

HANDBOOK OF CLEAN CONSTRUCTION PRACTICES IN SURAT

Developed Under
Surat Clean Air Action Plan
2020



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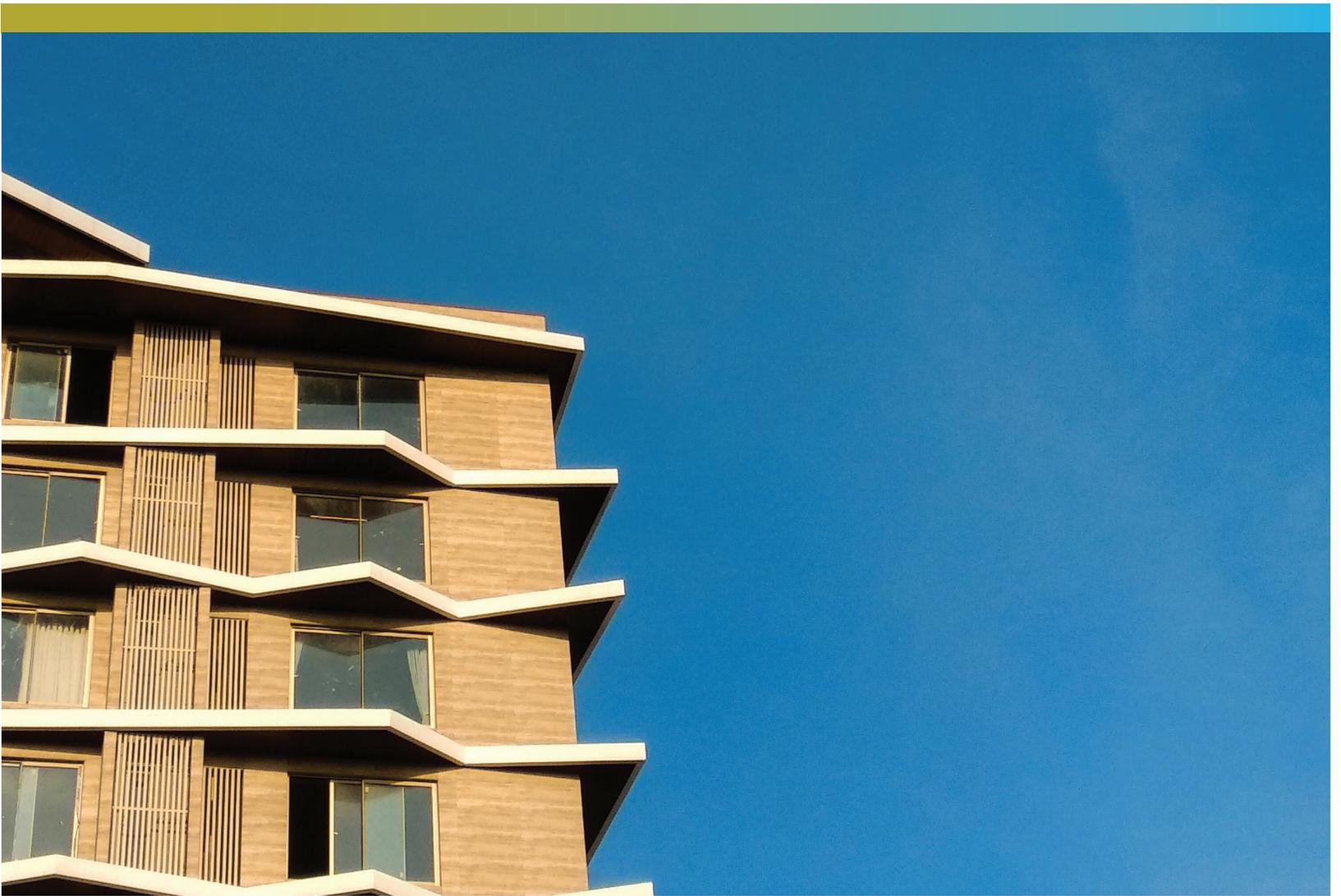
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Abbreviations

AAQI	Ambient Air Quality Index
APF	Assigned Protection Factor
ACGIH	American Conference of Governmental Industrial Hygienists (USA)
BIS	Bureau of Indian Standards
BAP	Best Available Practices
C & D	Construction and Demolition Waste
CPCB	Central Pollution Control Board
GPCB	Gujarat Pollution Control Board
CREDAI	Confederation of Real Estate Developers' Associations of India
DALY	Disability Adjusted to Life Years
DGFASLI	Directorate General Factory Advice Service and Labour Institutes (India)
DPM	Diesel Particulate Matter
IMD	Indian Meteorological Department
LEV	Local Exhaust Ventilation
LST	Land Surface Temperature
MoEFCC	Ministry of Environment Forest and Climate Change
NBC	National Building Code, 2016
NCAP	National Clean Air Programme
NGT	National Green Tribunal
NIOSH	National Institute of Occupational Safety and Health (USA)
NOx	Nitrogen Oxides
SOx	Sulphur Oxides
OHSA	Occupational Health and Safety Act (USA)
PM	Particulate Matter
PPE	Personal Protective Equipment
RCC	Reinforced Cement Concrete
RERA	Real Estate Regulatory Authority
RMC	Ready Mix Concrete
SCAP	Surat Clean Air Action Plan
SCBA	Self Contained Breathing Apparatus/Respirator
SMC	Surat Municipal Corporation
SOP	Standard Operating Procedures
SPM	Suspended Particulate Matter
SSEF	Shakti Sustainable Energy Foundation
STEL	Short Term Exposure Limit
SUDA	Surat Urban Development Authority
TERI	The Energy and Resources Institute
TLV-TWA	Threshold Limit Value – Time Weighted Average
ULB	Urban Local Body
WHO	World Health Organization
WRI-I	World Resources Institute India

1. THE NEED FOR THIS HANDBOOK

Air pollution has become a serious environmental and health concern in India, causing premature deaths of an estimated 1.2 million people every year (Global Burden of Diseases India, 2018). Over the years, there have been several significant developments in the policy space, by governments, institutions, and civil society, sometimes under the impulsion of the judiciary to mitigate the rising air pollution problem. With these policy interventions and regulations, air quality has purportedly shown some minor improvement, which is not sufficient and needs more focused initiatives. The stakeholder community at large is still not engaging enough on the issue, and there is a steep need of impartment of awareness and knowledge on the effects of poor air quality on community health in general. The best way to engage more and more stakeholders is by providing them with a fact-based approach and results indicating how different human activities are affecting the quality of air in their area.

World Resource Institute India (WRI India) has found that differences in the level of mitigation action by air pollution contributory sectors, such as transportation, industries, and construction, depends on sector awareness about impacts of pollution. Awareness of the problem represents a barrier to the effectiveness of air quality policy measures. Increasing public awareness about health benefits of clean air is therefore essential for improving success quotient and support for air quality management measures. WRI India believes that providing cities with improved information realization in the form of already existing legislation and retrofitting the action in the most people-friendly way through effective strategies and tools could contribute to delivering a sustainable measure of having healthy 'Air-Line.'

Construction materials and the building sector are responsible for more than 40% of global resource consumption.¹ The emission of particulate matter at construction sites has a negative impact on human health and the surrounding ecosystem. Studies have found that about 0.8 million premature deaths and about 6.4 million years of life lost was due to air pollution caused by PM_{2.5}. Many studies indicate that particulate matter can cause mortality or severe lower respiratory system damage at as low as 80 microgram per metercube.² Chemicals and noxious gases may enter the body through inhalation and cause injuries to the delicate tissues in the respiratory tract which eventually halts the exchange of oxygen.³ In the professional research community, limited research⁴ on PM₁₀ and PM_{2.5} has been done to identify the important sources of particulate matter emission from road and building construction activity and the mitigation measures for their subsequent control. Generation of dust, gaseous pollutants, particulate matter, noise, and other atmospheric contaminants result either indirectly or directly from building construction activities. However, number of sources that generate the pollutants are associated with mobile machinery (not restricted to roads), construction works and onsite machinery (off road emission).⁵

As indicated in the section above, construction sites are responsible for significant air and noise pollution. Linked to construction activities, the use of diesel machinery, lorry movements, and traffic congestion further adds to this problem. The goals of the Paris Agreement cannot be reached without action on clean construction. It is crucial to document clean construction practices in user-friendly guidelines to mitigate air pollution emissions during construction activities. Here we develop 'The Handbook of Clean Construction Practices in Surat' focusing on available rules, regulations, and mitigation actions for the building construction sector.

¹Environmental Impact of Construction Materials and Practices by S S Petkar (National Institute of Construction Management and Research), 2016

²Time-Series Studies of Particulate Matter. Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland. Annu. Rev. Public Health 2004. 25:247-80

³The Global Burden of Disease Due to Outdoor Air Pollution. Journal of Toxicology and Environment Health. Vol. 68 Issue. 13-14 by Aaron J C et al. 2005

⁴Muleski, G.E; Cowherd, C.Jr. and Kinsey, J.S. (2005). Particulate Emission from Construction Activities. Journal of the Air & Waste Management Association. Vol 55:772-783 ISSN 1047-3289

⁵Assessment of Particulate Matter (PM) concentrations at a typical construction site in Bangalore, India. International Research Journal of Environmental Sciences Chowdhury, A and Khosla, C. (2017)

This handbook has been prepared under the Surat Clean Air Action Plan (SCAP), which forms a part of the National Clean Air Programme (NCAP) launched by the Government of India in January 2019. World Resources Institute (WRI) India and The Energy and Resources Institute (TERI) have an agreement with Surat Municipal Corporation (SMC) and Gujarat Pollution Control Board (GPCB) to facilitate the development of Surat Clean Air Action Plan (SCAP), with support from Bloomberg Philanthropies and Shakti Sustainable Energy Foundation (SSEF).

Under the Surat Clean Air Action Plan (SCAP), WRI India has taken a sector-specific approach, where each sector (i.e., transportation, industries, solid waste, and construction) has been addressed separately for air pollution contribution and mitigation actions. For each sector, all directly or indirectly associated stakeholders have been consulted in a group or individually. Considering the contribution of construction towards air pollution in SMC area, especially for particulate matter (PM_{2.5/10}), a workshop was conducted in November 2019 at Surat. This was done with support from Bloomberg Philanthropies & SSEF and in association with SMC, GPCB, Confederation of Real Estate Developers' Associations Of India (CREDAI) Surat Chapter.

At the workshop, several participants highlighted the need for a user-friendly guidebook with all available rules, regulations, and mitigation measures. This guidebook must provide all the available rules, regulations, and best mitigation measures for real estate developers, builders, construction contractors, officials of Pollution Control Boards, and Urban Local Bodies. We hope this handbook will prove to be one of the best reference guide for scholars, policymakers, administrators, researchers, and students in the field of air pollution and urban governance.

This handbook will be helpful for different stakeholders involved in the construction practices to understand the air pollution mitigation actions as well as all major and minor retrofitting steps needed in the construction process to control air pollution.

2. CONTEXT SETTING

2.1. Construction in India

India is one of the fastest-growing economies in the world.⁶ Despite an uncertain global outlook where major economies have shown gradual progression, the Indian economy has continued to climb significantly and steadily.

The construction industry of India is an important indicator of the development as it creates investment opportunities across various related sectors. The construction industry in India shares the highest Gross Domestic Product (GDP) after agriculture. It accounts for about 9% of India's GDP and creates more than 45 million jobs either directly or indirectly.⁷ India is the 4th largest construction market in the world now behind the US, China and Japan. It is the fastest growing market now clocking around 7-8% annual growth. By 2025, India is poised to overtake Japan to become the third-largest construction market.⁸

In the prevailing scenario, infrastructure remains a top priority for addressing developmental gaps as it is considered omnipotent with the potential of lifting economies out of financial turmoil. Governments around the world are making finances available to generate demands for goods and services by creating jobs through higher spending into physical and social infrastructure. To boost urban

⁶International Monetary Fund Country Report No.19/385 released in December 2019

⁷India Construction Market - Growth, Trends & Forecast (2020 - 2025) by Mordor Intelligence published in 2019

⁸Urban Indian Real Estate - Promising Opportunities' by KPMG India & NAREDCO (August 2016)

infrastructure across the country, the Indian government has initiated multiple measures to lift the infrastructure and construction sectors from the ongoing slowdown. The government has allocated funds aimed at integrated development of infrastructure and services in rural areas and urban cities to boost allied sectors, including construction. It would encourage business opportunities for small and large organizations alike in the construction and infrastructure sector as they would offer sizeable scope for contractual work.⁹ About 250 economic areas such as cement, steel, brick, timber, and building material are dependent on this industry. A unit increase in expenditure in the construction sector has a multiplier effect with a capacity to generate income as high as five times.¹⁰

2.2. Brief Understanding of Air Pollution and its Impacts on Public Health

Air pollution is one of the leading environmental health risk factors and the impact of air pollution is not only limited to human health but also affects climate change, the water cycle, economy, and even energy and food production.¹¹ As per the Global Burden of Disease comparative risk assessment published in 2018, air pollution exposure contributes to approximately 1.2 million premature deaths and ranks among the top three risk factors for premature mortalities. In India, air pollution is a critical and growing risk factor for mortalities and morbidities, contributing significantly to the country's burden of disease. India is home to 15 of the top 20 polluted cities of the world with the highest annual average levels of PM_{2.5} (WHO, 2018). Several studies have showed that rapid urbanization and industrial development has adversely affected urban air quality due to emissions from transportation, construction, and industrial activity. Not just urban India, rural India is also affected by poor air quality.¹²

There is, however, heterogeneity in sources and pollutant profiles. For instance, the use of biomass or polluting cooking fuels varies between urban and rural households; vehicular density is vastly different in cities and villages; and differing climatology and geography across India affects regional and seasonal levels of ambient air pollution. Studies have shown that children and the elderly are particularly vulnerable to air pollution exposure. Those who belong to lower socioeconomic status are extremely vulnerable, with studies showing they are more susceptible to effects from air pollution exposure for a variety of reasons including occupation, housing, cooking fuel use; the common link being poverty. To address this multi-dimensional, multi-sectoral problem requires a cogent and considered approach. An approach that takes into account the best available epidemiological evidence, cost-benefit analyses of various interventions, and a robust communications platform to ensure broad awareness of the health impacts of air pollution and the advantages of mitigation.

