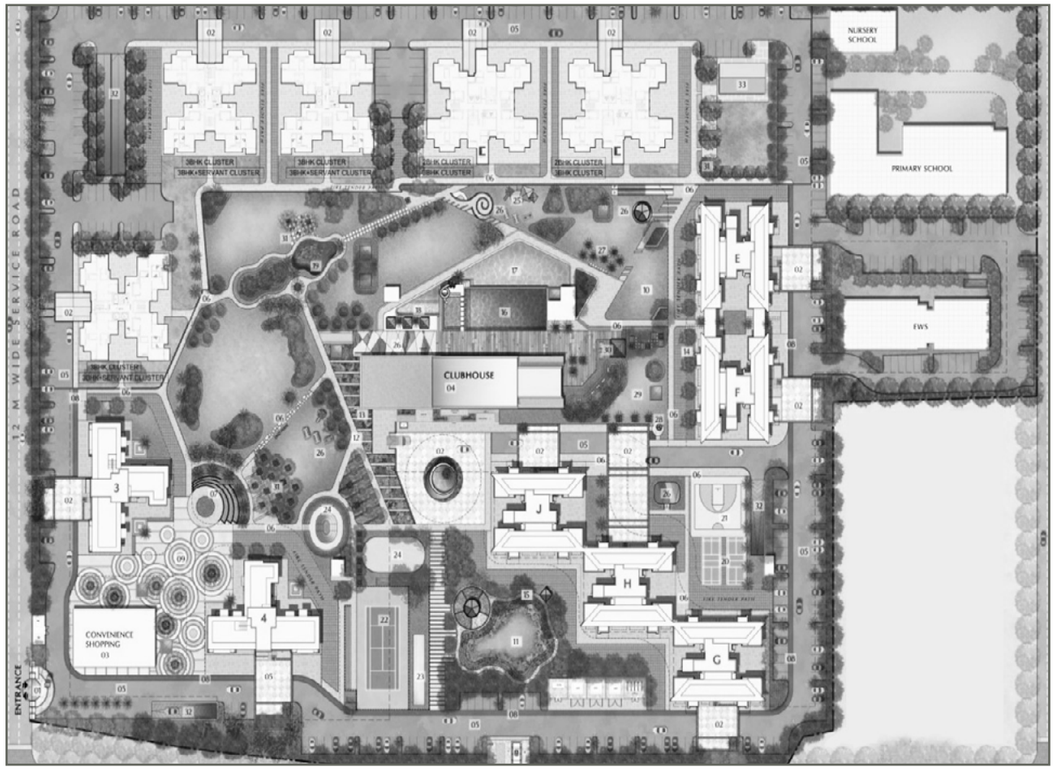
EXPECTED COMPLETION
**2025**

NUMBER OF TOWERS
**12**

NUMBER OF UNITS
**1094**

Figure
**Tower construction in progress**

Figure
**Master plan of Godrej Nature Plus**




Plan - Not to scale

## Godrej Golf Meadows

This project has a combination of 1, 2 and 3 BHK apartments. There are no basements and each tower has 27 floors.

LOCATION
**Panvel, Mumbai**

SITE AREA
**3.77 acres**

BUILT UP AREA
**677,759 sqft**

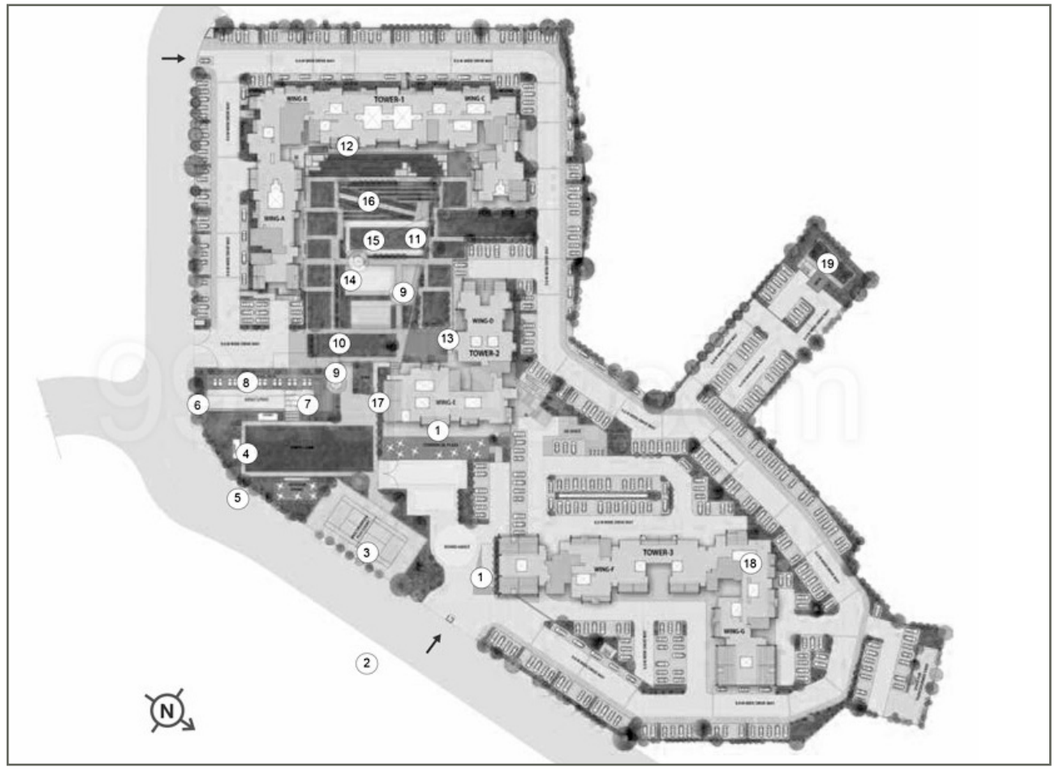
EXPECTED COMPLETION
**2023**

NUMBER OF TOWERS
**2**

NUMBER OF UNITS
**536**

Figure
**Phase 2 completion in progress**

Figure
**Master plan of Godrej Golf Meadows**




PLAN - NOT TO SCALE

## Godrej Nirvaan

This project has a combination of 1 and 2 BHK apartments. There are 2 basements and each tower has either 25 or 31 floors.

