Development of A Real Time Approach to Construction Dust Control & Preparation of Management Measures to 'Beat Air Pollution' in Construction Project

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Abstract— This paper addresses a major environmental problem associated with construction sites and the best mitigation strategies for minimizing or reducing the effects on the environment. Since construction dust emissions are one of the main causes of air pollution, improving the quality of the air on and around construction sites demands methodical, practical approaches that work.

•The National Green Tribunal (NGT), CAQM, regulatory bodies, and other enforcement agencies have taken varied degrees of severe action against project proponents/industries in the past few years for violating dust standards during building and demolition operations as well as for openly disposing of concrete waste. In order to comply with required and contractual provisions, contractors and subcontractors are frequently instructed and enforced to adopt environmental protection measures on sites.

- ***Adopting a multiple-option approach is necessary to minimize dust and air pollution on construction sites, given that various construction operations comprise a diverse range of activities. This paper aims to provide additional light on the most cost effective, real-world methods for minimizing the negative effects of dust in the field of sustainable mechanism.***
- ***Although, there are some general approaches to dust control but more efficient and cost effective pragmatic approaches for improving air quality in and around the construction sites depends on – (1) Identification of significant dust emission sources on every site, (2) Prioritizing such sources that needs to be tackled more prudently, (3) Weighing various practical and cost effective options for controlling the dust emissions from different sources, and (4) Sincerely implementing and managing such appropriate actions.***
- ***There is no doubt that construction dust control has now become new challenges for the construction activities in any large-sized infrastructure developmental project. The need of the hour is to intensify sincere efforts towards control of dust & air pollution and enhanced compliance level for control of dust pollution without affecting its progress.***

Index Terms— Construction dust, Debris, pollution.

I. INTRODUCTION

Air pollution is becoming a severe environmental problem, harming our health as well as economic activities and ecosystems. Every year, millions of people globally die prematurely as a result of air pollution, particularly occurring in Asia-Pacific.

Of all air pollutants, particulate matter (PM_{10}) and $PM_{2.5}$—particulate matter having a diameter of less than 10 and 2.5 microns—pose the greatest health concerns to the general public.

Dusts from various construction and other civil engineering activities contain a wide range of particle sizes (including PM10 and PM2.5) and material types, such as silica, and recognized as one of the major contributors to air pollution in India.

Construction dust is produced by a variety of on-site activities, including earth work, excavation work, rock blasting and drilling, bulk material transportation, loading and unloading of dusty materials, open-air material storages, concrete production, stone crushing, cutting and filling, equipment and vehicle movement and so on.

Because of their small size, dust are transported away from construction sites even in light wind blowing potentially harming the local environment, the health of nearby inhabitants, construction workers, and others operating on the site. Blowing dust on the Construction job site is also a possible safety issue.

Dust pollution has been worse in recent years amid India's extreme summer and winter climates. The deterioration of the situation year after year has compelled the National Green Tribunal (NGT) and other regulatory authorities like Commission for Air Quality Management in National Capital Region and Adjoining Areas (CAQM) to issue a various directive, guidelines, GRAP orders and actions to construction projects, requiring them to strictly adhere to all rules and regulations governing dust pollution. Violations of stipulated rules by construction activities result in penal sanctions, including a prohibition from conducting site operations.

In an effort to effectively address the problems of waste management and pollution, the government also announced the "Construction & Demolition (C&D) Waste Management Rules, 2016" and its amendments. A number of additional rules and action items have been established in response to the growing air pollution, making dust mitigation measures in infrastructure projects and demolition operations necessary. It is anticipated that using this strategy would aid in controlling dust in order to lower air pollution. But situations are worst day to day particularly in summer and winter, AQI level of air pollution in Delhi goes to very poor to severe + category.

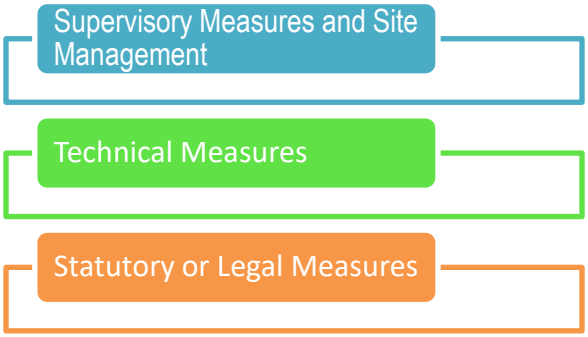
Although, there are some general method to dust control, such as sprinkling of water every day to suppress the suspension of dust at the construction sites; covering debris and materials when stored or when they are being taken; barricading along the perimeter of construction or demolition sites; use shade nets, tarpaulins or plastic sheets for staging, etc. but practical measures based on comprehensive framework approach need to be followed for improving air quality in and around the construction sites. This paper will be focused on this aspect and analyzed composite measures which are able to guide contractors and fulfill their knowledge gap for reducing dust emissions in a meaningful way and once applied their positive effects can easily be felt and recognized.