2.3. National Clean Air Programme by the Government of India

The Government of India launched the National Clean Air Programme (NCAP), a time-bound national-level strategy to tackle increasing air pollution. The NCAP was to be a mid-term, five-year action plan with 2017 as the base year. The main aim of the program would be a 20-30% reduction of PM_{2.5} and PM₁₀ concentration by 2024. The program may be further extended to a longer time horizon after a mid-term review of the outcomes. City-specific action plans are being formulated under NCAP for 122 non-attainment cities.¹³ The NCAP has proposed setting up an apex committee under Environment Minister, a steering committee under Secretary (Environment), and a monitoring committee under a Joint Secretary. There would be project monitoring committees at the state-level with scientists and

⁹ As per information shared on '<https://www.investindia.gov.in/sector/construction>' accessed on 28/12/2019

¹⁰ 'Construction In India: An Industry Growth and Future' – Blog Update by NKG Infrastructure, August 2019

¹¹ The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: The Global Burden of Disease Study 2017

¹² Public health & social determinants of health - WHO Global Urban Ambient Air Pollution Database - 2016

¹³ "A non-attainment area/city is an area considered to have air quality worse than the National Ambient Air Quality Standards as defined by the National Clean Air Programme, India" – NCAP Document, 2019

trained personnel. Besides sectoral working groups, national-level Project Monitoring Unit and Project Implementation Unit, state-level Project Monitoring Units (for Gujarat it will be Gujarat Pollution Control Board (GPCB)), city level review committee under the Municipal Commissioner, and District Magistrate level committee in the districts are also to be constituted for effective implementation and success of the programme. There are three main objectives of executing this plan:

1. To ensure stringent implementation of mitigation measures for prevention, control, and abatement of air pollution.
2. To augment and evolve effective and proficient ambient air quality monitoring networks across the country for ensuring a comprehensive and reliable database.
3. To augment public awareness and capacity-building measures encompassing data dissemination and public outreach programs for inclusive public participation and for ensuring trained workforce and infrastructure on air pollution.

2.4. Sectors Contributing to Air Pollution in India

Rising urban and rural population, increasing energy demands, transportation, biomass use, combined with local organized and unorganized sectors, are contributing to increased emission levels (specifically $PM_{2.5/10}$) in India. However, there is no reliable information available for source contribution in India, due to input data constraints. Based on the available knowledge, the most commonly identified emission sources for $PM_{2.5/10}$ are on-road transportation, industries, power plants, biomass use for cooking and biomass burning (crop-residual and trash) (CPCB, 2011; GBD India, 2018; Lal et al., 2016; Sharma & Dikshit, 2016; TERI, 2018) (Figure 1).

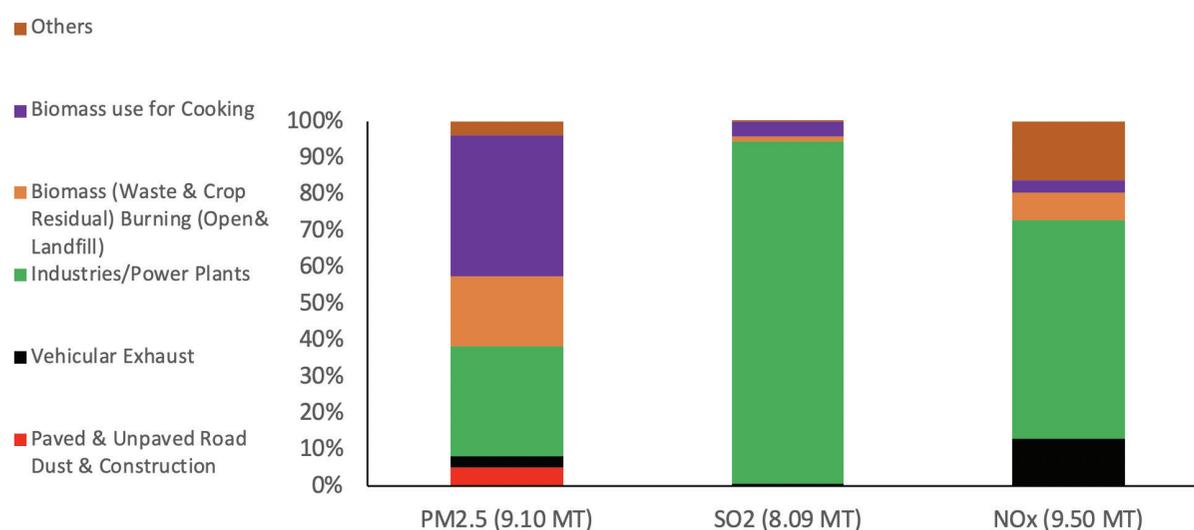


Figure 1: % Contributions of Different Sources for $PM_{2.5}$ and NOx in India for 2015 counted in Million Tons
Source: GBD MAPS Working Group. 2018. Burden of Disease Attributable to Major Air Pollution Sources in India. Special Report 21. Boston, MA: Health Effects Institute

Air pollution sources in India's urban and rural area vary according to regional economic, geographic, and socioeconomic characteristics. For example, in states like Bihar, Chhattisgarh, Jharkhand, Odisha, Meghalaya, Madhya Pradesh, Uttar Pradesh, and Assam, 80-90% of households using biomass or polluting fuels (i.e., fire-wood, crop residue, cow dung cake, coal, lignite, and charcoal) for cooking (Census of India, 2011) are responsible for outdoor and indoor air pollution. A large number of brick kilns in the Indo-Gangetic Plain and nexus between coal mines and power plants with extensive biomass use in states of east India, contribute to a high amount of air pollution.¹⁴

¹⁴ Brick kilns: Cause of Atmospheric Pollution by B M Skinder et al. Journal of Pollution Effects and Control (2015)

2.5. PM_{2.5/10} Contribution by the Construction Sector – Effects on Public Health and Economy

The construction sector, though not contributing significantly to Sulfur oxides (SO_x) and Nitrogen Oxides (NO_x) emissions, has higher contribution levels when it comes to PM_{2.5/10}.^{15,16} A Greenpeace Report published in 2017 said construction and related quarrying activities account for almost 19% of emissions at the national average. The sector contributes nearly 28% to the national average of air pollution while considering all kinds of pollutants (chemical formulation types as well as their sources). As per the¹⁷ World Green Building Council (WGBC) report published in 2018, “ambient, or outdoor, air pollution is caused by a range of factors, including transport, agriculture, and waste.

However, the contribution of the built environment, in both the construction and operational phases, cannot be underestimated.” Apart from this, the Indian apex judiciary body took a serious step in the year of 2019 while observing pollution as an ‘emergency’ situation to the public health of the National Capital Region (NCR) of India. As part of the directives issued for the Delhi Government to check on open waste burning and reducing the usage of air conditioners below 25 degrees Celsius, the court also banned construction activities for more than a month. This step was taken with directives from NGT (National Green Tribunal) in which it was stated that “Construction dust, at the construction sites is responsible for significant contribution in PM_{2.5/10} in surrounding 5 km radius. Thus, during winters, when the emissions tend to settle near the surface, all of the PM will be available in breathing zone (5ft to 6ft), causing major irreversible damage to the respiratory systems of people in general”.

According to the assessment report published in a national daily in 2019, for the duration of a month’s ban in the NCR region, commercial developers were found to be losing almost Rs 1 crores per day due to delay in their projects which were slated to be operational in November 2019.¹⁸ The economic loss is due to the spaces which had been taken on rent by these developers. In addition to this, the retail partners who had purchased property in these buildings made huge losses during the construction ban. The jobs of almost 20,000 daily wagers were also affected.

The court recommended Central Government to compensate daily wage workers from funds under Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act.¹⁹ Considering such restrictions are effective in every winter season in the NCR, it is worth noting how severely they impact the lives and livelihood of people in the field, since compensation for man-days lost due to a court order has never been recommended by any agency.

3. SCOPE OF THIS HANDBOOK AND THE PROCESS OF ITS COMPILATION

This publication is ideal for promoting sustainable construction practices with a focus on reducing PM_{2.5/10} in the Indian subcontinent. Since this document is a compilation of available legislations in India describing the standards, guidelines and BIS codes to be followed, gradual amendments in the listed rules and acts will be included in future editions. However, this handbook signifies the importance of controlling particulate matter in local air of construction sites in particular; thus, it doesn’t address other contributing sectors such as transportation and industries for any Urban Local Body (ULB) in India.

¹⁵Contribution of industry to pollutant emissions to air and water’ by EU Commission Report 2015

¹⁶Airpocalypse: Assessment of Air Pollution in Indian Cities’ by GPET (January 2017)

¹⁷Air Quality in the Built Environment – Causes of Air Pollution due to Build Environment’ 2018

¹⁸Delhi NCR Commercial Developers Hit Hard’ – By Faizan Haider, ET Bureau (December 2019)

¹⁹NGT suggests allowance for labourers affected by construction ban in Delhi’ – ET Reality (November 2019)

For this handbook, the following methods were employed to collect information:

1. **Secondary Research** – Guidelines, Bureau of Indian Standards Codes Acts, and Rules about clean construction practices were taken into consideration along with Best Available Practices (BAT) documents from all over the world.
2. **Primary Research** – Experts in sustainable construction practices and representatives from builders' associations were consulted for the preparation of this handbook. Their inputs have been included to bridge the gap between authenticity and the practicality of theoretical information on the varied aspects of construction practices in the Indian subcontinent.
3. **Documentation of Sectoral Practitioners** – This handbook was introduced as an idea at an event that saw more than 90 professionals and practitioners taking part in a review exercise focusing on reducing PM_{2.5/10} in ambient air through clean construction practices. Views gathered from these professionals, and sectoral experts formed a base for this handbook.
4. **Approval from the Authorities** – This handbook has been drafted with a positive nod from the authorities who are engaged in managing one of the major urban local bodies in Surat. Reviews provided by the regional office of the state pollution control board have been taken into consideration.

4. NEED FOR AMBIENT AND PERSONAL AIR QUALITY MONITORING AS A PART OF CLEAN CONSTRUCTION PRACTICES

Various activities responsible for air pollution in construction sites are discussed in the next section. To identify construction activities that contribute to air pollution, it is imperative to monitor air pollution levels for different activities associated in the construction process for particular time periods of a standard work day. Performing this action will ensure an evidence-based approach on which a control programme will be implemented. Here's why is it important to monitor air quality at a construction site:

1. Implementation of air quality monitoring plan will ensure that construction activities are not contributing to the generation of harmful substances in the form of PM_{2.5/10}, SO_x, and NO_x. For this, all monitoring results will be cross-verified with the available regional, national, and international standards as a mandatory process.
2. There are a lot of dust mitigation measures construction companies implement to reduce personal and community exposure to harmful airborne material. An effective air quality monitoring plan will help with the efficiency of such mitigation measures as well as assess implementation loopholes in maintaining the quality of breathable air for onsite professionals and the surrounding community.
3. Additionally, the continuous ambient air quality monitoring plan will provide space for alerting the construction company, contractor(s) and the local pollution control authority with strong evidence. Since there will be continuous monitoring at the construction sites for PM_{2.5/10}, any anomaly in normal concentration can be taken into registration for an improvement in mitigation and adaptation measures.
4. Effectively implemented ambient and personal air quality monitoring plans will act as a back up to construction companies/contractors and authorities when claims related to occupational health concerns is raised by onsite professionals or members from the surrounding community groups. An effectively implemented continuous monitoring plan will help provide engineering and administrative controls for onsite workers as well as measures which the construction company can take for surrounding community groups as a part of the social responsibility drive. An air quality monitoring plan in operation will only benefit construction companies in the longer run.

5. This personal and ambient air quality monitoring plan implementation will help the contractors/ companies understand the effectiveness of mitigation plans. As a result, a substantial amount of capital resources can be saved by targeting measures which are giving effective dust mitigation results.
6. Furthermore, the continuous air quality monitoring plan implemented at the construction project site will also help identify the major sources of particulate matter. The silica content of airborne dust is a major concern when it comes to exposure of PM_{2.5/10} from any source because it can result in serious health issues. Identifying and triaging activities/processes generating more airborne dust for mitigation measures will aid in focussed implementation of engineering and administrative controls.

Fugitive emissions from transportation channels and individual vehicles are difficult to monitor and attribute, as their exposure can be at times out of reach for primary stakeholders (construction companies/contractors and local authorities) to control. Guidelines published in 2011 by the Central Pollution Control Board (CPCB) provide detailed account on how to process the implementation of continuous air quality monitoring plan at industrial processing units (of which construction is a part) and the required criteria/parameters for chemical assessment of collected samples. Model strategies for establishing an air quality monitoring plan have been explained in point 8.3.

5. DIFFERENT TYPES OF CONSTRUCTION APPROACHES

Construction is usually associated with residential and commercial buildings, but there are other types as well. The four major types of construction include residential buildings, institutional and commercial buildings, specialized industrial construction, and infrastructure and heavy construction.

1. **Residential Buildings:** Residential housing construction involves building, repairing, and remodeling of structures for the purpose of housing people, supplies, or equipment. It includes individual houses, apartments, townhomes, condos, nursing homes, dormitories, etc. Garages and outbuildings like utility sheds are also considered as residential constructions. As mentioned above, residential construction also involves repair and installation of utilities like water and electricity around the structure.
2. **Institutional and Commercial Buildings:** This encompasses schools, sports arenas, shopping centers, hospitals, stadiums, retail stores, and skyscrapers. Like residential housing construction, institutional and commercial buildings involve both putting up of new structures and repair and maintenance of existing structures. Typically, a project like a retail store is commissioned by a company or a private owner. Other projects such as stadiums, schools, and medical facilities are often paid for and managed by both the local and national government.
3. **Specialized Industrial Construction:** Specialized industrial construction, which entails building structures that require a high level of specialization as well as technical skills in planning, construction, and design is carried out by for-profit or industrial corporations. For instance, a chemical industry can build oil refineries, and the power generation industry can build nuclear power plants and hydroelectric power plants.
4. **Infrastructure and Heavy Construction:** This includes building and upgrading of railways, communications, and roads. Railways are constructed on public interest and is often executed by government agencies and large private corporations. Some other projects that fall under this type of construction include tunnels, bridges, highways, transit systems, drainage systems, and pipelines.

6. DIFFERENT TYPES OF ACTIVITIES AND SUB-ACTIVITIES AT A CONSTRUCTION SITE RESPONSIBLE FOR PM_{2.5/10} GENERATION

There are certain common processes that are executed across the four types of construction processes listed above. Apart from drawing the layout and preparing paperwork for the building, every activity in the process of construction has the potential to expose workers on site as well and the surrounding area to PM_{2.5/10}. Here are some examples

- **A. Demolition Activities (Both Dry and Wet):** Demolition activities are carried out for either retrofitting/restructuring of the planned building or for creating space for a new plan to be executed. Following are the different types of demolition activities:
 1. **Interior Demolition:** Interior demolition is the taking apart of interior portions of a structure while preserving the exterior, usually in preparation for a renovation project. This usually includes the removal of walls, ceilings, pipes, etc.
 2. **Selective Demolition and Dismantling:** A selective demolition project involves the removal of specific interior or exterior portions of a building while protecting the remaining structure and nearby structures and areas. In comparison, the dismantling method involves the careful deconstruction of a structure to preserve components for reuse, recycling, or refurbishment. Dismantling process is generally more labor-intensive than demolition.
 3. **Mechanical Demolition:** This type of demolition uses specialized mechanical equipment and tools. These include hydraulic excavators equipped with specialized attachments that can break concrete and steel. Smaller equipment like remotely controlled skid steer loaders and automated demolition tools are used for smaller tasks and interior and selective demolition. One of the most simplest, and ways of demolition was through crane and wrecking ball. However, with the advancement in technology and time management, more precision-based equipments like excavators and large drilling machines mounted on cranes have replaced this method.
 4. **Implosion:** This is a rarely-used and highly-specialized type of demolition that employs the use of explosives to bring down high structures by undermining structural supports so that it collapses within its own footprint or along a predetermined path. Implosion is used in less than 1% of demolition projects.²⁰

Processes which are employed in a demolition activity with chances of PM_{2.5/10} generation are as follows:

Explosion – For an unused section of a building or for the whole interior structure of the building. In a latter case, the implosion technique will be employed.