LOCATION
**Kalyan, Mumbai**

SITE AREA
**349,047 sqft**

BUILT UP AREA
**11,24,229 sqft**

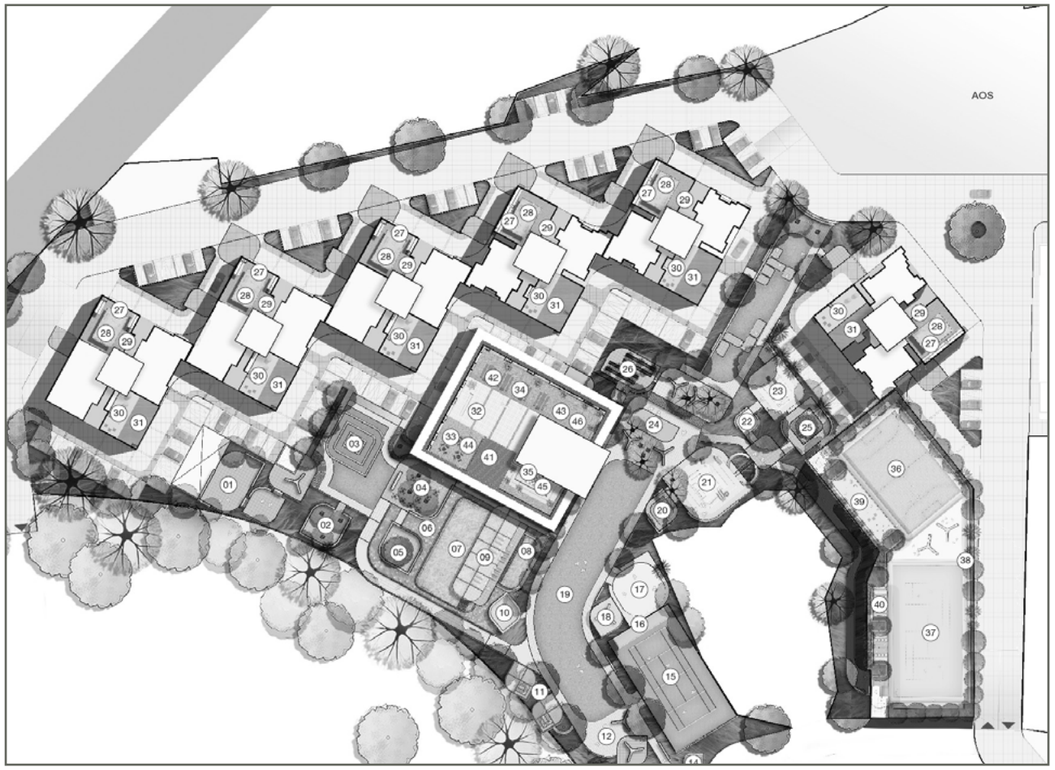
EXPECTED COMPLETION
**2023**

NUMBER OF TOWERS
**6**

NUMBER OF UNITS
**1176**

Figure
**Finishing stage in progress**

Figure
**Master plan of Godrej Nirvaan**




PLAN - NOT TO SCALE

## Godrej Emerald

This project has a combination of 2 and 3 BHK apartments. There is no basement and each tower has 27 or 30 floors. The project also has 3 podiums.

LOCATION
**Panvel, Mumbai**

SITE AREA
**6.29 acres.**

BUILT UP AREA
**18,80,000 Sft**

EXPECTED COMPLETION
**2025**

NUMBER OF TOWERS
**7**

NUMBER OF UNITS
**1279**

Figure
**Site development in progress**

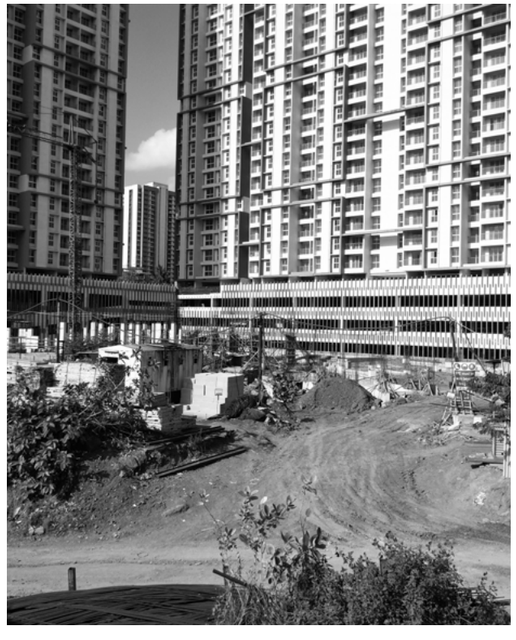
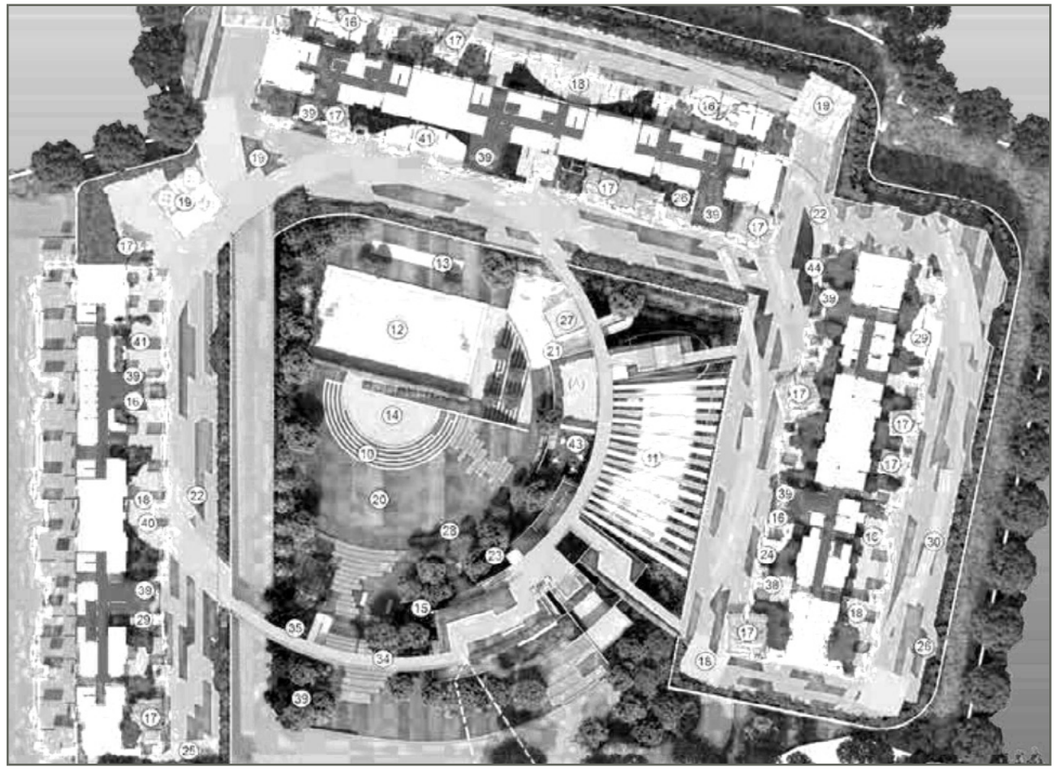


Figure
**Master plan of Godrej Emerald**



PLAN - NOT TO SCALE



## Godrej Nurture

This project has a combination of 1, 2 and 3 BHK apartments. There is single basement and each tower has 21 floors.