II. RESEARCH PROBLEM

A. Review Stage

The construction sector has a complicated structure and a wide range of sources of exposure, making it challenging to apply simple yet potentially effective control measures, despite the critical need for effective controls. The general consensus among contractors and construction agencies is to rely heavily on basic techniques such as using water tankers to sprinkle for dust suppression, barricading the site at the required height to prevent dust dispersal, and using ventilation systems with exhaust to reduce dust emissions. While these methods help reduce dust emissions, they are not always effective or desirable.

In order to help contractors understand the value and advantages of respiratory & public property and plants protection, this article has examined a number of methods that, when implemented, have clear and noticeable positive effects on dust emissions reduction. As seen in the graphic, the recommended strategy is divided into three major categories.



The next section covers these combinations of metrics using real-world site observations and inspections to provide analysis and solutions. In order to address the dust problem at building and construction sites, it is imperative that multiple strategies be used rather than just one.

III. OBJECTIVE

Although, there are some general approaches to dust control, but more efficient and cost effective pragmatic approaches for improving air quality in and around the construction sites depends on –

(1) Identification of significant dust emission sources on every site,

(2) Prioritizing such sources that needs to be tackled more prudently,

(3) Weighing various practical and cost effective options for controlling the dust emissions from different sources,

(4) Continuous air quality monitoring depending on site, and

(5) Sincerely implementing and managing such appropriate actions inclusion of human health, trees and plants and surrounding facilities.

It is to be noted that, a significant amount of work needs to be done to keep all of the suggested measures consistently more successful in order to keep dust emissions from all sources—stationary, mobile, and area—within the permissible limit. It's important to note that a variety of steps must be taken, rather than just one single strategy.

It requires increased awareness and change of mindset among contractors and its sub-contractors. It has to be understood that there are implementation risks in the form of stoppage of work or hefty penalties in case of non-compliance and non-adhering to the stipulated norms causing delay in timely execution of projects.

IV. LITERATURE REVIEW

Previously, there is used to be no official regulation that specified the preventive steps that needed to be followed for the control of dust, particularly C&D dust that develops during construction. Regulatory bodies, enforcement agencies, CAQM, the National Green Tribunal (NGT), etc. are regularly issuing various guidelines, action points & mitigation measures, notifications, etc., in response to the growing air pollution in recent years. Additionally, they have made dust mitigation measures mandatory in large-scale construction projects and infrastructure projects. All of these measures would help to keep the dust under control and reduce air pollution.

Recently, defying these instructions has resulted in severe consequences such as prohibiting construction operations, suing project implementation organisations, issuing stop orders that have a significant negative impact on the pace of work, and other severe measures.

Further, the Commission for Air Quality Management (CAQM) in NCR & Adjoining Areas has issued "New Policy to Curb Air Pollution in the National Capital Region" to regulate construction and other activities in the event of deteriorating air quality in Delhi-NCR during winter season. It has also revamped the "Graded Response Action Plan" (GRAP) whereby restrictions shall be imposed on construction and ancillary activities.

The primary dust pollution guidelines and legislative directives listed below have been taken into consideration for this paper's compilation of required action items and mitigation strategies:

1. Environmental Impact Assessment Guidance Manual for 'Building, Construction and Area Development Projects', 2010;
2. Central Pollution Control Board (CPCB) 42 Action Points to Mitigate Air Pollution;
3. National Clean Air Programme, 2019;
4. NGT Order OA 21 dated 04-12-2014;
5. NGT Order OA 95 dated 10-04-2015;
6. MoEF Dust Mitigation Measures Notification 25-01-2018; and
7. CPCB Guidelines on Dust Mitigation Measures in Handling Construction Material and C&D Wastes, 2017
8. No.120017/27/GRAP/2021/CAQM October 06, 2023 [Implementation of Actions under Stage-I ('Poor Air Quality) of revised Graded Response Action Plan in Delhi-NCR- steps to be taken
9. No.120017/27/GRAP/2021/CAQM October 21, 2023 [Implementation of Actions under Stage-II ('Very Poor' Air Quality) of revised Graded Response Action Plan in Delhi-NCR- steps to be taken
10. No.120017/27/GRAP/2021/CAQM November 02, 2023 [Implementation of Actions under Stage-III ('Severe Air Quality) of revised Graded Response Action Plan in Delhi-NCR- steps to be taken
11. No.120017/27/GRAP/2021/CAQM November 05, 2023 [Implementation of Actions under Stage-IV ('Severe + Air Quality) of revised Graded Response Action Plan in Delhi-NCR- steps to be taken
12. No.120017/27/GRAP/2021/CAQM November 18, 2023 [Revocation of Actions under Stage-IV ('Severe+' Air Quality) of revised Graded Response Action Plan in Delhi-NCR.]
13. No.120017/27/GRAP/2021/CAQM November 28, 2023 [Revocation of Actions under stage-Ill (.severe, Air quality) of revised Graded Response Action plan in Delhi-NCR]

V. METHODOLOGY

In order to carry out the assessment of existing dust / air pollution issue at the linear Construction projects and to identify potential mitigation, control and management measures required to be taken based on present site conditions, So, following steps are taken:

Identifications of several prominent locations based on surrounding variations (like residential zone, silence zone) in Delhi NCR;

- Site visit for identification of dust pollution influenced area in the particular location;
- Collection of the average particulate matter concentration of PM10 and PM2.5, SO2, NOx in upwind and downwind directions;
- Collection of relevant data through secondary/ source.
- Estimate the trend of site ambient air quality monitoring results and comparison with "NAAQS";
- Problem identification for dust pollution;
- Preparation of Indicative mitigation measures as per various guidelines / norms.

VI. TREND OF SITE AMBIENT AIR QUALITY MONITORING RESULTS

The ambient air quality with respect to the study zone around the proposed construction area gives the baseline information. The various sources of air pollution in these identified sites are construction activity, traffic, urban and rural activities. This is also be useful for assessing the conformity to standards of the ambient air quality during construction activities operation.

The average particulate matter concentration of PM_{10}, $PM_{2.5}$, SOx, NO_X in upwind and downwind directions between Dec 2023 to March 2024 was measured at four different locations at site to determine ambient air quality.

The annual predominant wind direction at Delhi NCR is from WNW to ESE and from E to W and accordingly, the ambient air quality monitoring locations were selected. The results are graphically represented in Figure-1 & 2 , 3 respectively

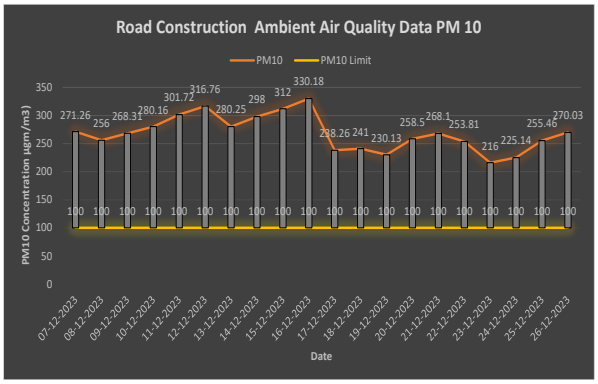


Fig 1Ambient Air Quality Monitoring data PM10 West Delhi

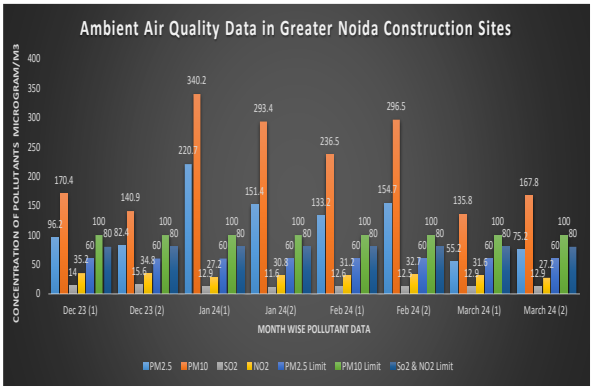
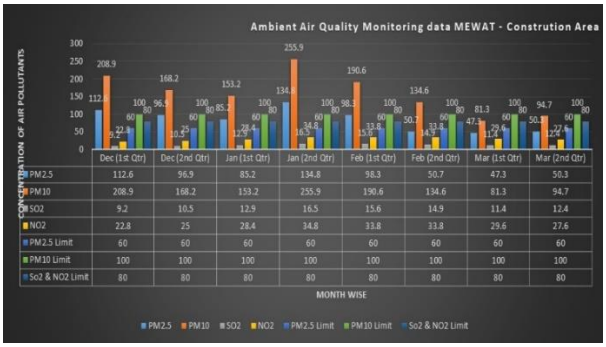