Cutting and Hammering – Mostly used in internal demolition or controlled tasks of retrofitting.

Crushing – Crushing larger boulders into a mechanized crusher for the ease of transfer.

Drilling – Cutting larger sections into smaller ones for ease of preparation.

Transportation and Transfer of Materials – From the demolition activities, the material is transferred internally or outside the construction site. This is done by small vehicles, manually pushed trollies, or mechanical conveyor belts.

²⁰ *The Science of Demolishing a Building – A blog update by 'constructioncitizen.com' representing global scenario for implosion activities (DoP June 21, 2019)*

Control Measures (only to control emissions of particulate matters) have been recommended for demolition activities based on the risk of particulate matter generation in different stages of the process.

1. The first and primary control measure is to have a comprehensive laid down plan of PPE (Personal Protective Equipment) to be provided to the workers. This PPE plan will ensure what kind of face masks to be provided along with other protective measures for eyes, face, hands, and other body parts. This will be supported by the regular personal breathing zone monitoring at the construction site.
2. Administrative changes such as the provision of intermittent breaks from the regular crushing and drilling activities (15 minutes for every hour worked) plus frequent changes in personnel working on the same job²¹, along with shift management, can reduce the continuous exposure of workers to harmful PM_{2.5/10} concentration.
3. Technical control measures, supported by engineering controls such as suction ventilation and provision of air exchange blowers at demolition activities along with a combination of wet processes to control dust at the source, will be employed. The selection of engineering control will be dependent on demolition activity. The broader scale of activity will have to be provided with different engineering controls; smaller and precision-based activities might require wet processes that are focusing on the source of particulate matter generation only.
4. Measuring particulate matter at the construction sites will provide real-time information on the concentration of PM_{2.5/10}. There shall be a monitoring program in place by the construction company or contractor, which will not only include personal monitoring but also ambient air quality monitoring. The results can be collected for 8 hours' average (both personal and ambient) and Short Term Exposure Limit (STEL) for a duration of 15 minutes. This data can be used as a base for designing other administrative measures such as a selection of PPEs and providing enclosures with scheduling shift changes for reducing exposures.
5. Engineering controls such as exhaust ventilation and air scrubbers can be accompanied by fogging.²² This is a very effective wet wherein dust particles that are too small to be captured by the air scrubbers can be converted into larger particles by combining them through the application of water droplets in the air. This way, harmful silica dust can settle on the floor at a faster rate, reducing chances of exposure or can be captured in ventilation duct since the particle size will be significantly increased. This method is effective in processes such as demolition and digging.
6. In addition to this, to control the ambient dust emissions, wet processes can be employed at the larger air shed level covering the area in which demolition activities are being carried out. In addition to these sprinklers, wet process applications are also employed to capture the sudden onset of dust from the demolition activities at construction sites.

● **B. Excavation Activities (Both Dry and Wet Types):** Excavation or disturbing the natural soil is undertaken so as to execute a new plan or to remove an existing structure completely. Excavation is a lengthy process that is governed by different geographical and meteorological features on which construction has been planned. Following are the common steps observed for the process across different continents,

1. **Excavation to the Approved Depth:** After processing the top level, as per the type of construction activity, the plan will have dimensions that will be followed for excavation. In this process, mechanized and human resources will be used to go till the depth wherein foundation work of road, building, or processing unit will be laid down. Specific arrangements will be made in this process for the erection and commissioning of large equipment if the excavation is being done for larger-scale industrial unit construction.
2. **Dressing the Loose Soil:** In this process, the excavated site will be applied with mechanized and manual dressing-up of loose soil section, which is to be treated before the foundation work begins.

²¹ Gujarat Factories Rules (1995) notification on providing administrative breaks to workers engaged in heavy labour work (which includes crushing, drilling and heavy lifting at construction sites) released in 1995 amendment.

²² The Importance of Dust Control during Construction and Remediation Projects by Michael A. Pinto (Wonders Makers Environmental, DoP March - 2017)

3. **The Construction of Dewatering Wells and Interconnecting Trenches:** In this process, dewatering is used on most construction sites due to accumulated water in trenches and excavations or in places with an inadequate slope or high water table. This water must be removed to provide a safe workplace. Normally, builders tend to use water pumps to dewater these areas, but if they are not paying attention to the place where water is discharged, erosion and other problems may occur. It is important to follow best management practices when water is being pumped to lakes, wetlands, or directly to storm sewer inlets.
4. **Conservation of Top Soil:** Appropriate measures shall be taken to conserve the topsoil, which has been excavated during the process. Apart from this being prescribed in the rules, it is important to have the top soil placed in a dedicated site for future use to be sold off for other activities such as agriculture, permaculture, or horticulture.
5. **Preparation of Bunds/drains and Backfilling of Trenches:** In this process, water conservation methods will be employed wherein bunds and drains will be prepared for conserving the surface runoff during seasonal changes. Trenches will be backfilled once the excavation is completed. The same principle can be applied with the reuse of treated waste water from the ULB's corporation owned tertiary treatment plants. This water supplied regularly on application basis, will be used for the top soil treatment and wet processes applications (e.g sprinkling system) for dust emission control at the excavation site.

Processes which are employed in an excavation activity with chances of PM_{2.5/10} generation are as follows:

1. **Digging** of the topsoil, processing, and transfer from one place to another generates the maximum amount of dust during the excavation process. This can be considered nuisance dust, depending on the silica content.
2. **Grinding and Cutting** of large boulders, especially while preparing to trench and level the site for foundation work, might also give rise to silica-based fine dust. This also applies to filling up the trenches with forceful water application.

Control Measures (only to control emission of particulate matters) have been recommended for excavation activities based on the risk of particulate matter exposure:

1. **PPE control program** supported by **ambient and personal air monitoring program**, measuring 24 hours, 8 hours, and 15 minutes' averages for PM_{2.5/10}, is ideal for providing protection to those who are working on site. For the fugitive dust escaping the construction site, an enclosure is the best way for control, which applies to the local excavation site or for transport vehicles carrying the soil within or outside the construction site.
2. At some locations, it has been observed that to reduce the effect of temperature and humidity on air borne dust, **wet sprinklers or showers along with blowers** are provided. This can be done especially during dry seasons such as summers and winters, wherein humidity goes to the minimum level in arid and semi-arid regions.
3. **Measurements of PM_{2.5/10} during excavation** will provide a realistic perception of how much exposure is there to onsite and off-site personnel.
4. **Fogging** (wet process) can be used for the control of soil dispersion.
5. **Mulching and application of chemical stabilizers** for the preservation of topsoil and soil conservation can also reduce particulate matter generation from the activity significantly.

- **C. Concreting (Both Dry and Wet Types):** Concreting is used when the foundation of the building (or road, industrial process operation unit installation) is being laid. As the name suggests, concrete (ready to mix or loose manual mixture) is the main material which is used in the mentioned process. It is made from cement, aggregate and water which acts as a skeleton to the building or infrastructure unit (if it is being made of RCC). Following are the major steps involved in the process:
1. **Batching:** Volume and weight batching are carried out to measure and mix different components of concrete in their dry form. However, this point gets relaxation in ready-to-mix concrete, yet it has its own implications against the conventional batching process.
 2. **Mixing:** In this process, measured components are thoroughly mixed manually or in a machine. At some construction sites, there are dedicated plants or hooded locations for batching and mixing processes. The goal is to achieve optimum composition of concrete which can be measured first by observation (color and consistency) or in a more advanced form through sampling.
 3. **Transportation:** The mixed material is transferred to a construction site by manual or mechanized transportation. Dedicated mixing and batch preparation plants which are away from construction sites require help of vehicles, or at times conveyor belts.
 4. **Compaction and Curing:** Both of these sub-steps are for increasing the durability of concrete. In compaction, concrete is cleared off the air bubbles or other internal faults. In curing, hydration of certain amount of time is required to minimize the future surface damages to concrete.

Processes which are employed in a concreting activity with chances of PM_{2.5/10} generation are as follows:

1. **Mixing** and **manual batching** pose the highest exposure to PM_{2.5/10} not only to the professionals working on site but also to the surrounding areas.
2. **Transportation** of batched components if not done in covered vehicles or hand trollies, poses great danger of emissions. Being concrete dust particles, these PM_{2.5/10} would be made up of higher silica dust giving rise to a hazardous health condition known as silicosis.
3. **Surface cleaning** and **refinement activities** along with **crushing and grinding** also exposes construction workers to hazardous particulate matter.
4. To reduce the dust generation from the mixing and manual batching activities there is an option of using Ready Mix Concrete (**RMC**) instead of conventional concrete. However, the **RMC plants at times have been seen to generate fine dust at their storage and processing facilities** due to continuous chain of production. Though RMC is considered a safer option against conventional mixing and batching of concrete preparation, it can generate PM_{2.5} proving to be hazardous for the exposed personnel.

Control Measures (only to control emission of particulate matters) have been recommended for concreting activities based on the risk of particulate matter exposure.

1. Providing an **enclosure, covering** or even just a **wet green sheet** to the mixing and batching plant will aid the reduction of dust particles getting air borne.
2. For fugitive emissions from transportation, **adequate coverage** along with **speed limit controls** (driving of vehicles at 15 to 20 kms per hour) can be employed as a part of administrative measures.
3. **Sprinklers system** and **other wet process measures** can be employed at the starting and end point of receiving concrete material. This is equally important for the RMC counterpart as well.

- **D. Cementing Work (Both Dry and Wet Types):** The supporting cementing work post preparation of concrete skeleton of the unit (road/building/industrial processing unit installation) is the one step which will give surface stability against timely wear and tearsince the components of this step will be exposed to the human usage the most. Depending upon the type of construction, body (wall and roof) construction can be of various materials, including brick, concrete blocks, fly ash bricks, natural stones, paver blocks, stone aggregates, bitumen mixture, etc. Following are the major processes which have been observed in this step:
 1. **Stone Cutting:** Shaping the construction material to be used for the body construction.
 2. **Mixing of Plaster:** A ready to mix or manually mixed plaster material is prepared and used as the binding material between the dimensionally cut body material.
 3. **Plastering:** Plastering is a wet process which involves making the refined surface out of the dimensionally placed body material which has already been sealed with plaster. In residential buildings, there is another fine layer of plaster applied before the surface cleaning.
 4. **Surface Cleaning:** Fine protrusions are removed through grinding and cutting.
 5. **Sand Blasting:** Especially for industrial process unit installations, metal enclosures or concrete enclosures are required. Thus sand blasting is done to ensure refined stability to the entire structure which will be exposed to production process at the later stage.

Processes which have potential to PM_{2.5/10} exposure have already been mentioned above.

Control Measures for above mentioned process steps are as follows:

1. **PPE Programme** is the foremost requirement for this step as it has the potential to reduce operating personnel to harmful silica PM_{2.5/10} exposure.
 2. In support of the above-mentioned step, **administrative control such as shift and time management** would provide adequate help in reducing the exposure.
 3. In infrastructure projects, it is possible to have an **enclosure** for stone cutting and grinding activities. In such cases, **exhaust ventilation as well as air exchanging blow dryers** would help in reducing the PM_{2.5/10} exposure.
- **E. Movement of Construction Material (Both Dry and Wet Types):** Every construction site has heavy human and mechanized movements. But the particulate matter exposure depends upon the construction material being transferred from one site to another. Usually, new construction material has inward movement and exposes the workers and surrounding community with fine dust containing high amounts of PM_{2.5}. On the other hand, a demolished building's construction waste material while moving outward exposes workers and surrounding communities with PM₁₀. Since there are only two types in this process, control measures have been mentioned as follows:
 1. **Fugitive emissions** are the most notorious component as far as any kind of transfer or material handling is considered. Depending on the atmospheric conditions along with their dispersion rate, particulate matter from moving vehicles (carriage section and tyres alike) escape and accumulate on different surfaces. At times they contain corrosive and other hazardous dust, causing allergic reactions in exposed personnel.
 2. **Wet processes, regular sprinkling of water** on movement paths would help in minimizing the dispersion.
 3. **Regular cleaning of carriage section and tyres of vehicles** would also help in reducing the emissions.
 4. **Reinforced Cement Concrete or Bitumen Reinforced Roads** can be constructed within the site to reduce dust emission.
 5. **Model Dust Control Programme** can be included with regular collection of construction dust being accumulated at movement aisles and roads within the site. This collected dust can be used for mulching, post site pit enclosures and leveling activities.

- **F. Commissioning and Cleaning of Site (Both Dry and Wet Types):**²³ Post-construction cleanup is meant to take care of debris and waste from a fresh commercial construction, remodeling, renovation or residential project, to set the stage for further interior touches. This applies to commercial applications like hotels, education, retail, restaurants and healthcare, as well as government buildings and manufacturing facilities. In this, a team of specialists perform a careful process of clearing out anything ranging from larger pieces of debris to small scraps of waste. This includes nails, screws, insulation, sealant remains, tile scraps, cement and wood pieces, etc left behind by builders and technical personnel. The process also includes wiping all surfaces and floors to remove drops of paint and other liquids. There are three phases in a typical building site clean-up. The following three steps will ensure that checklists are covered, and that premises are free of waste and debris:

1. **Rough Interior Cleaning:** This starts right after the heavy construction work is completed and the contractor is done with installing mechanical and electrical systems, plumbing and frames. A post-construction rough cleaning includes the removal of larger pieces of debris and trash along with construction material leftovers, disposable containers and tools. Basically, anything that can't be handled by a general sweeping and vacuum cleaning.
2. **Section by Section Cleaning:** This stage includes the deep cleaning of all building sections, which makes it the most time-consuming. New commercial or residential kitchens and bathrooms must be thoroughly cleaned. Freshly-installed cabinets, sinks, glass doors, windows, and fixtures must be dusted first, and then properly disinfected with detergents.
3. **Refinement Cleaning:** The stage is known as final cleaning, and it includes a thorough inspection of the property and a final to-do list. The activities carried out include deep cleaning of any carpets and rugs, pressure cleaning of concrete or outdoor surfaces, and window care. These elements usually don't receive much attention during a new construction cleanup. After that, the renovation site is inspected one last time.

Processes mentioned above have potential to expose the working personnel not only to PM_{2.5/10} but also to other chemical fumes and gases. Since refinement cleaning also employs surface coating and small repairs if needed, welding and cutting fumes are also abundant in this step of the process.

Control Measures (only to control emission of particulate matters) for the reduction of exposure are mentioned below:

1. **Blue tin sheet covering** for any chemical or dry material based cleaning would reduce the chances of exposure to working personnel or dispersion of emission to other location from construction site.
2. These sheets are fitted one above the other to achieve the desired height, in addition to which **exhaust ventilation or controlled air exchange mechanism** can dilute the fumes/emissions at source.
3. **Mechanized assistance** to the human resources employed at the site would reduce the health implications of any corrosive or hazardous material used for cleaning.
4. **PPE programme** has to be made as stringent as possible along with awareness generation to handle hazardous materials. This is especially important for those building contractors who do not employ specified agencies for post-construction cleaning. In such cases, it is the site engineers and workers who are involved in post-construction cleaning.
5. **Adequate ergonomic conditions** would have to be provided especially for those sections of the building which are not properly illuminated or aerated by natural light and air. Site monitoring plan can have sections measuring illumination and air exchange rates along with ambient air monitoring.