LOCATION
**Electronic city, Bengaluru**

SITE AREA
**5.91 acres**

BUILT UP AREA
**983,517 sqft**

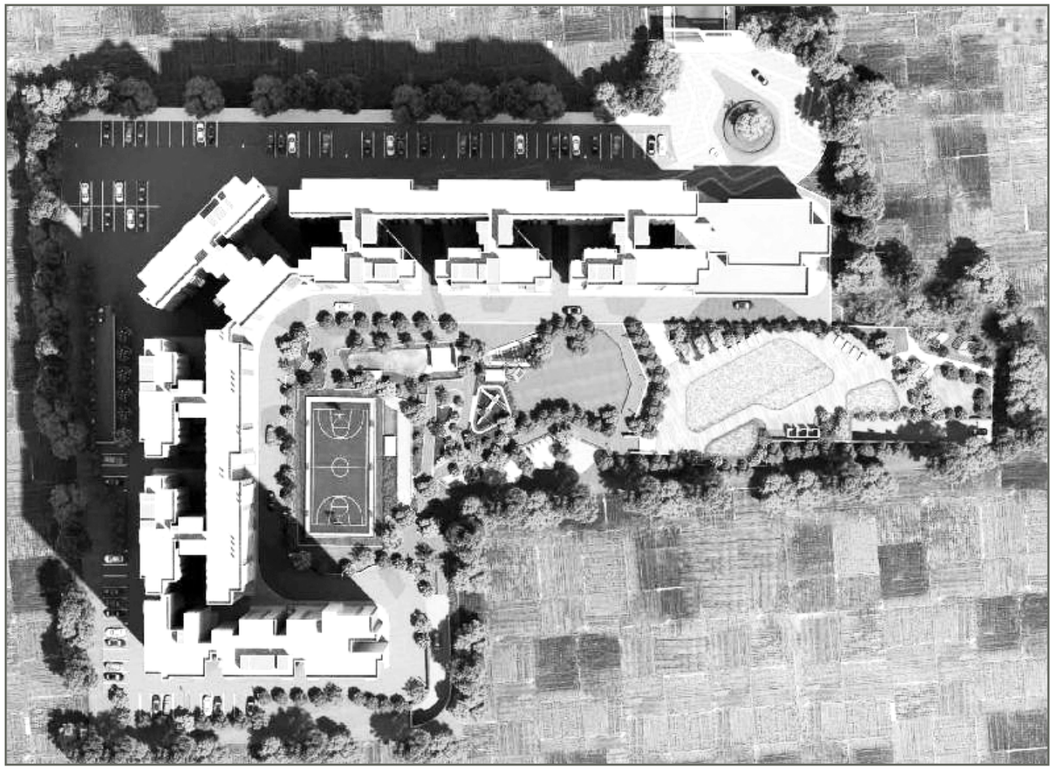
EXPECTED COMPLETION
**2023**

NUMBER OF TOWERS
**7**

NUMBER OF UNITS
**684**

Figure
**Tower 2 Construction in progress**

Figure
**Master plan of Godrej Nurture**



PLAN - NOT TO SCALE

## Godrej Ananda

This project has Studio, 2 and 3 BHK apartments. The towers have 28 floors.

LOCATION
**Bagalur, Bengaluru**

SITE AREA
**20.33 acres**

BUILT UP AREA
**10,29,317sqft**

EXPECTED COMPLETION
**2024**

NUMBER OF TOWERS
**3**

NUMBER OF UNITS
**806**

Figure
**Core and shell stage in progress**

Figure
**Master plan of Godrej Ananda**

PLAN - NOT TO SCALE



## Godrej Royale Woods

This project only has 3 BHK apartments. There is a single basement and each tower has 16 or 19 floors.

LOCATION
**Devanahalli, Bengaluru**

SITE AREA
**13 acres**

BUILT UP AREA
**1,319,439 sqft**

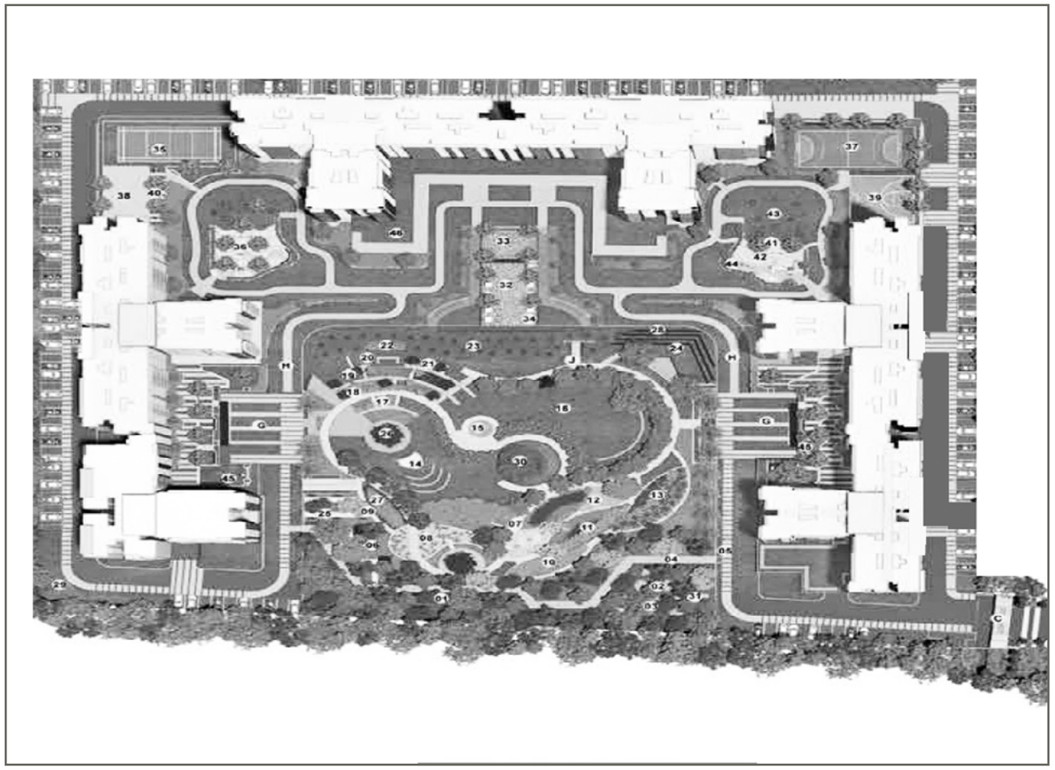
EXPECTED COMPLETION
**2025**

NUMBER OF TOWERS
**6**

NUMBER OF UNITS
**1178**

Figure
**Tower Construction in progress**

Figure
**Master plan of Godrej Royale woods**



Plan - Not to scale

## Mahindra Eden

This project has India's first eco-friendly 1, 2 and 3 BHK apartments. The towers have 26 or 28 floors.

LOCATION
**Kanakpura, Bengaluru**

SITE AREA
**337,590 sqft**

BUILT UP AREA
**10,53,000 sqft**

EXPECTED COMPLETION
**2025**

NUMBER OF TOWERS
**4**

NUMBER OF UNITS
**527**

Figure
**Site preparation stage in progress**

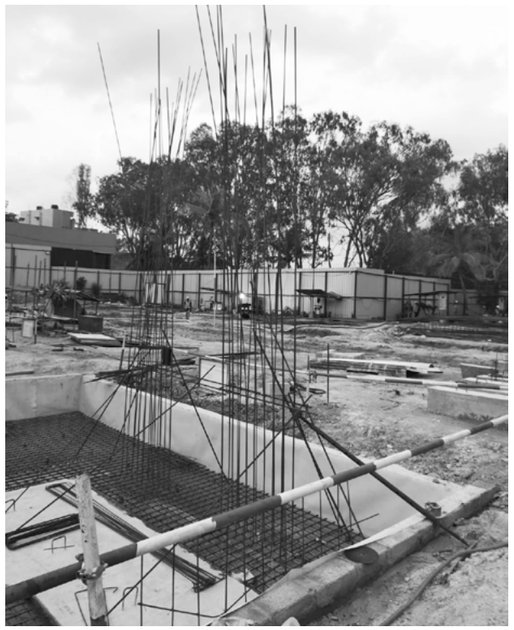


Figure
**Master plan of Mahindra Eden**

Plan - Not to scale



## Godrej Nurture

This project has a combination 2 and 3 BHK apartments. There are 3 podiums and each tower has 19 floors.