Fig 2 Quarterly Ambient Air Quality Monitoring data Greater Noida



	Dec (1st Qtr)	Dec (2nd Qtr)	Jan (1st Qtr)	Jan (2nd Qtr)	Feb (1st Qtr)	Feb (2nd Qtr)	Mar (1st Qtr)	Mar (2nd Qtr)
PM2.5	112.6	96.9	85.2	134.8	98.3	50.7	47.3	50.3
PM10	208.9	168.2	153.2	255.9	190.6	134.6	81.3	94.7
SO2	9.2	10.5	12.9	16.5	15.6	14.9	11.4	12.4
NO2	22.8	25	28.4	34.8	33.8	33.8	29.6	27.6
PM2.5 Limit	60	60	60	60	60	60	60	60
PM10 Limit	100	100	100	100	100	100	100	100
So2 & NO2 Limit	80	80	80	80	80	80	80	80

Fig 3 Quarterly Ambient Air Quality Monitoring data Mewat

Due to construction activities at different locations during the period Dec 2023 to March 2024, the average concentration of PM10 in upwind and downwind direction varies from 271.2 to 226.2 µg/m^3 & 302.2 to 275.8 µg/m^3 respectively and the average concentration of PM2.5 in upwind and downwind directions varies from 165.7 to 149.4 µg/m^3 & 169.5 to 160.5 µg/m^3 respectively. The low and medium wind speed in winter & summer seasons created settled, turbulent conditions, dust storms and which caused higher dust and soil borne particles like PM 2.5 and PM10 concentration levels.

VII. IDENTIFICATION OF MAJOR SOURCES OF CONSTRUCTION DUST EMISSIONS

After detailed site visit covering all locations in Delhi NCR between December 2023 to March 2024 to is conducted to monitor effectiveness of dust control measures being undertaken by the Construction project. It is observed that the most significant sources

of dust generation during the project construction works are:

- Stockpiles of Course and fine aggregates;
- Open areas during earthworks and excavations;
- Cement Handling and Concrete Batching Plants, RMC Plants, Sleeper Plants; and
- Construction Vehicle movements on haul roads and site roads.

Based on the primary activities being conducted in the project, dust pollution sources and the principal challenges they raise are categorized into three groups: (1) Stationary sources, (2) Mobile sources, and (3) Area sources.

(1) Stationary Sources

•Operation of Concrete Batching Plants *[such as, improper and irregular maintenance of cement silo vent air filters; uncovered aggregate bins; improper dust covering arrangements for conveyor belt and hopper; uncovered and unsecured cement feeding hopper area; etc.]*

Fig 4 improper and irregular maintenance of cement silo vent air filter

•Cement Handling and Go-down *[such as, poor housekeeping; untidy and open storage of bundles of empty cement bags; poor ventilation air arrangement; no PPEs to workers to prevent inhalation of cement dust particles]*

•Operation of Stone Crushers and Pug Mills

•Rock Drilling and Blasting Operation *[such as, fugitive silica dust pollution during drilling of blasting holes; no wet drilling to contain dust emissions; no PPEs to workers to prevent inhalation of harmful dust particles]*

•Sleeper Plants *[such as, unprotected loading point at aggregate bins; uncovered and unsecured cement feeding area; breaking of rejected sleepers; unsecured and unprotected storage of rejected or broken concrete sleepers*

Fig 5 Aggregate bins and conveyor belt for sand and aggregates are not covered to control fugitive dust emissions

(2) *Mobile Sources*

- Movement of vehicles, dumpers, transit mixers, etc. on unpaved and haul roads at site.
- Working of excavators for rock breaking at hard rock and blasting site area.
- Vehicles carrying loose construction materials like soil, sand, stone chips, GSB, etc.

Fig 6 Vehicles carrying loose construction materials like soil, sand, stone chips, GSB, etc.

Fig 7 Uncontrolled road dust in haul roads

(3) Area Sources

- Storage of overburdened material and muck piles.
- Accumulation of C&D waste and dumping it all over the site.
- Stockpiles of coarse and fine aggregate materials on site.
- Damaged and non-compaction conditions of internal site roads.
- Accumulation of unsuitable spoil material stockpiled within RoW.