²³ 'Post-Construction Cleaning: Overview, Checklists and Tips' – NYC Engineers and Material Handlers Handbook section 15 page; 114 (DoP – August 2018)

- **G. Measures for additional specific 'Particulate Matter' generating activities:** Apart from the different processes mentioned above, the following table indicates specific processes which need customized controls as per their requirement at construction sites. These processes and parameters have been listed on the basis of their potential for generating airborne specific hazardous material which can result in serious health issues in the form of respiratory and circulatory system failures.

Table 1: Additional Specific $PM_{2.5/10}$ Generating Activities

Sr. no.	Criteria	Cause of Emission	Control Measures (Common for all activities unless specifically mentioned)
1.	Use of Asbestos or Silica formulations	Grinding	PPEs with breathing apparatus
		Crushing	
		Cutting	Regular personal and ambient air monitoring. Special High Efficiency Particulate Air (HEPA) filters with Suction Ventilation System
		Sand Blasting or surface refining	Air Exchange Management with blowers. Cleaning of air at breathing zones
2.	Diesel Particulate Matter (DPM) from generators and engines of vehicles at site	Transfer of material	Exhaust smoke capture at the source
			Regular air exchange through fresh air blowing
			Ensuring Efficient Combustion (i.e. Motor vehicles with older engines shall not be engaged for work)
			Combustion Control on site
3.	Use of surface cleaners which can give rise to indoor emissions of carbonic compounds	Surface cleaning	PPEs with breathing apparatus
		Surface coating	
		Surface refinement	Confinement with blue sheet enclosures
		Application of paint and varnishes	Air Exchange Management with blowers - Cleaning of air at breathing zones
		Spraying	Suction ventilation

7. PARAMETERS CONTROLLING PM_{2.5/10} EMISSION AND DISPERSION

7.1. Considerations for Local Meteorology

There are several factors controlling the generation and dispersion of particulate matter from construction sites. Geographical and meteorological conditions govern the airborne nature of these minute particles.²⁴ The role of meteorology in affecting the dissemination of information about PM emissions has been documented.

The process of dispersing information such as chemical formations of particulate matter and the mechanisms for removing them have been affirmed to be shaped by parameters such as the amount of rainfall, atmospheric pressure, humidity, solar radiation, wind speed, and temperature.

Findings suggest that as the speed of wind increases, mass concentration of PM₁₀ reduces significantly.²⁵ Other factors documented to contribute to a reduction in mass concentration include increased temperature arising from high traffic density and an increase in the level of precipitation. Also, the increase in temperature, which predicts a reduction in mass concentration, is seen to accrue from domestic heating; especially during the winter season. In these scenarios, it can be inferred that the parameters of temperature and PM₁₀ exhibit a negative or inverse correlation.

In a case specific to India, an article²⁶ published in January 2020 mentioned 'the climate in India is characterised by four seasons: pre-monsoon/summer (March–May), monsoon (June–August), post-monsoon (September–November) and winter (December–February). Notable inter-seasonal changes in meteorology lead to significant differences in PM_{2.5} loading. Benefitting from the cleansing effect of precipitation in the monsoon season (Ghosh et al., 2015), the hourly PM_{2.5} is generally less than 50 µg/m³ in the inland cities (Delhi and Hyderabad) and less than 30 µg/m³ in the coastal cities (Chennai and Mumbai). Apart from cleansing by precipitation, frequent deep convection during summer monsoons in India can lift air pollutants near the surface to the troposphere or even upper troposphere. Hence, to control the dispersion of PM_{2.5/10} at construction sites, one has to understand the following features:

1. Storage temperature of source material
2. Local season of precipitation (i.e. rainfall patterns)
3. Local wind-rose diagram updated fortnightly by India Meteorological Department (IMD) office by using Land Surface Temperature and other micro-environment data.
4. Type of soil – with respect to the emissions during excavation and digging activities. Sandier the soil, more chances of airborne PM.
5. Methodologies in storing the unused construction materials or preparation of site for a possible break: In many countries, mulching is being used for the prevention of erosion by water and wind alike. Thus, wet mulching using mesh or simple method of mulching can be employed for durably storing the site/pile of excavated soil when more than 15 days of break from construction activities is anticipated.

7.2. Selection of Controls Based on the Type of Emissions

There are specific kinds of emissions from construction sites. Table 2 indicates different types of emissions from a common construction site and their possible control measures (with respect to maintaining ambient air quality).

²⁴ *Particulate Matter (PM_{2.5}) At Construction Site: A Review* by Putri Shazlia Rosman, Mohd Armi Abu Samah, KamaruzzamanYunus, Mohd Ramzi Mohd Hussain

²⁵ Keary, J., Jennings, S. G., O'Connor, T. C., Mcmanus, B., & Lee, M. (1998). *PM10 concentration measurements in Urban Agglomeration. Environmental Monitoring and Assessment Journal (Vol 53, 3-18)*

²⁶ *Local characteristics of and exposure to fine particulate matter (PM_{2.5}) in four Indian megacities* by Ying Chan et al

Table 2: Types of Emissions from Construction Site

Sr. No.	Type of Emission	Control Measure to maintain AAQ	*Average Reduction in PM _{2.5} (%)	Consequences if not controlled
1.	Dust/particulate matter from soil	1. Ventilation system (in controlled environment)	Upto 82%	1. Severe respiratory problems in onsite workers
				2. Mild to severe breathing problems in communities surrounding construction sites
		2. Blower system for air exchange (in controlled environment)	Upto 47%	3. Accumulation of dust on vehicles and inside homes
		3. Blue sheet covering (inside-outside measurement)	Upto 47%	4. Mechanical failure of vehicles and other motorized equipment engaged in construction activity
		4. Green mesh covering	Upto 22%	
		5. Wet Processes	Upto 65%	
	6. Wet cover during within the site transportation	Upto -60%		
2.	Diesel Particulate Matter (DPM)	1. Engineering control at the exhaust of vehicle or DG set	Upto 92%	1. Severe respiratory problems in onsite workers
				2. Breathing issues for surrounding communities
				3. Film formation on surrounding trees. Thus, reduction of tree covers due to toxic effects of diesel.
				4. Nuisance of cleaning surfaces due to excessive oil film formation.
3.	Welding fumes	1. Local exhaust ventilation	Upto 92%	1. Cardiovascular Diseases
		2. Covering welding location in an air exchanged enclosure by wet green carpet or blue fibre sheets	Upto 47% + 47%	2. Severe eyesight damage
4.	Odour/foul smell/ fog	1. Wet Spraying	Upto 25%	1. Headache and nausea among workers on site
				2. Aesthetic issues towards the site and location
		2. Covering or enclosure of odour causing material at the site	Upto 55%	

[(*) - The Average Reduction has been considered for the Time Weighted Average of Threshold Limit Value comparison for 8 Hours sampling in ambient air. The enclosures provide controlled atmosphere which has been considered for pre and post assessment of average reductions. OHSAS annual update data has been taken as a reference point to carry out % reduction in PM_{2.5}

Source: Toolkit Based on 'Risk of Bias Assessment Instrument for Systematic Reviews Informing WHO Global Air Quality Guidelines'

In addition to the controls mentioned here, which are mostly mechanized and need power to operate, surrounding the construction site with trees which can develop more than 10 feet height in duration of one year would capture most of the emissions (especially PM₁₀) escaping from construction sites.

8. LEGAL PROVISIONS – CENTRAL AND STATE RULES WITH PROVISIONS ON CONTROL OF PARTICULATE MATTER AT CONSTRUCTION SITES

There are legal guidelines and advisories available to control PM_{2.5/10} emissions at construction sites in central acts and state level rules. A majority of these provisions are for emission controls at the site and for fugitive emissions arising out of transportation of construction materials from and to the site. Following are the acts, rules and notifications which have been referred for the mention of such advisories as per their importance of maintaining damages to natural components at bay.

1. Air (Prevention and Control of Pollution) Act 1981 – The Environment (Protection) Amendment Rules, 2018
2. The Ozone Depleting Substances (Regulation and Control) Rules, 2000
3. Construction and Demolition Waste Management Rules, 2016
4. Solid Waste (MSW matter) Management Rules, 2016
5. Guidelines for Maintaining Buffer Around Waste Processing and Disposal Facilities, 2017
6. Water (Prevention and Control of Pollution) Act, 1974
7. Model Building Bye-Laws, 2016 (Ministry of Urban Development)
8. Maharashtra Pollution Control Board Notification of Consent to Initiate operation with RMC
9. EIA Guidance Manual for Building, Construction, Townships and Area Development Projects, 2010 (MoEFCC)
10. National Building Code, 2016
11. Handbook on Building Construction Practices, SP:62 :1997 BIS

8.1. Dust Control (Particulate Matter Control) Measures Under The Environment (Protection) Amendment Rules. 2018 – For Construction Companies

1. According to rule 106 of the document, any construction project requiring Environmental Clearance (EC) from Pollution Control Authority as well as from Local Municipal Corporation, will have to show that they have specifically laid down dust mitigation measures through wet processes at the site. In failing to do so, the EC cannot be given to construction contractor/company.
2. As per the notification, the requirements, specified in a gazette, say that
 - i. Roads leading to or at construction sites must be paved and black-topped.
 - ii. No soil excavation without adequate dust mitigation measures in place.
 - iii. No loose soil, sand, construction waste should be left uncovered.
 - iv. A water sprinkling system is mandatory, and measures taken should be prominently displayed at the construction site.
 - v. The grinding and cutting of building materials in open area is prohibited.
 - vi. No uncovered vehicles carrying construction material and waste is permitted.

8.2. Model Dust Mitigation Plan at Construction Site – As per The Environment (Protection) Amendment Rules, 2018

The dust mitigation measure plan will have components such as (1) training employees, (2) assuring that they have the correct tools (respirators, tools with integrated water systems, and tools with integrated High-Efficiency Particulate Air (HEPA) vacuum systems), and (3) assuring that personnel who need medical evaluations are identified and receive them as mentioned in the standard.

The following table shows what can be done for the 18 identified techniques being used in construction wherein dust exposure to the working personnel is the highest, as well as what can be done to control the same. In an extended plan, provisions for medical tests on workers involved in these high-risk tasks has been enshrined.

Table 3: Model Dust Mitigation Plan as per the Control of Substances Hazardous to Health (COSHH) Regulations HSE, UK

Sr. No.	Task	Engineering and Work Practice Control Measures	Method / Equipment for Dust Control
1.	Cutting concrete kerbs, blocks and paving with a cut-off saw	1. Limit the number of cuts during design/layout	1. Water Suppression 2. PPE with an Assigned Protection Factor (APF) of 20
		2. Use lower energy equipment like block splitters	
		3. Using material is cut off-site and delivered	
2.	Chasing concrete and raking mortar	1. Limit the need for chasing at the design/layout stage itself	1. On-tool extraction using an H or M Class extraction unit and
		2. Use work method that limits/does not need chasing, like over-covering cables	2. PPE with an APF of 20 – consider powered Respiratory Protection Equipment (RPE) for longer duration work
3.	Cutting roofing tiles with a cut-off saw	1. Hand cut natural/fibre cement slates and other tiles where possible	1. Water Suppression
		2. Use ½ and 1½ tiles	2. A dedicated cutting area with scaffold board protection
		3. Use Correct setting out/design	3. PPE with an APF of 20
		4. Minimize valleys	
4.	Scrabbling or grinding with hand-held tools	1. Specify architectural finishes that do not need scrubbling	1. Where possible use on-tool extraction using an H or M Class extraction unit and
		2. Use (ultra) high-pressure water jetting	2. PPE with an APF of 20
		3. Use chemical retarders and pressure washing	
		4. Cast with proprietary joint formers, e.g. mesh formwork	
5.	Short-duration drilling (15–30 min) with hand-held rotary power tools	1. Limit the number of holes during design/planning	1. Where possible use equipment that stops dust from getting into the air. Thumb rule is larger holes provide ease of operation and reduction of emissions. Other options range from drilling through a dust 'collector' or using cordless extraction attached to the drill (for smaller drill bits)

Sr. No.	Task	Engineering and Work Practice Control Measures	Method / Equipment for Dust Control
		2. Use direct fastening or screws	2. Otherwise use PPE with an APF of 20
6.	Drilling holes with handheld rotary power tools as a 'main activity'	1. Limit the number of holes during design/ planning	1. Where possible use on-tool extraction using an H or M Class extraction unit and
		2. Use direct fastening or screws	2. PPE with an APF of 20
7.	Dry coring	1. Limit the number of holes during design/ planning	1. On-tool extraction using an H or M Class extraction unit
			2. Longer duration work (i.e. over 15–30 min of accumulated time over the day) will also need PPE with an APF of 20
8.	Wet coring	1. Limit the number of holes during design/ planning	1. Water Suppression
			2. Long periods of wet coring in enclosed spaces will also need PPE with an APF of 20
9.	Using a hand-held breaker in enclosed spaces with limited ventilation	1. Limit the number of holes during design/ planning	1. On-tool extraction using an H or M Class extraction unit
		2. Remote controlled demolition	2. PPE with an APF of 20
		3. Hydro-demolition	
10.	Abrasive pressure blasting	1. Use a different method of work like (ultra) high-pressure water jetting	1. Wet or vacuum blasting
		2. Using 'silica free' abrasive material	2. PPE will depend on silica content of building materials, blasting equipment & length of work
			3. In most instances use RPE with an APF of 40
			4. Use PPE with an APF of 20 for lower risk work
			5. Shrouds or screens to contain the flying abrasive material
11.	Soft strip demolition	1. Plan the work carefully	
		2. Limit the number of holes during design/ planning	1. Use water suppression or on-tool extraction for those tasks where possible
		3. Screening off areas to prevent dust spreading	2. PPE with an APF of 20 – consider powered PPE for longer duration work

Sr. No.	Task	Engineering and Work Practice Control Measures	Method / Equipment for Dust Control
12.	Removing rubble, dust and debris'	1. Limit waste materials during design/ planning	1. Damping down and using a brush, shovel and bucket for minor/small 'one-off' amounts
		2. Consider where waste material is created and how frequently it needs removing	Or for regular removal/site cleaning: 1. Water spray for damping down
		3. Use correct dust controls when making rubble/debris	2. Rake, shovel and bucket/wheelbarrow to remove larger pieces
			3. Covered chutes and skips where needed
			4. Vacuum attachments fitted to an H or M Class extraction unit
5. PPE with an APF of 20 depending upon location, duration and type of work			
13.	Cutting wood with power tools	1. Use less toxic wood	1. On-tool extraction using an H or M Class extraction unit
		2. Order pre-cut materials	2. Longer duration work (i.e. over 15–30 min of accumulated time over the day) will also need PPE suitable for the wood dust, particularly in enclosures and confined spaces operations.
		3. Use dedicated cutting areas to minimize spread	3. Air Exchange Options can be matched with the provision of blow dryers in such limited space entry operations
14.	Sanding wood with power tools	1. Use less toxic wood	1. On-tool extraction using an H or M Class extraction unit
		2. Use 'pre-finished' materials	2. PPE suitable for the wood dust in most situations
15.	Sanding plasterboard jointing	Using other finishes/systems	On-tool extraction using an H, M, or L Class extraction unit

Explanation: In above *Table 3*

1. **APF** refers to Assigned Protection Factor for the Personal Protective Equipment (here: face masks)
2. **On Tool Extraction** refers to²⁷ a type of Local Exhaust Ventilation (LEV) system which is fitted directly onto the tool being used in the construction process. The tool consists of several individual parts – the tool, captor hood, extraction unit and tubing. Each part plays a role in establishing how effective the system is and the level of control it gives. In generic cases, the tools are available from the manufacturers/suppliers but some parts, especially the extraction units can be adjusted and detached/attached with other tools as

²⁷ Controlling construction dust with on-tool extraction – Health and Safety Executive Newsletter (www.hse.gov.uk)

well making it an wide range procedure. However, it is important to choose parts that are compatible and help achieve maximum extraction at source. It must be ensured that the tool is ideal for the task and material which is generating dust. This can be done through noting down perception of construction professionals using the tool. Its effectiveness can be increased by providing adequate PPEs with effective APF.