LOCATION
**Mamurdi, Pune**

SITE AREA
**16.90 acres**

BUILT UP AREA
**10,87,552 sqft**

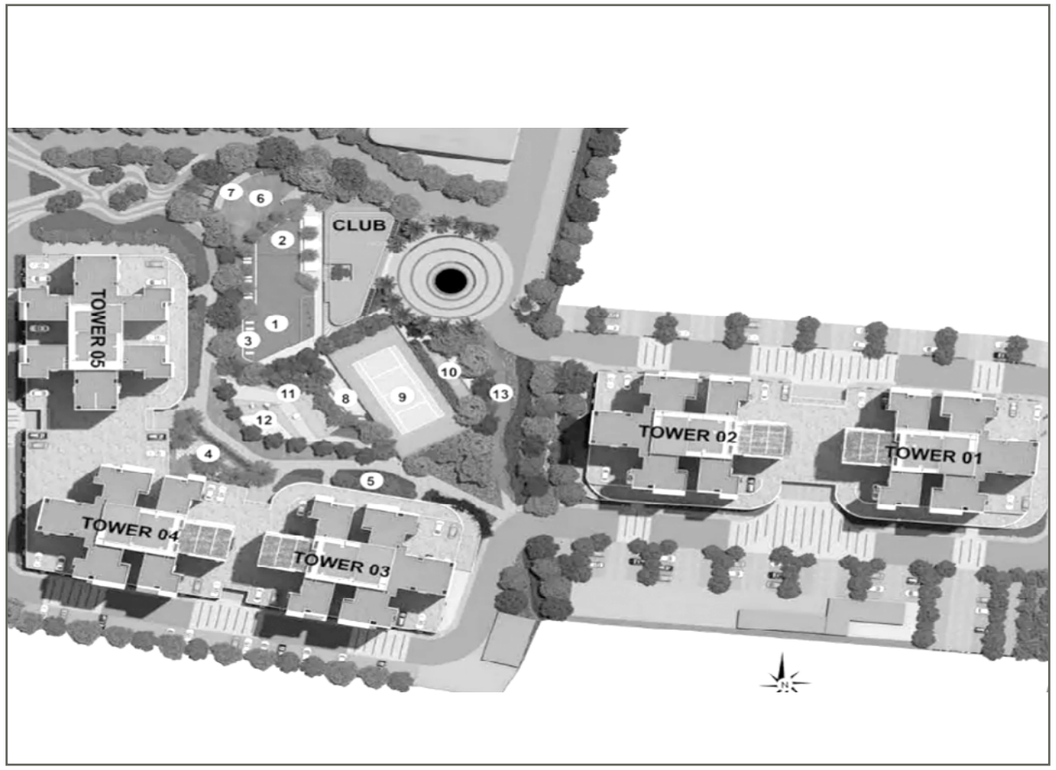
EXPECTED COMPLETION
**2024**

NUMBER OF TOWERS
**5**

NUMBER OF UNITS
**714**

Figure
**Podium Construction in progress**

Figure
**Master plan of Godrej Nurture**




PLAN - NOT TO SCALE

## Godrej Park Greens

This project has a combination 2 and 3 BHK apartments. There are stilts in the project and each tower has 22 floors.

LOCATION
**Mamurdi, Pune**

SITE AREA
**8.13 acres**

BUILT UP AREA
**3,145,795 sqft**

EXPECTED COMPLETION
**2024**

NUMBER OF TOWERS
**7**

NUMBER OF UNITS
**1190**

Figure
**Site work in progress**

Figure
**Master plan of Godrej Park green**

PLAN - NOT TO SCALE

## Mahindra Happinest

This project has a combination 1 and 2 BHK apartments. There is a multi-level car parking in the project and each tower has 14 or 22 floors and 1 basement.

LOCATION
**Tathawade, Pimpri-Chinchwad, Pune**

SITE AREA
**6.91 acres**

BUILT UP AREA
**517,845 sqft**

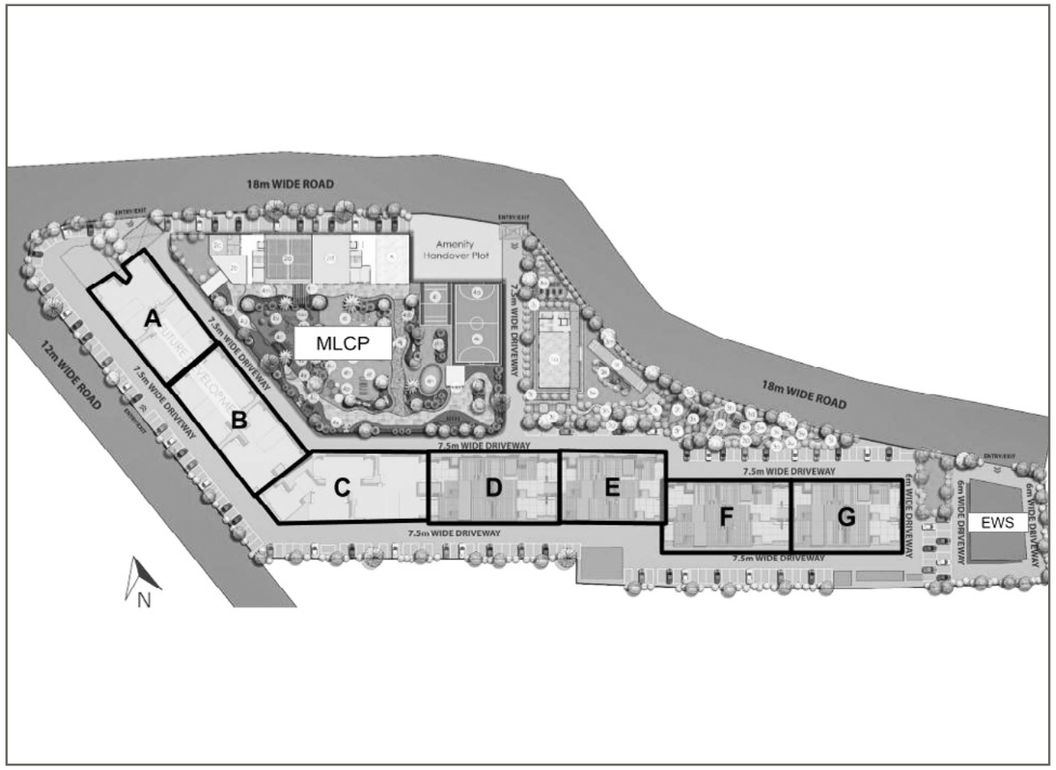
EXPECTED COMPLETION
**2024**

NUMBER OF TOWERS
**4**

NUMBER OF UNITS
**692**

Figure
**Core and shell stage in progress**

Figure
**Master plan of Mahindra Happinest**




PLAN - NOT TO SCALE

## Godrej Hillside

This project has a combination 1, 2 and 3 BHK apartments. There is a multi-level car parking in the project and each tower has 24 floors.