Fig 8 Improper Disposal of C&D Waste Leading to Dust Pollution

Fig 9 Storage of Coarse Aggregates w/o Dust Suppression Measures

VIII PROPOSED MITIGATION MEASURES

COMMON WORK AREAS AND NECESSARY METHODS FOR CONSTRUCTION DUST MITIGATION & CONTROL

In order to reduce dust emissions during wind blowing and other site disturbances, exposed stockpiles on worksites, such as fine and coarse aggregates, concrete waste, excavated soil, etc., require suitable dust management and mitigation solutions.

A. Exposed Dust Generating Stockpiles & Excavated Soil

Typical control techniques consist of:

- To control dust, it is recommended to use a water spray system to moisten the excavated soil and exposed stockpile.
- Such exposed areas must to be completely covered with sheets that are impermeable.
- These kinds of materials need to be kept downwind of residential areas and away from the site boundaries.
- Reduce the amount of time that is stored on site.
- Reducing the height of stockpiles and using dust suppression techniques will help manage them.
- Dusty material stockpiles should be temporarily stored in designated areas.

Fig 10 Stockpiles covered with tarpaulin sheets

B. Concrete Production

A number of dust control procedures must be followed in captive batching plants in order to produce Concrete.

Typical control techniques consist of:

The area used for debagging or feeding cement hoppers needs to be enclosed in a secure structure.

- Vent Air from the silo exhaust should only be released by setting up a bag filter assembly with an air injection or auto cleaning mechanism.
- All storage silos should be vented to bag filters, which should have proper bag cleaning arrangement so as to avoid choking of filter bags, thereby to avoid over-pressurization of silos.
- Over-pressurization of silos result in fugitive emissions from leakages etc.
- Proper Control in Handling of Collected Cement from the Bottom of Bag Filter System, since this is a much neglected area:
- Maintain good-housekeeping;
- Provide green net (or other better system) at the bottom to control fugitive dust emission;
- Remove all loose cement dust settled at the bottom of the bag filter system at all the times to avoid cement dust becoming air borne;

- Regularly remove all open lying cement filled bags and store them in a covered area.
- Empty cement bags must to be promptly removed from the site and placed in a covered area for temporary storage.
- Air from the cement godown should be ventilated using a ducting setup, then either a bag filter or a wet suppression system.
- When loose cement gathers at the bottom of the silo hopper, it should always be bagged and never left out in the open.

Fig 11 Controlling cement dust emissions from cement go-down area by providing ducting arrangement at the outlet of all exhaust fans and connecting them to the wet suppression dust extraction system

D System for Belt Conveyor

Dust control methods are necessary for belt conveyor systems in stone crusher units, pug mills, batching plants, etc. in order to reduce fugitive dust emissions at work.

Several common control techniques include of: Covering the top and two sides of conveyor belts over their whole length is recommended.

- There should be coverage for all places of transfer between belt conveyors.
- Covering the top and three sides of the unloading area—such as the storage bin is recommended.

Fig 12 Green net cover all sides

E. Transportation of Dusty Materials

One of the major sources of dust pollution is the loading and unloading of dusty goods on site, which calls for the use of suitable dust avoidance techniques. Typical control strategies include the following: Before loading and unloading operations, all dry, dusty goods should be quickly sprinkled with water to control dust.

- Before departing the location, cover the coarse and fine materials carried into trucks, dumpers, etc. with impermeable sheeting.
- When transit mixers, dumpers, trucks, and other vehicles must drive on roadways that pass through residential zones or carriageways intended for regular traffic, provide effective means of "Wheel Washing Facility" at the site exit points to minimize deposition of dust on the public roads, which helps in reduction of dust pollution.

Fig 13 Covering all Materials

F. Good Housekeeping

One efficient way to reduce dust pollution at construction sites is to practice good housekeeping.

Several common control techniques include of:

- All surplus soil and debris are removed / disposed off from the working sites to designated dumpsites in a timely manner.
- No waste, scrap of any kind should be allowed to store on worksites. Disposal from site should be in regular interval and cleaning the outer surface after disposal of cement bags which leads to dust pollution
- Empty cement bags, other construction materials, accessories, etc. should be either kept in a covered area / store or if in open, they should be appropriately covered with a tarpaulin / plastic sheet.

- Avoiding over storage of material at site and covering top with tarpaulin sheet and securing it properly.