3. **Classification of Extraction Unit Terms** as per their capture range and material of construction generating harmful dust,
 - i. **H Class** - < 0.005% Dusts with Maximum Allowable Concentrations (MAC) < 0.1 mg/m³ suitable for highly carcinogenic dust, asbestos, formaldehyde, mold, germs and bacteria.
 - ii. **M Class** - < 0.1% Dusts with MAC ≥ 0.1 mg/m³ suitable for hard wood, board materials, concrete and brick dust.
 - iii. **L Class** - ≤ 1.0% Dust with MAC > 1 mg/m³ suitable for soft wood and solid surface material dust.

8.3. Environment and Natural Resource Conservation at 'During and Post - Construction' Activities - As per Construction and Demolition Waste Management Rules 2016

Presently, construction and demolition waste generation in India accounts up to 23.75 million tons annually and these figures are likely to double in 2020.²⁸ Age of the demolished building and composition of demolition waste (soil, sand and gravel (26%), bricks & masonry (32%), Concretes (28%), metal (6%), wood (3%) others (5%)) control PM generation from the site. According to an assessment done by Technology Information, Forecasting and Assessment Council (TIFAC) in 2017, the generation of construction and demolition waste is project specific. The ranges which has been indicated in this assessment is as follows,

1. 40-60 kg/sqm for new construction
2. 40-50 kg/sqm for building repair or retrofitting works
3. 300-500 kg/sqm for demolition of buildings

Table 4 indicates different natural components, resource conservation concerns and guidance points indicated in The Construction and Demolition Waste Management Rules 2016.

Table 4: Resource Conservation Details - During and Post Construction

Sr. No.	Damaging Cause/ Action	Resolution as per the Construction and Demolition Management Rules 2016
1.	Lack of designated sites for dumping construction and demolition waste	Identification of a spare area near the construction site where the waste can be accumulated before transportation. No exemption: <ol style="list-style-type: none"> 1. Roadside and vacant open space (e.g. playground in commons of the city) be used for the dumping of waste. 2. Riverbed used for the dumping of waste. 3. Pond or landfill site used for unauthorised dumping of the waste.

²⁸ Karnataka State Pollution Control Board guidelines on management of construction and demolition waste published in January 2018

Sr. no.	Damaging Cause/ Action	Resolution as per the Construction and Demolition Management Rules 2016
2.	Lack of effective reuse and recycling of construction and demolition waste	<ol style="list-style-type: none"> 1. Construction and demolition waste treatment plant which converts the waste into reusable slurry or small gravel to be provided at strategic locations of the city. 2. The construction and demolition waste treatment plant will have to be connected with GPS tracked 'waste collecting' vehicles (to be provided and controlled by the city municipal corporation) and a laid down route covering major commercial and residential sites of the city. 3. The demand of collecting waste can be generated by putting up 'request call' to the municipal corporation or treatment plant facility by the construction companies and residential localities as per their requirement.
3.	Lack of understanding - recycled waste is worse than fresh construction material.	<ol style="list-style-type: none"> 1. Effective reutilization of construction and demolition waste will have to be ensured by the construction company. This will include reutilization of waste within construction circle and recycling at the designated treatment facility. 2. Key benefits of using recycled construction and demolition waste, <ul style="list-style-type: none"> - Cost - purchase - Cost - utilities (water and electricity) - Cost - transportation - Lesser emission (GHG - process cumulative) - Proper segregation of construction and demolition waste will be ensured. - Reduced accumulation of waste material on road side and vacant public spaces

1. Linking with the Application Based Codes/Standards/SoPs (Here National Building Codes 2016) guiding construction of buildings,

- i. Establishing utilization of construction and demolition waste in concrete and concrete based products by following standards (BIS-IS:383; NBC of India 2005: Part 11 'Approach to Sustainability')
 - Recycled coarse aggregate may be used in concrete for bulk fills, bank protection, base /fill of drainage structures, pavements, sidewalks, kerbs and gutters etc.
 - Up to 30 percent of natural crushed coarse aggregate can be replaced by the recycled concrete aggregate.
 - This percentage can be increased up to 50 percent for pavements and other areas which are under pure compression.
- ii. Establishing procedure of quality control and certification of reused material in building construction.
- iii. Triaging products from reused material in construction over fresh material from market.
- iv. Subsidizing the rate of purchase of reused products made from construction and demolition waste.
- v. Optimizing utilization pattern of traditional materials by interfacing the same with supplementary materials.

8.4. Management of Buffer Area Surrounding Construction and Demolition Waste Processing Plant- As per Construction and Demolition Waste Management Rules, 2016 and Municipal Solid Waste Management Rules, 2016

The purpose of a buffer zone or a separation plot between the construction waste processing site and residential/commercial surroundings is to minimize the potential environmental impact. This area is also important because it provides space and time for the dispersed particulate matter to settle down, which has lesser damaging effects on health of surrounding communities. *Table 5* summarizes criteria briefed under mentioned rules for the buffer/separation zones specifically directed to be implemented by the owner/contracting agency.

Table 5: Development of Buffer Zone as per Legislation at construction site

Under Construction and Demolition Waste Management Rules, 2016	Under MSW Management Rules, 2016
Schedule 1 – Site Selection for Storage and Processing of Construction and Demolition Waste (Rule 7(1) Sch I (6)) - A buffer zone of no development shall be maintained around solid waste processing and disposal facility, exceeding 20 tons or more in one day or 300 tons per project in a month of installed capacity. This will be maintained within the total area of the construction and demolition waste processing and disposal facility. The buffer zone shall be prescribed on a case to case basis by the local authority in consultation with concerned State Pollution Control Board.	Rule 3 Definitions, Sub-rule 7: “buffer zone” means a zone of no development to be maintained around solid waste processing and disposal facility, exceeding 5 tons per day of installed capacity. This will be maintained within total and area allotted for the solid waste processing and disposal facility. ³ The demand of collecting waste can be generated by putting up ‘request call’ to the municipal corporation or treatment plant facility by the construction companies and residential localities as per their requirement.
Exempted Actions/Projects - For construction work, where at least 80% 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.	The Pollution Control Board shall (sub-rule (h)) publish guidelines for maintaining buffer zone restricting any residential, commercial or any other construction activity from the outer boundary of the waste processing and disposal facilities for different sizes of facilities handling more than 5 tons per day of solid waste;
A vegetative boundary shall be made around processing or recycling plant or construction site to strengthen the buffer zone objective.	No Development Area to be maintained surrounding the waste processing site. This will be maintained within the total area of the solid waste processing and disposal facility. The buffer zone shall be prescribed on a case to case basis by the local body in consultation with concerned State Pollution Control Board.

As per the Guidelines for Maintaining Buffer Around Waste Processing and Disposal Facilities, 2017, buffer zones and separation plot/distance of threshold processing facility receiving ‘exceeding 20 tons or more in one day or 300 tons per project in a month of installed capacity’ shall not be located

- i. **300 m** from institutional land use property/any residential area/designated protected area.
- ii. **150 m** from any Industrial/commercial land use property/bank or high-water mark of any watercourse or wetland (source of domestic water).

- iii. **150 m** from right-of-way boundary of a public highway.
- iv. **50 m** from any type of adjacent property (commercial or residential)

8.5. Air Pollution Concerns Highlighted Under Construction and Demolition Waste Management Rules, 2016

In the Construction and Demolition Waste Management Rules, 2016 under **Schedule I Criteria for Site Selection for Storage and Processing or Recycling Facilities for construction and demolition waste (Rule 7(1))**. In the *Table 6*, the following environmental conditions have been listed:

Table 6: Air Pollution Control Measures as per C & D Waste 2016

Sr. No. (As per the Schedule I of C n D waste rules 2016)	Recommended Actions/Procedures for Resolving Environmental Issues
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.	Drinking water and sanitary facilities (preferably washing/bathing facilities for workers) and lighting arrangements for easy landfill operations during night hours shall be provided.
10.	Health inspection and especially Lung Function Test/Pulmonary Function Test to be done every 6 months along with other body fluid checks to determine harmful effects of heavy metals or silica-based product dust exposure.
11.	To minimize air dispersal at the site, a. Storm water drains to be provided so that accumulation of water shall not be there on the ground. b. Pavement of heavy movement roads to be done for minimizing air dispersal of particulate matter due to vehicle and workers movements. c. Reuse of treated water as per The Environment Protection Rules, 1986 at the site for settlement of dust as well as development of onsite green patch boundary. d. PPE provision to the workers to protect them from PM _{2.5/10} breathing zone exposure.
12.	Personal monitoring of breathing zone of workers (also mentioned as work zone) and Ambient Air Quality monitoring of the site shall be done every six months for Time Weighted Average (8 Hrs) exposure comparison

Dust mitigation strategies as per the Construction and Demolition Waste Management Rules, 2016 at the processing site include following steps:

1. Marking of areas within the site for 'dust generation'. Breathing zone cover as an administrative control is a 'must' in these demarcated locations.
2. A normal sheet cover or daily/regularly spraying of wastewater/normal water over the accumulated material responsible for dust generation at the site.
3. Loading and unloading points to be regularly sprayed with water sprinklers.

4. Within site transportation of material to be done under cover irrespective of the mode of transport used.
5. Engineering controls to be provided with all motorized equipment such as lifts, conveyor belts and concrete mixers. These controls include, ventilation system with scrubber or at least an area air replacement fan.
6. If possible, treated wastewater from the concerned authority shall only be allowed to be used in dust suppression measures.
7. No industrial waste mixed with concrete waste shall be allowed for treatment.
8. Unloading sites shall be inspected for remaining waste material and professionals with PPE shall be given task to clean the unloading site to reduce amount of fugitive emissions from unloading vehicles.
9. Best practices in handling construction and demolition waste have been adopted at Surat city in the form of Surat Green Precas Pvt. Ltd. PPP model plant which is operational since 2016. Details about this plant can be accessed in Annexure 1.

Consent Notification (DoP: 01/03/2018) by Maharashtra State Government Pollution Control Board (Under The Air (Prevention of Pollution) Act, 1981 and The Water (Prevention of Pollution) Act, 1974) on Ready to Mix Concrete Use at Construction Site

As per the indicated notification, regulation of production and usage of RMC has been defined for and at construction site. The major points have been bifurcated separately in two heads which are as follows:

Under 'The Water (Prevention of Pollution) Act, 1974'

1. The daily limit of effluents from Ready Mix Concrete (RMC) activity shall be 0.2 m³/day.
2. If RMC is being produced, the sewage effluent shall not cross more than 1.5 m³/day.
3. Non-hazardous slurry remaining at the end of process shall be disposed of at the landfill site.
4. The construction site has to have a well-designed drainage system with a collection pit. This will have to be provided at the RMC mixing site. Any liquid waste or discharge post washing activity will have to be collected in the pit and then treated before reused or discharged in open.
5. The collection pit must be cleaned periodically, and no deposits shall be allowed to form on its walls. The liquid discharge post-washing of the collection pit needs to be treated and then reused in gardening activity at the construction site only.
6. 13 cm³/day (0.01 Megaliters/Day) is the limit specified for water consumption for industrial mixing of RMC at the construction site.

Under 'The Air (Prevention of Pollution) Act, 1981'

1. The location where RMC is mixed has to be covered on all four sides with tin sheets.
2. All material transfer points shall be covered with permanent enclosures or temporary tarpaulin sheets while material is being transferred for mixing.
3. All engineering controls provided, like fan or ventilation system at the mixing point has to be continuous and permanent in nature. Temporary or intermittent shifting of these controls will reduce their effectiveness by 30% and raise the PM emissions at the mixing point/construction site.
4. Wherever RMC is being mixed, barricading the whole location with 20 ft or 5 ft above free fall emission area whichever is higher shall be provided. Same can be extended for achieving more height if larger quantities or multiple mixing sites are being operated at the construction site with Netlon Cloth.
5. Water sprinkling and dust stabilizing in the barricaded area is mandatory where RMC is being mixed or handled.
6. Planting of trees within a 5-meter inner boundary with foliage height of 20 m is advisable where RMC is being produced or mixed.
7. Roads within the construction site where RMC is loaded for mixing has to be Reinforced Cement Concrete (RCC) or asphalted. No loose soil roads are allowed.

8. Industrial vacuum cleaners shall be used to clean dry and wet accumulates at the RMC mixing and handling area.
9. For the transit mixture vehicles, a two level tyre washing facility shall be provided to prevent the escape of PM emission from the mixing area.
10. Manual operations of RMC is allowed only in enclosures with engineering controls (primary and secondary stage) systems working.
11. All conveyor belts shall be covered with tin sheets and dust collection system or ventilation system shall be in place.
12. Mixing section of RMC with added cement, aggregate and sand shall have multi cyclone dust collection system with bags to avoid any kind of fugitive emission escape.
13. Continuous air pollution monitoring shall be done at the site where RMC is being handled with PM_{10} (100 micrograms/m³) and for $PM_{2.5}$ (60 microgram/m³) as 24 hours monitoring Time Weighted Averages.
14. Monitoring can be done twice a week for 24 hours and commercial sites can introduce continuous ambient air quality monitoring station with failsafe design with power backup.