LOCATION
**Mahalunge, Pune**

SITE AREA
**4.3 acres**

BUILT UP AREA
**442,885 sqft**

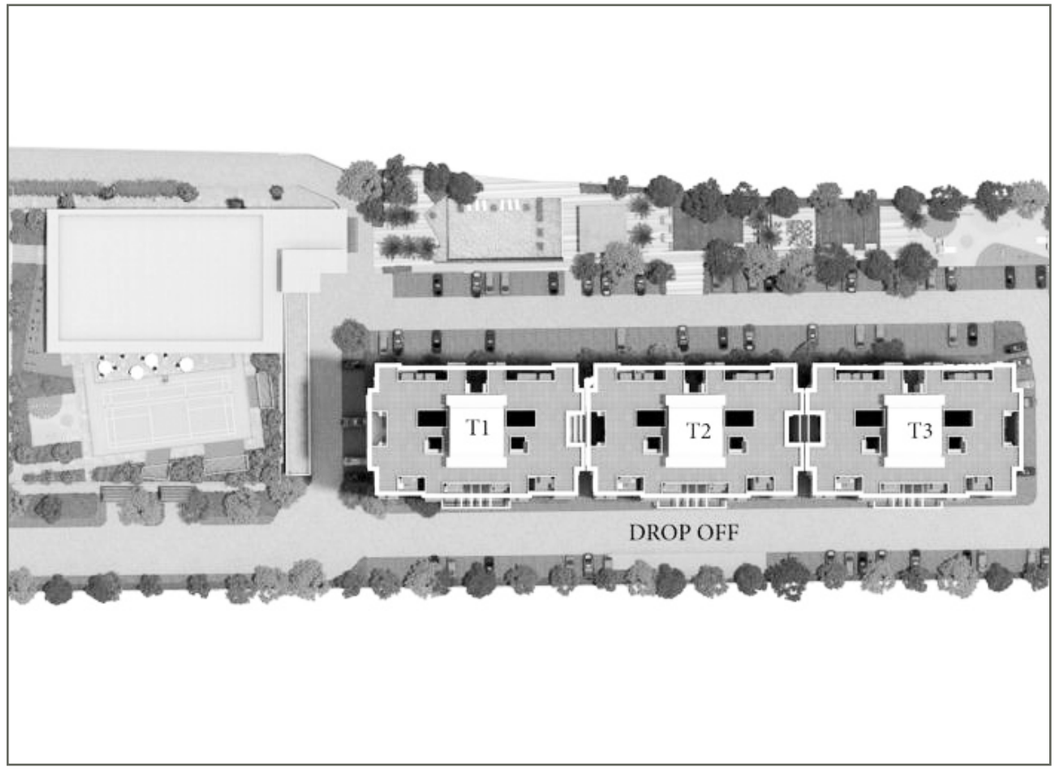
EXPECTED COMPLETION
**2023**

NUMBER OF TOWERS
**3**

NUMBER OF UNITS
**588**

Figure
**Finishing stage in progress**

Figure
**Master plan of Godrej Hillside**




PLAN - NOT TO SCALE



## Godrej Park Springs

This project has a combination 1, 2 and 3 BHK apartments with 23 floors in each tower. There is a multi-level car parking in the project.

LOCATION
**Manjari, Pune**

SITE AREA
**4.9 acres**

BUILT UP AREA
**741,000 sqft**

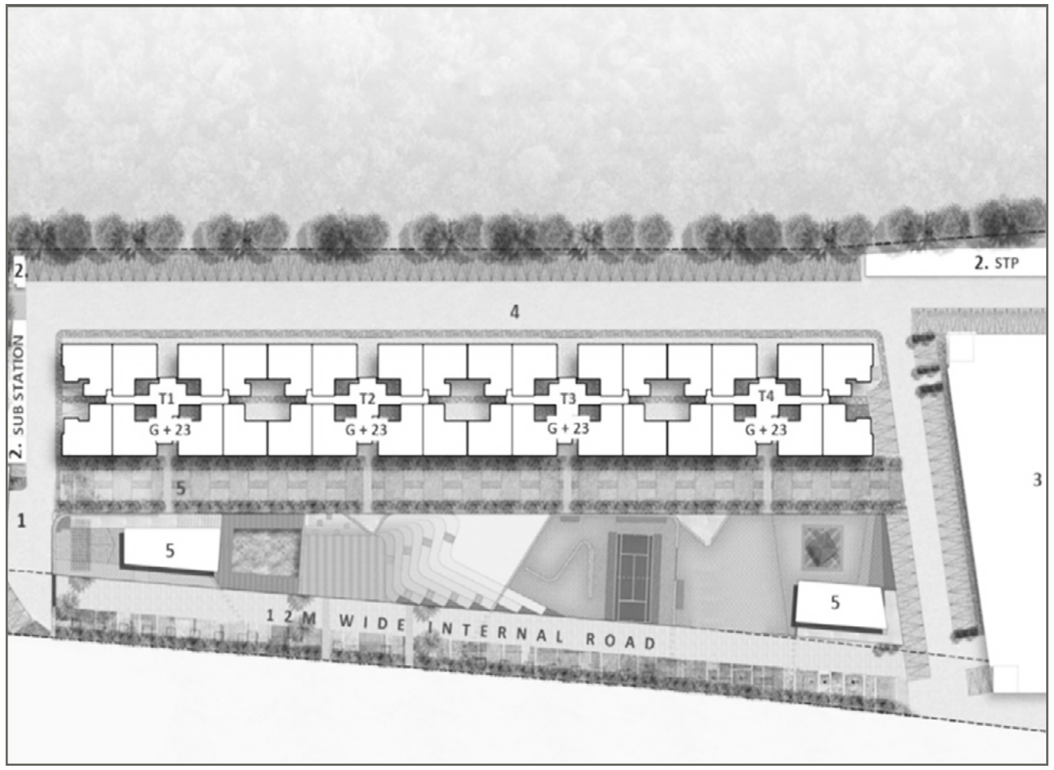
EXPECTED COMPLETION
**2025**

NUMBER OF TOWERS
**4**

NUMBER OF UNITS
**752**

Figure
**Site work in progress**

Figure
**Master plan of Godrej Park Springs**




PLAN - NOT TO SCALE

**[Published In the Gazette of India, Part-II, Section-3, Sub-section (ii)]**
**Ministry of Environment, Forest and Climate Change**

**NOTIFICATION**

**New Delhi, the 29th March, 2016**

**G.S.R. 317(E).-**Whereas the Municipal Solid Wastes (Management and Handling) Rules, 2000 published vide notification number S.O. 908(E), dated the 25th September, 2000 by the Government of India in the erstwhile Ministry of Environment and Forests, provided a regulatory frame work for management of Municipal Solid Waste generated in the urban area of the country;

And whereas, to make these rules more effective and to improve the collection, segregation, recycling, treatment and disposal of solid waste in an environmentally sound manner, the Central Government reviewed the existing rules and it was considered necessary to revise the existing rules with a emphasis on the roles and accountability of waste generators and various stakeholders, give thrust to segregation, recovery, reuse, recycle at source, address in detail the management of construction and demolition waste.