Fig 14 Covering all materials

G. Haul Road & Access Road

Regular movement of construction vehicles and machineries, site vehicles, etc. on haul roads, access roads, and site internal roads leads to significant dust pollution and requires sincere efforts to control the dust emissions.

Some typical control methods include:

- Most traversed roads should be compacted and sprayed with water for dust suppression to maintain the entire road surface wet.
- Limit the speed of vehicles to 15-20 km/hr.
- The portion of any road only leading to a construction site that is within 30 m of a vehicles entrance or exit should be kept clear of dusty materials.
- Deploy Mechanical Broomer throughout the GRAP period.
- Utilize it effectively and in a targeted manner to achieve the intended purpose.
- All collected dust should be simultaneously removed to avoid resuspension.
- Cleaning of Silica and Non silica Dust on the plants leave immediately.
- Appropriate measures to be taken to grow more and appropriate vegetation at median of the road.
- Repairing and black-topping of damaged road for public transportation.
- Use of Anti smog gun for suppress the dust.

Fig 13 Water Sprinkling arrangement

IX SAMPLE STUDY AFTER TAKING MITIGATION MEASURES

In order to determine the changes in air quality data at sites following mitigating measures, a sample study for air quality monitoring was carried out in in two locations of Construction site.

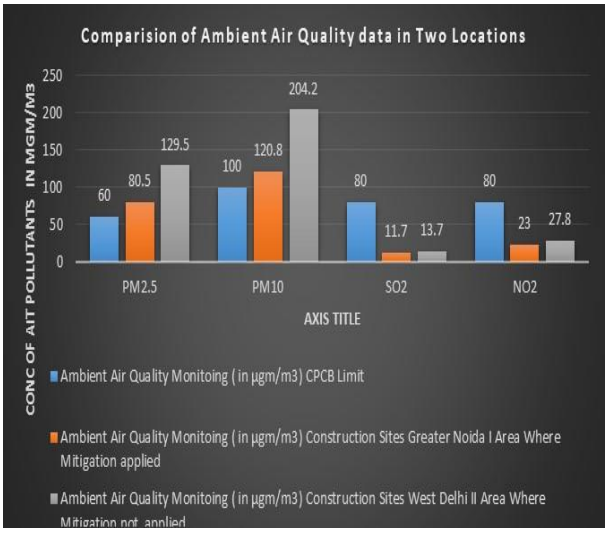


Fig 14 Comparative Study of Two Location

It demonstrates that areas with mitigation measures implemented have lower air pollution concentrations than those without mitigation measures.

IX. ABBREVIATIONS AND ACRONYMS

C&D –Construction and Demolition
GSB- Granular subbase
CPCB-Central Pollution Control Board
NGT -The National Green Tribunal
CAQM - Commission for Air Quality Management
GRAP – Graded Response Action Plan

X. LIMITATIONS AND FUTURE WORK

As discussed above, the technological measures encompass both preventive and end-of-pipe solutions. Thus, organizational measures function as institutional guarantees for technological innovation and help define governmental responsibilities properly. But this study generates the data in the particular locations of the several construction sites which may include road dust in few locations.

XI: CONCLUSION

Construction dust emissions have caused severe environmental pollution, which has prompted numerous public complaints and strong directives from State Pollution Control Boards and District Authorities. One of the difficulties faced on Construction sites is dust control, that has to be mitigated by the contractors and respond quickly and take a comprehensive approach to the problem. To address this issue, it is imperative that multiple strategies be used rather than just one.

This paper has clarified a number of workable control and management strategies for various construction operations in order to reduce dust pollution at and near the construction sites. Controlling construction dust emissions has also become necessary in recent years to prevent fines from the agencies in charge of enforcement and regulations.

A significant amount of work needs to be done to keep all of the suggested measures consistently more successful in order to keep dust emissions from all sources—stationary, mobile, and area—within the permissible limit. To reduce the effects on the environment and air pollution, systematic and efficient methods must be combined with appropriate construction practices. For contractors and their subcontractors, it necessitates heightened awareness and a mental shift. It is imperative to acknowledge that implementation risks may manifest as work halt or severe fines for failure to comply with established protocols, hence impeding timely project completion.

XII: ACKNOWLEDGMENT

The authors express their gratitude to the authority's different construction sites in Delhi NCR and for their invaluable assistance and providing crucial data. We would like to express our gratitude to the reviewers for their insightful feedback, which greatly enhanced the work.

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