9. MANAGEMENT OPTIONS FOR THE CONTROL OF $PM_{2.5/10}$ EMISSIONS AT CONSTRUCTION SITE

9.1. Assessment of Construction Site for Possible Loopholes

Following are the points which should be considered for the assessment of construction site by the competent person (as per The Factories Act 1948)

1. One shall take into consideration all previously available records of utilities, processes, personnel and implementation of SoPs for dust minimization.
2. The site maps shall be marked while performing 'Walk Through Survey' or 'Observational Reporting'. This will help track the issues of dust generation at the specific points of concerns.
3. Apart from visible sources of dust generation, one shall also consider:
 - i. Manual construction activities being carried out on site. Human exposure and chances of human errors are more in such activities.
 - ii. General housekeeping of aisle and walkways.
 - iii. Movement of material – where steady flow of material is needed there shall be provision of mechanized conveyor belt with adequate covering as well as suction ventilation at both ends.
 - iv. Display of SOPs for effectively operating different engineering control devices as well as other motorized equipment shall be checked.
 - v. Scheduled operation with responsibilities assigned shall be checked with the site in charge. This has to be done specifically for dust generating activities such as sand blasting.
 - vi. Has a standardized PPE program been implemented for the construction site? A personalized protection program will ensure the ownership of worker and manager alike to control dust emissions at the site.

9.2. Enforcement – Who Shall do What?

Enforcement of dust mitigation activities is not possible unless stakeholder mapping is done. Authorities shall first identify the on-site and off-site list of stakeholders. Following are the list of possible stakeholders that can be engaged in the enforcement of dust mitigation measures on construction site:

1. On-site stakeholders and their duties:

- i. **Location considerations (for leased out sites)** - Locations of storage/dumping materials used in construction within the site are to be such that dust dispersal during handling (loading/unloading) is minimum.
- ii. **Builders Association** – The Contractors/builders associated in construction work must ensure quantity of construction material available at site synchronizes with its utilization so that the storage period is minimal, thereby reducing dust dispersal.
- iii. **Demolition contractors and workers** – Demolition sites to be cordoned off and adequate measures to reduce dispersal of dust beyond site limits must be taken.
- iv. **Workers engaged in construction activities** – Workers shall be trained on engineering controls (wet processes and air exchange ventilations systems in controlled environment) as well as administrative controls such as taking care of plantation and PPEs, for better dust control from the construction site.

2. Off-site stakeholders and their duties:

- i. **People residing in the vicinity** – Communities being affected by construction activity, will have to do following:
 - Consult the construction contractor from time to time if dust exposure is reaching their indoor environments for effective implementation of wet processes at site.
 - Major construction sites involving more than 2000 ton of concrete processing at location, must submit a report to the local pollution control authority or Corporation's Urban Development Cell or Local Public Health Clinic for possible health ailment which can arise due to increased dust concentration.
 - Report to the local waste management department for unused/untreated construction material lying in the vicinity of their house so that it can be regulated by concern personnel in time.
- ii. **Local authority** – The city corporation and pollution control board will have to enforce environment clearance guidelines at major construction sites as mandated by:
 - The Air Act, 1981
 - The Water Act, 1974
- iii. Members of the civil society shall monitor issues with people working in construction sites with respect to their livelihood and health, which can be addressed by taking them to the respective labor welfare officer or the local government hospital. This is crucial, especially if any construction worker develops medical issues such as silicosis due to prolonged exposure to silica dust. This is a compensable disease which can be prevented and the afflicted person can benefit from the vigilance of civil society members. However, engagement protocol for civil societies will have to be developed in coordination with the local ULB corporation and Gujarat Pollution Control Board.
- iv. ULB can monitor for damages to existing green cover due to the construction activities. They can also direct and advise the construction contractors for their boundary green buffer development.

As per The Construction and Demolition Waste Management Rules, 2016 following duties have been laid down:

1. For the construction companies/individuals/infrastructure development firms

- i. Every waste generator will have to segregate the waste coming out from their construction site in which they shall not be able to submit any industrial hazardous contaminated article along with construction waste.
- ii. The segregated waste shall be handed over to authorized personnel on request call basis who will also have to maintain chain of custody to ensure it reaches a treatment facility.

- iii. Construction companies and individuals who have 80% in-situ utilization of waste need not send their waste to treatment facilities (as explained earlier).
- iv. No littering and deposition on roads along the construction site will be allowed.
- v. It is mandatory to use water sprinklers/wet processes which ensures 85% suppression effectiveness of air borne dust specifically in demolition, segregation, loading and unloading activities.
- vi. Construction waste needs to be transported in covered vehicles. No fugitive emissions will be allowed in transit.
- vii. Large generators (companies generating more than 20 tons per day and 300 tons per month) will have to submit their waste management plan to the pollution control authority along with the municipal corporation.
- viii. All the charges will have to be borne by generator – from segregation to processing of waste.

2. For the local authorities and state government officials

- i. An approval of 18 months will be provided to the construction company for storage, processing and recycling facilities.
- ii. 10 to 20% of total construction and demolition waste (from ULB's annual generation) to be procured and used in construction and infrastructure development works.
- iii. Any ULB with a population in excess of one million will have to have a construction and demolition waste processing plant.
- iv. Judicial action can be taken against a local corporation and state government if the construction company proves that they were not given adequate approval within 18 months of starting of construction site for processing of construction and demolition waste.

In addition to these, as per the 'Guidelines On Environmental Management of C&D Wastes' published in March 2017 by Ministry of Environment Forest and Climate Change (MoEF&CC), the following timeline shall be followed for operationalizing construction and demolition waste facility for effective dust mitigation measures across the ULB limit:

Table 7: Timeline for Operationalizing C & D waste facility

Compliance Criteria	Cities with > 1 mn Population	Cities with 0.5 to 1 mn population	Cities with < 0.5 mn population
Formulation of policy by state government	12 months	12 months	12 months
Identification of sites for collection and processing facility	18 months	18 months	18 months
Commissioning and implementation of the facility	18 months	24 months	36 months
Monitoring by SPCBs	3 times a year, or once every 4 months	2 times a year, or once every 6 months	2 times a year, or once every 6 months

9.3. Monitoring of Ambient Air Quality

As per the **National Building Code 2016 'Sustainability Guidelines (12.4.3)** 'Depending upon the project size, location and the type of activities involved, ambient air quality in respect of Suspended Particulate Matter (SPM) or Particulate Matters (PM), Respirable Particulate Matter (RPM), SO₂, NOx and CO, shall be monitored at representative locations in the site and study area at a frequency of twice a week at each location adopting a 24 hourly schedule (8 hourly for CO). The monitoring locations shall be located on the basis of predominant wind directions, land use pattern and height of the proposed stacks. At least one station shall be located at the maximum pollution deposition area due to the proposed stacks of generators. The number of air quality monitoring locations should be at least five including one at the project site'

The monitoring plan for any location is dependent upon the types of pollutants being dispersed from that particular location. In a model construction site, apart from the particulate matter pollution, there are welding fumes, DPM exposure and carbonic compounds exposure from organic and volatile compounds containing varnishes/paints. **'Guidelines for the Measurement of Ambient Air Pollutants' volume 1 & 2 (2011) by the Central Pollution Control Board of India** dictates detailed procedures for manual sampling and real-time analysis for the ambient air pollutants. Here are some common assessment steps to keep in mind before initiating exposure monitoring:

- 1. Monitoring location** – Selection of monitoring location has to be strategic and detailed grid intersections of the entire construction site have to be prepared before initiating the survey. The grid map will help in selection through proper location codes and reference landmarks. This way in an ambient air monitoring plan to be executed in different seasons, same locations can be selected giving exact and precise comparative analysis of SPM emissions from the site. The selection of location also depends upon density of population in that particular area, vicinity to common infrastructure features such as roads, flyovers, institutional buildings and points wherein vehicle density is more.
- 2. Distribution of sampling stations/samplers** – The CPCB guidelines also talks about distribution of sampling stations for an implementation of ambient air quality plan. For this, the population ratio of the area is taken into consideration, taking reference from the formula used for the numbers of people (population) and type of activities being carried out in the area. The distribution of sample carries 60% triage weightage for commercial and industrial activity and 40% for residential locality. For the personal air monitoring of 24 hours continuous high flow samplers will be selected on the basis of number of people to whom the pumps will be attached to. The total number of personnel will be divided by the number of locations wherein sampling to be done. This will be depending upon the priority sampling areas and pollutants which have been determined for the personal sampling at breathing zone.

As the guideline states, "Distribution of monitoring station in a city depend on the distribution of pollution sources and population in a city. More stations should be located in areas where population density is high, number of industries are more and vehicular density is high. Distribution of stations can also be carried out by dividing the entire area in a grid and locating stations at intersections of a grid or within a grid. However, the grid pattern is not very economical as most often it requires large number of stations in a city. Dispersion models can be used to find maximum pollution levels and spatial variation of pollutant concentration can be used to determine distribution of stations."

Table 8: Ideal Distribution of Station between Industrial (+Commercial) areas and Residential Areas of a city

Sr. no	Total Number of Stations	Distribution Stations	
		Industrial + Commercial Activity	Residential Area
1.	1	1	0
2.	2	1	1
3.	3	2	1
4.	4	2	2
5.	5	3	2
6.	10	6	4

3. **Walkthrough survey** – This will provide information on which are the possible emission activities at construction site. This survey will include observational reporting, photographic documentation, checklists and reference from available documents such as Job Safety Analysis Report and interview with the site manager and in-charge workers. A walkthrough survey can be assisted by pre-decided checklists for standard operating procedures. This saves time and ensures that processes which are manual in nature can be focused on.
4. **Assessment of prioritization** – This is an important step through which selection of locations for the manual and real-time monitoring will be decided. On the grid which was formed as a part of first step, a triangulation approach for cross-section pathways will be preferred for optimum verifiable result. In any ambient air monitoring plan, execution triage of SPM source holds the utmost importance. However, the samplers cannot be directly placed at the source since a lot of other factors contribute to air sampling. These criteria have been mentioned in point 5:5.1 'Parameters Controlling PM_{2.5/10} Emission and Dispersion: Considerations for local Meteorology'.
5. **Monitoring station selection** – The monitoring station can only be selected and placed by the hired consultant or a competent professional who has legal authority to conduct such studies. The Factories Act 1948 Section 2(ca) defines the criteria for the selection of competent person/agency who can be hired for conducting air monitoring. This will also vary on which preliminary pollutant has been assessed by the team at different locations. Usually the station selection will also depend upon local microclimate data such wind speed, humidity and land surface temperature.
6. **Time Weighted Average (TWA) and/or Short Term Exposure Limit (STEL)** – Studies will be conducted depending upon the base material used in various construction activities for which monitoring plan is being laid down. The TWA will have a shift time averaged out while the STEL analysis will have a monitoring time of 15 minutes. The latter one can be done by the real-time analyzers or direct reading monitors.
7. **Chemical analysis of composition** – This will be done only for the samples taken every 8 hours to find out hazardous pollutants or concentration of PM_{2.5} in collected samples. Details analytical procedures to be followed has been laid down by the CPCB in their two volumes of Guidelines for the Measurement of Ambient Air Pollutants published in 2011.
8. Provided there is a monitoring exercise at the construction site, **a customized ambient and personal air monitoring plan** can also be devised as per the requirement, which will have specific set of rules and procedures to be followed for each construction site.
9. **Cost considerations and resource availability** - This is an important aspect when it comes to setting up a Ambient Air Quality monitoring program for a construction site. Resource availability must be addressed very early in the process of designing a regulatory air quality monitoring network. This is the key determinant in network design that influences numbers of sites, pollutants to be monitored and instrumentation to be selected. A wide range of commitments and costs is likely to be incurred in any air monitoring programme. Equipment operation budget typically amounts to approximately 10 per cent per year of the initial capital expenditure. Typically, a budget of 20–50 per cent of the total annual operating costs may be appropriate for quality assurance and control, depending on the complexity of the programme and the stringency of its data quality objectives. The number of sites required depends on the intended use of the data, area covered, spatial variability of pollutants, and availability of resources and instruments deployed. Estimated costs of setting up air quality monitoring station in India indicates that often it is capital intensive and requires regular provisions for adequate Operation and Maintenance (O&M) cost. As per the estimates, about Rs 4 to 5 lakh is required for setting up a manual station and Rs 3.5 lakh per annum for the O&M. In case of a real time monitoring station, the cost could be Rs 1.1 crore to Rs 1.5 crore for the station and Rs. 8 lakh for O&M per annum. The O&M cost, which includes data checking, validation and transfer to state level pollution control boards and committees are estimated to be 12 to 18 per cent of the capital cost of the real time stations.²⁹

²⁹ Reinventing Air Quality Monitoring Potential of low cost alternative monitoring methods' by Centre for Science and Environment, August 2016

10. SELF-DEVELOPED MODEL CHECKLIST FOR DUST SUPPRESSION AT CONSTRUCTION SITE

Table 9: Generalised Checklist for Dust Suppression at Construction Sites

Sr. No	Criteria	Response	Remark
1.	Address	To be filled by the builder	
2.	Site Location	Mention latitude-longitude of the location	
3.	Owner's Name	To be filled by the builder	
4.	Inspection Details	To be filled by the inspecting person	
*	Date		
*	Time		
*	Name of the agency		
*	Name of the person		
5.	Contact Details	To be filled by the inspecting person	
*	Phone number		
*	Fax number		
*	Email		
6.	Topography	To be filled by the inspecting person	
*	Wind speed - to be measured on site		
*	Soil type - Info to be collected from the contractor		
*	Average maximum temperature - to be measured on site		
*	Average minimum temperature - to be measured on site		
*	Humidity - to be measured on site		
7.	General housekeeping	In 'yes' or 'no'	
*	Aisle clear?		
*	Are the walkways clean?		
*	Signs displayed - direction and tagging (dust emission)		
*	Has PPE signs been displayed		
*	Has housekeeping personnel contact details been displayed?		
*	Has adequate housekeeping training been given to persons engaged?		

Sr. no	Criteria	Response	Remark
*	Has specific training been given to house-keeping persons for handling hazardous material?		
*	Have floor openings and protruding objects been marked?		
*	High dust generating areas have been marked?		
*	Has dust gathered on illumination equipment?		
*	Have physical barriers been installed with warning signs properly displayed?		
*	Has the transfer equipment carrying dust generating articles been provided with protective cover?		
*	Review of maintenance plan for vehicles and other motorized equipment		
*	Have physical barriers been installed with warning signs properly displayed?		
*	Has a predetermined waste collection area been allocated with proper covering for dust control?		
8.	Dust generating activities	Observation at the site	
*	Name of department		
*	Area tagged with 'Hazardous Process Sign' as well as 'PPE usage' sign		
*	Title of the activity		
*	Type of material being processed		
*	Type of dust in first observation - colour, smell, type of mist		
*	Type of dust in opinion of management personnel present at the site - name, description		
*	Downward movement of dust - speed in meters per second		
*	Upward movement of dust - Speed in meters per second		

Sr. no	Criteria	Response	Remark
8.	Management Operations	Observation at the site	
*	Are dust suppression system in place?		
*	Details of dust suppression system - mechanical and technical operation criteria		
*	Numbers of dust suppression systems installed		
*	How many locations have been installed with wet processes?		
*	How many locations have been covered with blanketing?		
*	How many locations been covered under sprinkler system?		
*	How much area has been covered with green vegetation?		
*	How many workers on site have been provided with training to operate dust suppression system if they are not working at a fixed location?		
*	Have the internal vehicles been tested for regular maintenance to reduce DPM emissions?		
*	Is regular maintenance programme in place for the mechanically operated dust suppression system e.g. motorised water sprinkler system or any other automatic motorised wet processes?		
10.	Locality details	Observation at the site	
*	Distance from the nearest school and total number of schools within 3 kms		
*	Distance from the nearest hospital and total number of hospitals within 3 kms		
*	Distance from the nearest public health or 'water, sanitation and hygiene' (WaSH) management facility with total numbers		
*	Distance from the nearest residential building		
*	Have the activities at site been done under controlled operation to reduce PM emissions?		