And whereas, the draft rules, namely, the Solid Waste Management Rules, 2015 with a separate chapter on construction and demolition waste were published by the Central Government in the Ministry of Environment, Forest and Climate Change vide G.S.R. 451 (E), datedthe 3rd June, 2015 inviting objections or suggestions from the public within sixty days from the date of publication of the said notification;

And Whereas, the objections or suggestions received within the stipulated period were duly considered by the Central Government;

Now, therefore, in exercise of the powers conferred by sections 6, 25 of the Environment (Protection) Act, 1986 (29 of 1986), and in supersession of the Municipal Solid Wastes (Management and Handling) Rules, 2000, except as respect things done or omitted to be done before such supersession, the Central Government hereby notifies the following rules for Management of Construction and Demolition Waste –

**1. Short title and commencement.-**(1) These rules shall be called the Construction and Demolition Waste Management Rules, 2016.

(2) They shall come into force on the date of their publication in the Official Gazette.

**2. Application.-**The rules shall apply to every waste resulting from construction, re-modeling, repair and demolition of any civil structure of individual or organisation or authority who generates construction and demolition waste such as building materials, debris, rubble.

**3. Definitions –**(1) In these rules, unless the context otherwise requires,-

(a) " ACT' means the Environment ( Protection) Act, 1986 (29 of 1986);

(b) "**construction**" means the process of erecting of building or built facility or other structure, or



building of infrastructure including alteration in these entities,;

(c) "**construction and demolition waste**" means the waste comprising of building materials, debris and rubble resulting from construction, re-modeling, repair and demolition of any civil structure;

(d) **"de-construction"** means a planned selective demolition in which salvage, re-use and recycling of the demolished structure is maximized;

**(e) "demolition"** means breaking down or tearing down buildings and other structures either manually or using mechanical force (by various equipment) or by implosion using explosives.

**(f) "form" means a Form annexed to these rules;**

**(g) "local authority"** means an urban local authority with different nomenclature such as municipal corporation, municipality, nagarpalika, nagarnigam, nagarpanchayat, municipal council including notified area committee and not limited to or any other local authority constituted under the relevant statutes such as gram panchayat, where the management of construction and demolition waste is entrusted to such agency;

**(h) " schedule"** means a schedule annexed to these rules;

**(i) "service provider'** means authorities who provide services like water, sewerage, electricity, telephone, roads, drainage etc. often generate construction and demolition waste during their activities, which includes excavation, demolition and civil work;

**(j) "waste generator" means any person or association of persons** or institution, residential and commercial establishments including Indian Railways, Airport, Port and Harbour and Defence establishments who undertakes construction of or demolition of any civil structure which generate construction and demolition waste.

(2) Words and expressions used but not defined herein shall have the same meaning defined in the ACT.

**(4) Duties of the waste generator -**

(1) 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.

(2) The generator shall ensure that other waste (such as solid waste) does not get mixed with this waste and is stored and disposed separately.

(3) Waste generators who generate more than 20 tons or more in one day or 300 tons per project in a month shall segregate the waste into four streams such as concrete, soil, steel, wood and plastics, bricks and mortar and shall submit waste management plan and get appropriate approvals from the local authority before starting construction or demolition or remodeling work and keep the concerned

authorities informed regarding the relevant activities from the planning stage to the implementation stage and this should be on project to project basis.

(4) Every waste generator shall keep the construction and demolition waste within the premise or get the waste deposited at collection centre so made by the local body or handover it to the authorised 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 drains.

(5) Every waste generator shall pay relevant charges for collection, transportation, processing and disposal as notified by the concerned authorities; Waste generators who generate more than 20 tons or more in one day or 300 tons per project in a month shall have to pay for the processing and disposal of construction and demolition waste generated by them, apart from the payment for storage, collection and transportation. The rate shall be fixed by the concerned local authority or any other authority designated by the State Government.

**(5) Duties of service provider and their contractors -**

(1) The service providers shall prepare within six months from the date of notification of these rules, a comprehensive waste management plan covering segregation, storage, collection, reuse, recycling, transportation and disposal of construction and demolition waste generated within their jurisdiction.

(2) The service providers shall remove all construction and demolition waste and clean the area every day, if possible, or depending upon the duration of the work, the quantity and type of waste generated, appropriate storage and collection, a reasonable timeframe shall be worked out in consultation with the concerned local authority.

(3) In case of the service providers have no logistics support to carry out the work specified in sub-rules (1) and (2) , they shall tie up with the authorised agencies for removal of construction and demolition waste and pay the relevant charges as notified by the local authority.

**(6) Duties of local authority-**The local authority shall,-

(1) issue detailed directions with regard to proper management of construction and demolition waste within its jurisdiction in accordance with the provisions of these rules and the local authority shall seek detailed plan or undertaking as applicable, from generator of construction and demolition waste;

(2) chalk out stages, methodology and equipment, material involved in the overall activity and final clean up after completion of the construction and demolition ;

(3c) seek assistance from concerned authorities for safe disposal of construction and demolition waste contaminated with industrial hazardous or toxic material or nuclear waste if any;

(4) shall make arrangements and place appropriate containers for collection of waste and shall remove at regular intervals or when they are filled, either through own resources or by appointing private operators;



(5) shall get the collected waste transported to appropriate sites for processing and disposal either through own resources or by appointing private operators;

(6) shall give appropriate incentives to generator for salvaging, processing and or recycling preferably in-situ;

(7) shall examine and sanction the waste management plan of the generators within a period of one month or from the date of approval of building plan, whichever is earlier from the date of its submission;

(8) shall keep track of the generation of construction and demolition waste within its jurisdiction and establish a data base and update once in a year;

(9) shall device appropriate measures in consultation with expert institutions for management of construction and demolition waste generated including processing facility and for using the recycled products in the best possible manner;

(10) shall create a sustained system of information, education and communication for construction and demolition waste through collaboration with expert institutions and civil societies and also disseminate through their own website;

(11) shall make provision for giving incentives for use of material made out of construction and demolition waste in the construction activity including in non-structural concrete, paving blocks, lower layers of road pavements, colony and rural roads.

**(7) Criteria for storage, processing or recycling facilities for construction and demolition waste and application of construction and demolition waste and its products-**

(1) The site for storage and processing or recycling facilities for construction and demolition waste shall be selected as per the criteria given in **Schedule I**;

(2) The operator of the facility as specified in sub- rules (1) shall apply in **Form I** for authorization from State Pollution Control Board or Pollution Control Committee.

(3) The operator of the facility shall submit the annual report to the State Pollution Control Board in **Form II.**

(3) Application of materials made from construction and demolition waste in operation of sanitary landfill shall be as per the criteria given in **Schedule II.**

**(8) Duties of State Pollution Control Board or Pollution Control Committee-**

(1) State Pollution Control Board or Pollution Control Committee shall monitor the implementation of these rules by the concerned local bodies and the competent authorities and the annual report shall be sent to the Central Pollution Control Board and the State Government or Union Territory or any other State level nodal agency identified by the State Government or Union Territory administration for generating State level comprehensive data. Such reports shall also contain the comments and suggestions of the State Pollution Control Board or Pollution Control Committee with respect to any comments or changes required;

(2) State Pollution Control Board or Pollution Control Committee shall grant authorization to construction and demolition waste processing facility in **Form-III** as specified under these rules after examining the application received in **Form I**;

(3) State Pollution Control Board or Pollution Control Committee shall prepare annual report in **Form IV** with special emphasis on the implementation status of compliance of these rules and forward report to Central Pollution Control Board before the 31st July for each financial year.