Sr. no	Criteria	Response	Remark
*	Have the vehicles used in transfer of materials covered to reduce fugitive emissions?		
*	Take details of complaints coming from residential buildings regarding dust accumulation.		
*	Details of adequate waste collection system		
*	Details of adequate collected dust management system from filters.		

To use the above checklist in effective manner, the following operational inputs have to be considered at construction site:

1. Every development to have an Environmental Management Plan (EMP) that includes specific details in regard to management of dust impact on site.
2. Adequate and appropriate training of contractors in regard to the provisions in the EMP for each development. This is with respect to implementation of protocols suggested under EMP and not for centrififying their involvement. Any act or guidelines dealing with reduction of PM emissions, there must a provision of mandating centrifified contractors for the implementations of protocols.
3. Identification of high-risk areas to be undertaken upfront and on an ongoing basis, and additional measures implemented if necessary.
4. Areas adjacent to existing residential properties are to be provided with sufficiently high dust fence.
5. The stockpiling of material to be limited as far as possible and where stockpiling is necessary, suitable measures are to be implemented to ensure that such do not generate dust.
6. A sufficient number of watering trucks are to be engaged from the commencement of construction and their effectiveness are to be monitored on a regular basis and additional carts/trucks added where necessary. If water is unavailable, the local municipal corporation can be contacted for the provision of treated tertiary waste water which can be effectively used for different activities.
7. Primary movement routes to be kept clean, to be made of reinforced cement and if not, shall be regularly watered by a dedicated truck/cart
8. Weather conditions to be monitored by contractors ahead of time and suitable plans implemented in times of high wind. Contractors to check weather forecasts daily to plan watering operations.
9. Vehicles travelling to and from the construction site must adhere to speed limits so as to avoid excessive dust escaping. They have to be covered in a way that can hold hard materials such as large boulders (i.e. construction and demolition debris).
10. All contractors working within the site are to implement the dust control measures as covered in the EMP.
11. Stand by water trucks to be deployed in case a refill is required especially for those activities which are continuous and are being carried out even on weekends when minimum workers are attending the site.

11. IMPLEMENTABLE PPE PROTOCOL FOR ENGINEERS AND DAILY WAGE WORKERS AT CONSTRUCTION SITE

The primary approach should be to protect workers from hazardous air. Personal protective equipment as per national/international standards and right usage plays an important role in reducing accidents at site. In construction work, the basic requirements for the protection of the workers are safety helmets, safety shoes and other protective equipment depending upon the nature of work. PPEs should ensure absolute and full protection and should be designed and built to withstand the hazard against which it is intended to be used. As per the Gujarat Factories Rules, 1995 the assigned protection factor for any respirator depends on 'the work- place level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by this section.'

1. The selection of right type of PPE requires the following considerations:

- **Nature and severity of the hazard:** As mentioned above, PPEs will be selected on the basis of APFs and how much protection they provide against particular health hazard. Especially in case of respiratory protection, PPEs covering full mask along with eye protection are selected based on the nature of the work. The PPE assignments will be logged on daily basis. During the monthly safety review, demand and supply logs will throw more light on how workers use these PPEs. Ideally these PPEs would have to be replaced every 48 hours for tasks that involve $PM_{2.5}$ generation.
- **Type of containment, its concentration etc:** Table 10 indicates all types of respiratory protection to be used in activities which have been deemed hazardous as per the Gujarat Factories Rules 1995.
- **Nature and duration of work:** It is also important to anticipate the needs of workers while designing a PPE protocol for a construction site. Since a construction site includes many people performing different tasks at the same time, it is at times difficult to design a subjective PPE protocol for each worker, but as per the rules enumerated in the section above, respiratory protection is a must. The most hazardous activities will have to be covered with more and more efficient PPEs. As per the Gujarat Factory Rules 1995, it is the job of safety professional on site or project manager to handle the triage process. The whole process shall be completed for each process within 2 weeks of the commencement of construction. There will be continuous monitoring and improvements in the process of allocating PPEs with special attention given to the most hazardous processes.

Comfort in using PPE: Along with protection factors, the PPE must also provide comfort to workers. As engineering controls are likely to cause restriction in movements and operations, PPEs must not add to it. Thus it is imperative that owner must spend a good amount of financial resources in allocating PPEs to the workers. Comfort factors along with APFs have been mentioned in the schedule 11 notification of the Gujarat Factories Rules 1995.

Conformity to national /international standards: The Factories Act 1948, The Gujarat Factories Rules 1995 are two implementable standards to be followed by the construction companies while ensuring providing PPE protocols in construction site. Apart from this, the service provider can design internationally verifiable PPE protocol using US-EPA, OHSAS, NIOSH or ACGIH standards.

Table 10: PPE protocol for respiratory protection at construction site

Sr. no	Hazard Type	PPE Specified	Remark
1.	Dust or fume	1. Dust respirator 2. Air line respirator	
2.	Gas or vapor (non toxic) facility with total numbers	1. Cartridge respirator 2. Air line respirator	
3.	Toxic gas or vapor	1. Canister respirator 2. Self contained breathing respirator 3. Air line respirator	For IDLH only SCBA to be used
4.	Non toxic mix of dust gas and vapor	1. Cartridge respirator with particulate matter filter 2. Air line respirator	
5.	Toxic mix of dust, gas and vapor	1. Canister respirator with particulate filter separate for PM _{2.5} and PM ₁₀ 2. Self contained breathing apparatus 3. Air line respirator	
6.	Oxygen deficient environment (less than 19% - to be covered in personal monitoring programme under AAQI protocol)	1. Self contained breathing apparatus 2. Air line respirator	
7.	Toxic substances that can be absorbed through skin.	1. Positive-pressure ventilated plastic suits	

- Capacity development and awareness generation:** It is imperative for the construction company to engage a specific person or agency to impart knowledge and importance of using PPE while working on construction site for the reduction of damages and hazards. This can be done through the same competent person or agency who have been hired for the effective implementation of monitoring protocol as they would have better knowledge of different air borne hazards present at th site. In a technical specifications, it is important to provide induction training to every worker or engineer joining at the construction site while the refresher course can be provided at every 3 months for basic safety which will also include PPE protocol implementation.

(Reference for this section has been taken from National Occupational Safety and Health (OSH) profile prepared by the Directorate General Factory Advice Service and Labour Institutes (DGFASLI - Sion, Mumbai (India)) in collaboration with International Labour Organization (ILO - Geneva, Switzerland) published in the year 2017.

ANNEXURE 1

CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN SURAT CITY

A Case of SGPPL (Kosad, Surat)

1. Introduction

As per C & D waste Rules 2016 dated: 29th March 2016, it is mandatory for all Construction and Demolition Waste (C & D Waste) generator to maintain their demolished or under construction building waste inadequate manner. As per this requirement, SMC has taken responsibility for managing construction and demolition waste in the city, which creates physical and air pollution nuisance for the city's day-to-day operations. Processing construction and demolition waste can provide a positive pointer for a neglected section of solid waste, which is usually ignored while dealing with municipal solid waste.

Looking at the importance of having a specific construction and demolition waste processing and management facility in Surat city, Surat Municipal Corporation has entrusted the work of Construction & Demolition (C & D) Waste Management system in Surat city to an agency named R. K. bricks and tiles; vide standing committee resolution No: 592/2016, Dated: 31/03/2016 on PPP basis for 20 years and accordingly, land lease deed has been signed for land admeasuring 13000 sq.mt. The area situated at Block no: H-29, Moje: Kosad, Dist: Surat, for the establishment of Construction & Demolition (C&D) waste processing plant. Moreover, the Agency has formed the SPV named Surat Green Precast Pvt. Ltd. With the approval of standing committee vide resolution No: 1468/2016, Dated: 29/08/2016.

Surat Green Precast Private Limited is an Initiative with Surat Municipal Corporation (SMC) on a PPP basis to Collect and recycle 300 tons of Construction & Demolition waste a day for resource recovery of C&D aggregates for 20 years with a motive of commitment to "Surat Smart City Mission." Surat Municipal Corporation aims to take care of all the present construction and demolition waste of the city and scientifically process the same to develop various building products. The plant has a specialized segregation system, debris handling system, crusher, and other required units, including a multiple section screening unit. The plant's processed product is then being used as a raw material for producing a wide range of eco and green building materials like brick, paver, blocks, etc. The whole system, right from waste receiving to final finished eco-product, uses state of the art technology and has no adverse impact on the environment. The recycling of construction and demolition waste being processed at this facility reduces mining for aggregates (like sand and blue metal) and saves the valuable land that is otherwise wasted by mere dumping of waste surrounding Surat's city. Project details of this facility are as follows:

2. Project Details - SGPPL

Following are few initial details for the Surat Green Precast Pvt. Ltd.,

Table 1: Surat Green Pre-Cast Pt. Ltd - A construction and demolition waste processing facility

Sr. no	Criteria	Response
1.	Sanctioning Authority	Surat Municipal Corporation
2.	Work Order Tag for SGPPL (As per the records provided by the Surat Municipal Corporation)	DNG/OUT/WO/67, Dt: 04/06/2016
3.	SPV Name	Surat Green Precast Pvt. Ltd.

Sr. no	Criteria	Response
4.	Concession Agreement	Dt: 16/11/2016
5.	Concession Period	20 Years
6.	Estimated project cost	19.50 Crores

Surat Municipal Corporation governs policies and procedures for the SGPPL, and the ULB decides the frequency and by what all mean (physical and administrative) raised queries shall be addressed. As indicative, the SPV generates revenue from the sale of Sand, Soil, and Aggregate from the operations to SMC and local markets. This can be explained from the aspects that SGPPL receives for crushing operations, sand-making operations, and ready-mix concrete products manufactured from the byproducts and primary products.

3. Business plan of SGPPL

The plant is situated at Kosad location, which is about 15 km away from Surat's central city. All the waste related to the construction and demolition of buildings and other structures must be collected from the city and brought to the SGPPL plant. The plant operational in an MoU with the Surat Municipal Corporation; thus, all the requests for the processing and collection must be made through Surat Municipal Corporation. The facility size and other details have been mentioned in Table 1, yet in addition to this, one must note that land which has been allotted for this facility is on Rs rate. 1/ SqM for the next 20 years from the day of its inception. In the year 2020, the facility is ready to take waste processing to its full potential. However, it needs a little push for the construction companies and contracting agencies operational within Surat's city to send out their construction and demolition waste to SGPPL.

In the plant's processing cycle, the final and intermediate output, which is crushed goods of construction and demolition waste products sent to the facility, would be sold for generating revenue for the company. Before putting them in the market, since these crushed goods would be best of the quality coming from waste, there is a branding channel available to increase the outlook of sellable goods through SGPPL. The final fine aggregates, as well as the crushed products intermediates, can be used in the production of masonry blocks, pavers blocks, landscaping products, articles for garden decorations as well as some portion can be utilized in the manufacturing of fertilizers since the final product from the plant would be rich in minerals which are needed for better horticulture production.

As indicated in the above section, Surat Municipal Corporation makes all policy-level decisions for the plant processing, thus even for the transportation of construction and demolition waste SMC has decided a specified charge, which is Rs. 333/Metric Ton. The request for collecting waste can be raised in an online portal, explained in a later portion of this literature.

4. Project Components

There are two main stages of procedures for waste treatment followed at SGPPL:

1. Collection
2. Processing

The following section of this literature is discussing these steps in detail.

4.1 Collection of Construction and Demolition Waste for SGPPL

As soon as the construction site contractor or owner raises a request, SGPPL would be collecting waste from the construction and demolition site at Rs. 333/MT. These charges are for the private contractors, and if Surat Municipal Corporation is diverting their construction and demolition waste to SGPPL, then there would be no charge taken. Once the waste is collected, it will be sent to the SGPPL site for the treatment, which will be following steps as below:

Step.1. - the vehicles arranged for collection as per the requirement of waste collection. The major categories are:

1. Up to 1 Ton
2. Between 1 to 3 Ton
3. 3 to 5 Ton and
4. More than 5 Ton of C&D waste

Step.2. - All vehicles will be arranged with GPS.

Step.3. - Agency started a toll-free number (1800-212-2829) & Mobile application facilities for waste generator.

Step.4. - Request will be completed within 24 hours after approval by a waste generator.

Step.5. - If the waste generator denies the request, the message will be forwarded to the respective SI for necessary action.

Step.6. - Once waste received at the processing site message will be conveyed to the waste generator & respective SI.

Step.7. - Economic Waste Collection process is followed as charges for collection, Transportation, and Processing are Rs. 333/- Per MT as per agreement with SMC.



Figure 1: Construction and Demolition Waste Collection Vehicles by SGPPL in Surat

Table 2: Transportation and Processing Charges in Different Cities Compared

Sr. no	Cities	Processing Charges	Transportation + Processing Charges
1.	New Delhi	-	375
2.	Bangalore	550	1250
3.	Ahmedabad	180	(*5% increase every year)
4.	Surat	-	333

Sources of waste collection and their related implications would be as follows,

1. New Construction Site: For the new construction site, as per the policy made by SMC, a membership certificate along with fees shall be taken. Developers/ Builders / Landowner/ SMC contractor etc. must become members of Concessionaire with following terms and conditions (TIFAC Rules)

- a. New construction generates about 40-60 kg per sqm of the buildup area.
- b. Repair and renovation of existing buildings generate 40- 50 kg per sq. meter
- c. Demolition of buildings generates 300-500 kg per Sqm.

So as per the calculation for New Construction, the waste generator must deposit Approx. Rs 17/SqM for which a certificate to developers/builders on completion of the project for the quantity of C & D waste given will be provided. This certificate must be submitted to SMC before acquiring Building Under Construction consent. All payments shall be cleared by a member to get a certificate of given C & D waste. In addition to this closure, certification shall be issued at the time of project completion by the agency. The respective department of SMC shall proceed for plan approval and BUC after verification of the certificate.