**(9) Duties of State Government or Union Territory Administration-**

(1) The Secretary in-charge of development in the State Government or Union territory administration shall prepare their policy document with respect to management of construction and demolition of waste in accordance with the provisions of these rules within one year from date of final notification of these rules.

(2) The concerned department in the State Government dealing with land shall be responsible for providing suitable sites for setting up of the storage, processing and recycling facilities for construction and demolition waste.

(3) The Town and Country planning Department shall incorporate the site in the approved land use plan so that there is no disturbance to the processing facility on a long term basis.

(4) Procurement of materials made from construction and demolition waste shall be made mandatory to a certain percentage (say 10-20%) in municipal and Government contracts subject to strict quality control.

**(10) Duties of the Central Pollution Control Board -** (1) The Central Pollution Control Board shall,-

(a) prepare operational guidelines related to environmental management of construction and demolition waste management;

(b) analyze and collate the data received from the State Pollution Control Boards or Pollution Control Committee to review these rules from time to time;

(c) coordinate with all the State Pollution Control Board and Pollution Control Committees for any matter related to development of environmental standards;

(d) forward annual compliance report to Central Government before the 30th August for each financial year based on reports given by State Pollution Control Boards of Pollution Control Committees.

**(11) Duties of Bureau of Indian Standards and Indian Roads Congress -**The Bureau of Indian Standards and Indian Roads Congress shall be responsible for preparation of code of practices and standards for use of recycled materials and products of construction and demolition waste in respect of construction activities and the role of Indian Road Congress shall be specific to the standards and practices pertaining to construction of roads.

5



**(12) Duties of the Central Government -**

(1) The Ministry of Urban Development, and the Ministry of Rural Development, Ministry of Panchayat Raj, shall be responsible for facilitating local bodies in compliance of these rules;

(2) The Ministry of Environment, Forest and Climate Change shall be responsible for reviewing implementation of these rules as and when required.

**13. Timeframe for implementation of the provisions of these rules -**The timeline for implementation of these rules shall be as specified in **Schedule III:**

**14. Accident reporting by the construction and demolition waste processing facilities-**In case of any accident during construction and demolition waste processing or treatment or disposal facility, the officer in charge of the facility in the local authority or the operator of the facility shall report of the accident in **Form-V** to the local authority. Local body shall review and issue instruction if any, to the in-charge of the facility.

**Schedule I**
**Criteria for Site Selection for Storage and Processing or Recycling Facilities for construction and demolition Waste**
**[See Rule 7(1)]**

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

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

(3) Construction and demolition waste shall be utilized in sanitary landfill for municipal solid waste of the city or region as mentioned at Schedule I of thse rule. Residues from construction and demolition waste processing or recycling industries shall be land filled in the sanitary landfill for solid waste.

(4) The processing or recycling shall be large enough to last for 20-25 years (project based on-site recycling facilities).

(5) The processing or recycling site shall be away from habitation clusters, forest areas, water bodies, monuments, National Parks, Wetlands and places of important cultural, historical or religious interest.

(6) A buffer zone of no development shall be maintained around solid waste processing and disposal facility, exceeding five Tonnes per day of installed capacity. This will be maintained within the

total area of the solid waste processing and disposal facility. The buffer zone shall be prescribed on case to case basis by the local authority in consultation with concerned State Pollution Control Board.

(7) Processing or recycling site shall be fenced or hedged and provided with proper gate to monitor incoming vehicles or other modes of transportation.

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

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

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

(11) In order to prevent pollution from processing or recycling operations, the following provisions shall be made, namely:

(a) Provision of storm water drains to prevent stagnation of surface water;
(b) Provision of paved or concreted surface in selected areas in the processing or recycling facility for minimizing dust and damage to the site.
(c) Prevention of noise pollution from processing and recycling plant:
(d) provision for treatment of effluent if any, to meet the discharge norms as per Environment (Protection) Rules, 1986.

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

(13) The measurement of ambient noise shall be done at the interface of the facility with the surrounding area, i.e., at plant boundary.

(14) The following projects shall be exempted from the norms of pollution from dust and noise as mentioned above:

For construction work, where at least 80 percent construction and demolition waste is recycled or reused in-situ and sufficient buffer area is available to protect the surrounding habitation from any adverse impact.

(15) A vegetative boundary shall be made around Processing or Recycling plant or site to strengthen the buffer zone.



**Schedule II**

**Application of materials made from construction and demolition waste and its products.**

**[See Rule 7(3)]**

| Sl. No. | Parameters | Compliance Criteria |
|---|---|---|
| **1** | Drainage layer in leachate collection system at bottom of Sanitary Landfill Gas Collection Layer above the waste at top of Sanitary Landfill and<br>Drainage Layer in top Cover System above Gas Collection Layer of Sanitary Landfill<br>For capping of sanitary landfill or dumpsite, drainage layer at the top | Only crushed and graded hard material (stone, concrete etc.) shall be used having coarse sand size graded material (2mm – 4.75mm standard sieve size).<br>Since the coarse sand particles will be angular in shape (and not rounded as for riverbed sand), protection layers of non-woven geo-textiles may be provided, wherever required, to prevent puncturing of adjacent layers or components. |
| **2** | Daily cover | Fines from construction and demolition processed waste having size up to 2 mm shall be used for daily cover over the fresh waste.<br><br>Use of construction and demolition fines as landfill cover shall be mandatory where such material is available. Fresh soil (sweet earth) shall not be used for such places and borrow-pits shall not be allowed. Exception – soil excavated during construction of the same landfill.<br>During hot windy days in summer months, some fugitive dust problems may arise. These can be minimised by mixing with local soil wherever available for limited period. |
| **3** | Civil construction in a sanitary landfill | Non-structural applications, such as kerb stones, drain covers, paving blocks in pedestrian areas. |

**Schedule III**
**Timeframe for Planning and Implementation**
**[See Rule 13]**

| Sl. No. | Compliance Criteria | Cities with population of 01 million and above | Cities with population of 0.5-01 million | Cities with population of less than 0.5 million |
|---|---|---|---|---|
| 1 | Formulation of policy by State Government | 12 months | 12 months | 12 months |
| 2 | Identification of sites for collection and processing facility | 18 months | 18 months | 18 months |
| 3 | Commissioning and implementation of the facility | 18 months | 24 months | 36 months |
| 4 | Monitoring by SPCBs | 3 times a year – once in 4 months | 2 times a year – once in 6 months | 2 times a year – once in 6 months |

***The time Schedule is effective from the date of notification of these rules.***

**FORM – I**
**See [Rule 7 (2)]**
**Application for obtaining authorisation**

To,
The Member Secretary

_____Name of the local authority or Name of the agency : appointed by the municipal authority

| | |
|---|---|
| Correspondence address<br>Telephone No.<br>Fax No. | |
| Nodal Officer and designation (Officer authorized by the competent authority or agency responsible for operation of processing or recycling or disposal facility) | |
| Authorisation applied for (Please tick mark) | Setting up of processing or recycling facility of construction and demolition waste |
| Detailed proposal of construction and demolition waste processing or recycling facility to include the following<br>Location of site approved and allotted by the Competent Authority.<br>Average quantity (in tons per day) and composition of construction and demolition waste to be handled at the specific site.<br>Details of construction and demolition waste processing or recycling technology to be used.<br>Quantity of construction and demolition waste to be processed per day.<br>Site clearance from Prescribed Authority.<br>Salient points of agreement between competent authority or local authority and operating agency (attach relevant document).<br>Plan for utilization of recycled product.<br>Expected amount of process rejects and plan for its disposal (e.g., sanitary landfill for solid waste).<br>Measures to be taken for prevention and control of environmental pollution.<br>Investment on project and expected returns.<br>Measures to be taken for safety of workers working in the processing or recycling plant.<br>Any preventive plan for accident during the collection, transportation and treatment including processing and recycling should be informed to the Competent Authority (Local Authority) or Prescribed Authority | |
| **Date:** | **Signature of Nodal Officer** |

**Form-II**

**See [Rule (7) (3)]**
**Format for Issue of Authorisation to the Operator**

File No.: _____
Date : _____

To,

_____
_____
_____

**Ref : Your application number _____Dt. ……**

The _____ State Pollution Control Board or Pollution Control Committee after examining the proposal hereby authorizes _____ having their administrative office at _____ to set up and operate construction and demolition waste processing facility at_____ on the terms and conditions (including the standards to comply) attached to this authorisation letter.

1. The validity of this authorisation is till _____. After expiry of the validity period, renewal of authorisation is to be sought.

2. The _____ State Pollution Control Board or Pollution Control Committee may, at any time, for justifiable reason, revoke any of the conditions applicable under the authorisation and shall communicate the same in writing.

3. Any violation of the provision of the construction and demolition Waste Management Rules, 2016 shall attract the penal provision of the Environment (Protection) Act, 1986 (29 of 1986).

**Date:**
**Place:**

**(Member Secretary)**
**State Pollution Control Board/**
**Pollution Control Committee**



**Form –III**

**See [Rule 8(2) ]**

**Format of Annual Report to be submitted by Local Authority to the State Pollution Control Board**

(i) Name of the City or Town…….
(ii) Population……
(iii) Name and address of local authority or competent authority

Telephone No : ……
Fax : …….
Email ID: …….
Website: ……..

(iv) Name of In-charge or Nodal Officer dealing with construction and demolition wastes management with designation ……

**1. Quantity and composition of construction and demolition waste including any deconstruction waste**

(a) Total quantity of construction and demolition waste generated during the whole year in metric ton

Any figures for lean period and peak period generation per day ……..
Average generation of construction and demolition waste (TPD)
Total quantity of construction and demolition waste collected per day
Any Processing / Recycling Facility set up in the city ……
Status of the facility

(b) Total quantity of construction and demolition waste processed / recycled (in metric ton)

Non-structural concrete aggregate :
Manufactured sand :
Ready-mix concrete (RMC) :
Paving blocks :
GSB :
Others, if any, please specify :

(c) Total quantity of Construction & Demolition waste disposed by land filling without processing (last option) or filling low lying areas

No of landfill sites used :
Area used :
Whether weigh-bridge facility used for quantity estimation? : Yes No

(d) Whether construction and demolition waste used in sanitary landfill (for solid waste) as per Schedule III

: Yes No

**2. Storage facilities**

(a) Area orlocation or plot or societies covered for collection of Construction and Demolition waste

(b) No. of large Projects (including roadways project) covered

(c) Whether Area or location or plot or societies collection is
Practiced (if yes, whether done by
Competent Authority or Local Authority or through Private Agency
or Non-Governmental Organization) :

(d) Storage Bins : ----------

| | Specifications (Shape & Size) | Existing Number | Proposed for future |
|---|---|---|---|
| (i) Containers or receptacle (Capacity) : | | | |
| (ii) Others, please specify : | | | |

(e) Whether all storage bins/collection spots are
attended for daily lifting : Yes No

(e) Whether lifting of Construction & Demolition
Waste from Storage bins is manual or mechanical
(please tick mark) please specify mode : Manual Mechanical Others,
and equipment used (specify equipment)

**3. Transportation**

| | Existing Actually Required/Proposed number |
|---|---|
| Truck : | |
| Truck-Hydraulic : | |
| Tractor-Trailer : | |
| Dumper-placers : | |
| Tricycle : | |
| Refuse-collector : | |
| Others (Please specify) : | |

**4. Whether any proposal has been made to improve Construction and Demolition waste management practices**

**5. Have any efforts been made to involve PPP for processing of Construction & Demolition waste :**
**If yes, what is (are) the technologies being used, such as:**

| Processing / recycling Technology | (Quantity to be processed) | Steps taken |
|---|---|---|
| Dry Process : | | |
| Wet Process : | | |
| Others, if any, Please specify : | | |

**6. What provisions are available to check unauthorized operations of:**

Encroachment on river bank or wet bodies :
Unauthorized filling of low line areas :
Mixing with solid waste :
Encroachment in Parks, Footpaths etc. :

**7. How many slums are provided with construction and demolition waste receptacles facilities:**

**8. Are municipal magistrates appointed**
**for taking penal action for non-compliance with these rules:** Yes No
[ If yes, how many cases registered & settled during last three years (give year wise details)]

**Dated:** **Signature of Municipal Commissioner**

**Form –IV**

**See [Rule (8)(3)]**

**Format of Annual Report to be submitted by the State Pollution Control Board / Committees to the Central Pollution Control Board**

To,

The Chairman,
Central Pollution Control Board,
PariveshBhawan, East Arjun Nagar,
Delhi-110032

**Form –IV**

**See [Rule (8)(3)]**

**Format of Annual Report to be submitted by the State Pollution Control Board / Committees to the Central Pollution Control Board**

To,

The Chairman,
Central Pollution Control Board,
PariveshBhawan, East Arjun Nagar,
Delhi-110032

1. Name of the State/Union territory :

2. Name & address of the State Pollution Control Board/Pollution Control Committee :

3. Number of municipal authorities responsible for management of municipal solid wastes in the State/Union territory under these rules :

4. A Summary Statement on progress made by municipal authorities in respect of implementation of **Schedule III**] : Please attach as Annexure-I

5. A Summary Statement on progress made by municipal authorities in respect of implementation of **Schedule IV** : Please attach as Annexure-II

**Date:** **Chairman or the Member Secretary**
**State Pollution Control Board/**
**Place:** **Pollution Control Committee**

**Form –V**
**See [ Rule14]**
**Accident reporting**

1. Date and time of accident :

2. Sequence of events leading to accident :

3. The type of construction and demolition waste involved in accident :

4. Assessment of the effects of the accidents
   a. on traffic, drainage system and the environment :

5. Emergency measures taken :

6. Steps taken to alleviate the effects
   a. of accidents :

7. Steps taken to prevent the recurrence
   a. of such an accident :

8. Regular monthly health checkup of workers at

   a. Processing / recycling site shall be made

9. Any accident during the collection,
   a. transportation and treatment including
   b. processing and recycling should be informed
   c. to the Competent Authority (Local Authority) or
   d. Prescribed Authority

Date : Authorized Signatory
Place: Designation

[18-6/2014-HSMD]
Joint Secretary

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