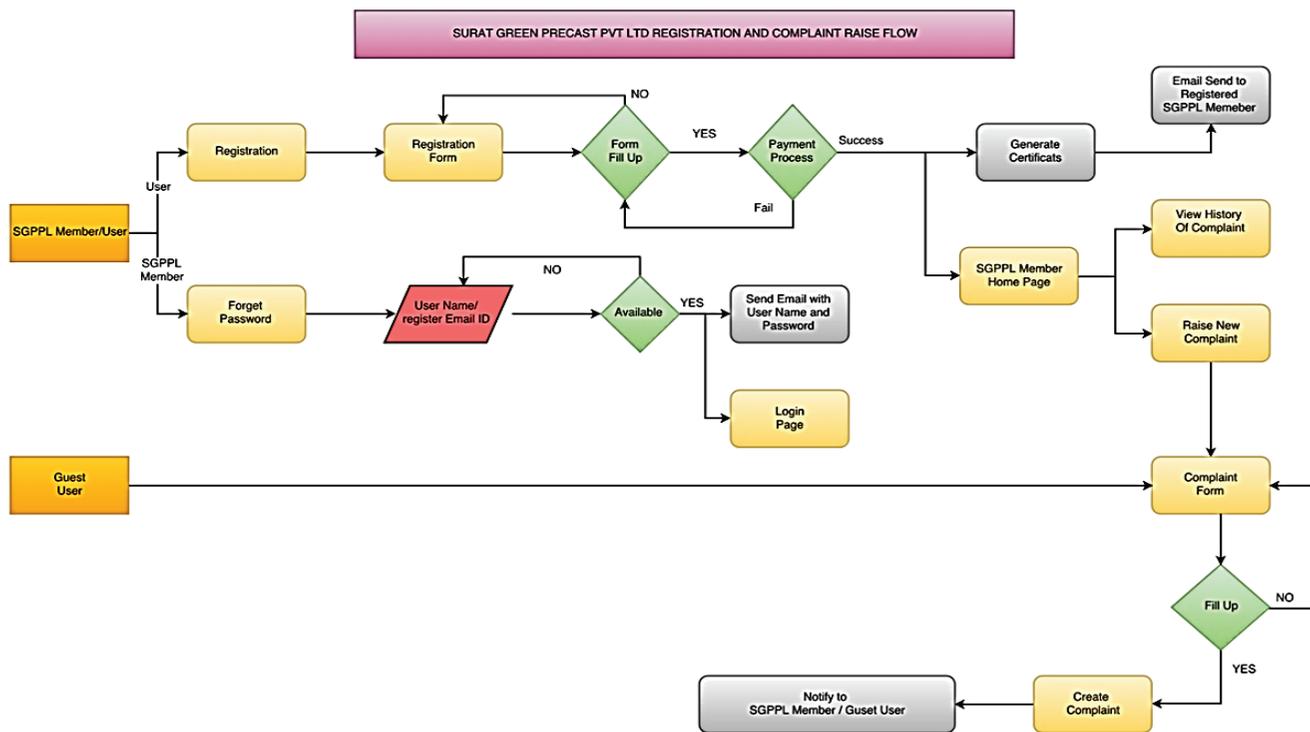
2. Renovation: When it comes to renovation, the party itself must contact the authorized agency (SGPPL) to collect waste.
3. Demolition: In case of demolition, the party must take membership from SGPPL; after that, SMC will permit demolition activity. As per TIFAC estimation, the waste generator must deposit Approx., Rs 167/sqm
4. Collection from Zone Depot of SMC: As SMC has provided us the depot in every zone, the waste collected by SMC or the unauthorized waste dumped by private vehicles has to be dispatched SGPPL site by SMC. Following Table 2 contains details on different disposal depots SMC has assigned for C & D waste
5. Government work: As per the Construction and Demolition Waste (Management & Handling) Rules Dated: 29th March 2016 [Published in the Gazette of India, Part- II, Section - 3, Subsection (ii)] framed by The Government of India under the Municipal Solid Wastes (Management and Handling) Rules, 2000 published vide notification number S.O. 908(E), dated the 25th September 2000, SMC to make compulsory to take our membership for all government contractor including SMC contracts for proper recycling of C & D waste.

Table 3: Construction and Demolition Waste Collection Centre est. by SMC

Sr. no	Name of Zone	C & D Waste Collection Centre
1.	Central	Rudrapura Technical Vahan Depo
2.	East - A	TP 16, Kapodara, FP 14
3.	East - B	TP 22,FP 66, Sarthana (Valak)
4.	West	44 Jahangirabad FP 47 District Centre
5.	North	Kosad C&D Waste Plant
6.	South	TP 1, FP F 122, Beside Sosiyo Circle
7.	South West	Near DGVCL Office, Aventis farm, and Uttar Gujarat Vahan Depo
8.	South East	TP 61 FP61 Man Society Road, Godadra and Near Ashtik Party Plot, Parvat

For the construction and demolition waste collection, SGPPL has launched an application and a toll-free number. After following the procedures mentioned above, as per the quantity and type of waste (depending on the source), the customer can register their request at either application, web page, or toll-free number. The webpage at which these complaints can be registered is (www.sgppl.co.in). A toll-free number has been assigned 1800 212 2829 for the grievance's management. Following **Figure 2** show snapshots of the application and webpage request registration process:

Figure 2: IT Registration Process at SGPPL of Construction and Demolition Waste



4.2. Processing of Construction and Demolition waste at SGPPL

Primarily, the SGPPL facility was started with the primary processing plant. The plant processed the construction and demolition waste debris to form the aggregates of 300 mm size. The machine installed in this plant had a jaw crusher, and this primary facility later started an integral part of the advanced SGPPL facility functioning today. Following, Figure 4 shows a picture taken of this facility,

In Figure 3, as indicated currently, the SGPPL employs more complex crushing, separation, and finishing of desired sizes of aggregates from construction and demolition waste received at the plant. These steps include, Primary Screening – Removal of Larger Waste Articles – Collection of Separated Waste Articles – Feeding and Crushing of Collected Waste Articles – Aggregates formation of Desired Size – Cleansing of Collected Desired Sized Aggregates – Final Packaging. The detailed steps of this procedure are explained in the following flowchart, which is self-explanatory,



Figure 3: Secondary Procedures at SGPPL (Surat: Surat Municipal Corporation)



Figure 4: Primary Processing Plant Section of SGPPL (Source: Surat Municipal Corporation)

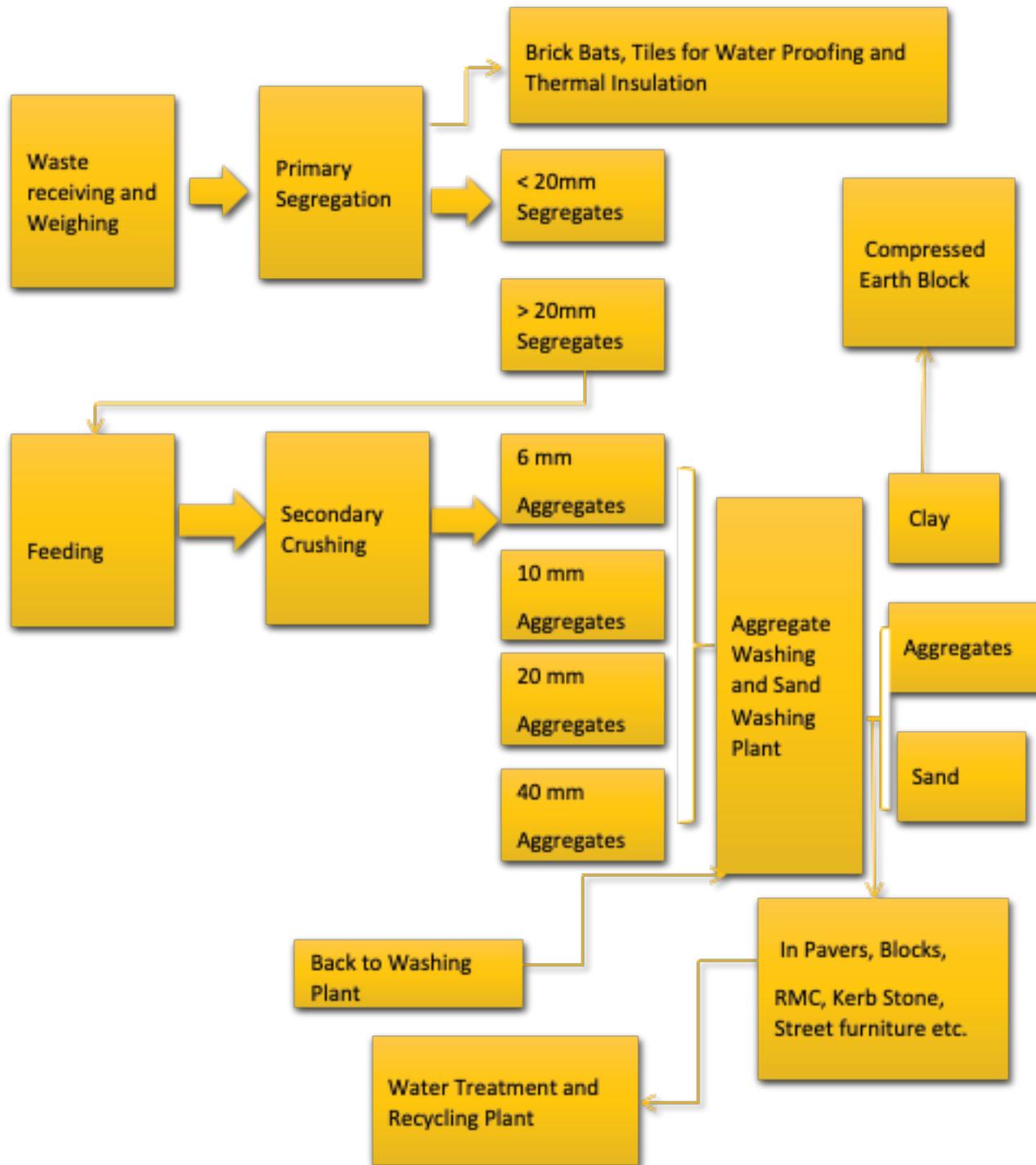


Figure 5: Detailed Process Flowchart - Construction and Demolition Waste at SGPPL

Following are the final recycled products and their possible usage channels,

1. Kerb Stone, Road Edge Stone, Paving Stone, Granite
2. Mortar less Paving Blocks which will be used in the concrete and other interlock pathways
3. Solid and hollow cement/cement material type blocks for the building
4. Ready Mix Concrete
5. Maintenance hole and Tree Pits

Representative images of the above five products are displayed below:

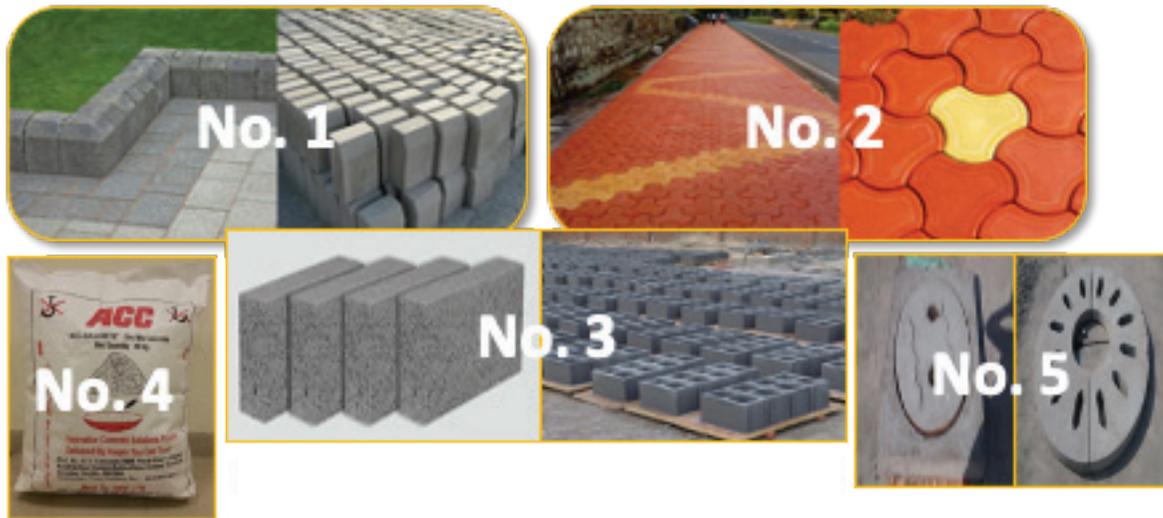


Figure 6: Compilation of figures - Products from SGPPL Plant Processing

With each step, as explained in Figure 5, there are sub-steps involved. These sub-steps are associated with activities observed in the processing of construction and demolition waste at the SGPPL facility. In addition to these sub-steps, there are ways through which they can be achieved, which has been explained in the following flowchart:

Feed Conveyor

1. Feeding of material into the hopper
2. Collection of crushed material

Screening

1. Addition of water to improve quality & to retrieve fine particles
2. Material is sent to the Log washer to separate light contaminants (wood & plastic)

Washing

1. Rinsing & resizing screens used to size aggregates
2. Clean and dry aggregates are sized and stockpiled

Fine Recovery

1. Washed sand is recovered which is free from any silt,
2. Size of washed sand is maintained at -3 mm to +75 microns

Water Treatment

1. -75 micron material is passed to Aqua Cycle Thickener
2. Specifically chosen flocculent is added to it in controlled quantities
3. Formation of condensed sludge

The process which has been explained in the above flowchart would be employing different kinds of mechanical equipment, a list of which have been given below:

1. Jaw Crusher
2. Vibrating Grizzly Feeder
3. Feeding Hopper
4. Feed Conveyor
5. Log Washer
6. Vibrating Screen
7. Dewatering Screen
8. Hydro cyclone
9. Thickener
10. Dosing System

4.3 The final product of waste processing at SGPPL

Aggregate (+20 MM)



Aggregate (+5 to 20 MM)



Fine Sand



Coarse Sand



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DISCLAIMER

The report does not mention mandatory implementable activities taking procedural reference from the central and state government agencies' acts and rules. The reader shall understand that this report is rather a compilation and collation of actions which have been suggested in captioned rules and acts throughout this report. It shall be taken as a snapshot of these protocols which are usually neglected unintentionally because of their scatterness in different relatable documents. As a way forward, penalty procedure, civil society engagement protocols and micro-area grid based AAQI protocol for different activities mentioned in this report can be developed in close coordination with government agencies and other technical agencies/professionals.

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ABOUT WRI INDIA

WRI India, an independent charity legally registered as the India Resources Trust, provides objective information and practical proposals to foster environmentally sound and socially equitable development. WRI India's mission is to move human society to live in ways that protect Earth's environment and its capacity to provide for the needs and aspirations of current and future generations. Through research, analysis, and recommendations, WRI India puts ideas into action to build transformative solutions to protect the earth, promote livelihoods, and enhance human well-being.

We are inspired by and associated with World Resources Institute (WRI), a global research organization. Currently over 150 researchers are working with WRI India in our offices at Delhi, Mumbai and Bengaluru.

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Shakti Sustainable Energy Foundation seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following areas: clean power, energy efficiency, sustainable urban transport, climate change mitigation and clean energy finance.

ABOUT CREDAI

Since its inception in 1993, CREDAI Surat has been operating to promote the real estate sector. It is an affiliated body to CREDAI Gujarat, an associate member of CREDAI (Confederation of Real Estate Developers Association of India). CREDAI Surat's motive is the promotion of ethical and better practices by adopting a self-code of conduct amongst the builders, developers, and promoters to maintain honor & dignity and to secure the spirit of friendly co-operation with customers for the benefit of their members. CREDAI Surat ensures that the member shall promote the highest standard of development into the real estate industry to attain transparency and fair practices. This way, the member shall be able to discharge their responsibilities towards the community in general. CREDAI Surat has emerged as a leading platform for addressing problems of Real Estate Promoters and Developers of Surat city.



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