Review Paper:

A Study on the Environmental Impact and Disaster Management Strategies in the Redevelopment of Buildings: Case Mumbai

Thethi Santosh Ajit Singh[1] and Kalyandurgmath Kavita[2*]

1. Legal Department, Prin. L.N. Welingkar Institute of Management, Development and Research (PGDM), Mumbai, Maharashtra, INDIA
2. Research and Business Analytics, Prin. L.N. Welingkar Institute of Management, Development and Research (PGDM), Mumbai, Maharashtra, INDIA
*kavita.kalyandurgmath@welingkar.org

Abstract

The demolition of more than 15 years old buildings with less than four stories being now converted to towers of minimum 20 stories has increased manifold in the last five to ten years. The rampant demolitions and construction of towers have resulted in rising levels of pollution in cities like Mumbai. Cement is one of the highest pollutants just next to the oil industry. Right from manufacturing, transportation and its use in construction, it causes pollution at distinct levels. This study focuses on the study of pollution caused by rampant redevelopment of buildings in cities like Mumbai. Progressive humanity needs to improve on the infrastructure and improve living styles, but at the same time high rise buildings warrant construction where cement is one of the main ingredients and causes pollution in the densely populated cities like Mumbai. This construction aggravates the pollution levels.

The research is also dealing with the best use of construction and demolition material. In addition, the research is exploring the alternative to cement usage or limited usage of cement so that pollution can be contained. The study demonstrates the direct influence of cement usage in construction. On one side redevelopment cannot be halted, as halting it would mean static society living. Development of the economies and living standards will call for redevelopment. The solution lies in rational usage of cement and construction and demolition material.

Keywords: Demolition, Construction, Redevelopment, Living Standards, Limited use of cement, Pollution, Environmental impact.

Introduction

India's construction industry is seeing tremendous growth, which is ascribed to factors such as population growth, population moving to urban area, increase in industries and the coming up of several changes. A better standard of living needs more construction or demolishment and rebuilding. The main reason for the redevelopment of old buildings is the geographical layout of cities like Mumbai that it cannot expand horizontally, so to accommodate more population, it has to increase vertically. The building sector uses enormous amounts of materials and a variety of processes. The environment is severely impacted by these processes. Waste from building and demolition processes is produced during these processes. It is the outcome of any civil structure's construction, refurbishment, repair, or demolition.

The debris is produced while demolishing old buildings and constructing new buildings. As per the management of the solid waste regulations, Debris is also construction and demolition (C&D) trash. Surplus and damaged items and resources from construction activities are also considered waste. Because construction and demolition trash is large, heavy, inert and not biodegradable, managing it can be difficult. Demolition and construction projects produce enormous amounts of garbage. Waste from construction and demolition is building up, endangering human life, the environment and ecological resources.

Waste is a contributing factor to a few pollution types, including soil, water, air and nasal pollution. It is having an impact on all living things because, in addition to humans, plants and animals are also being negatively impacted. Recycling material is governed by law and policy. Reusing masonry and concrete is high in Germany, Denmark, France, the United Kingdom and Japan. The construction and demolition trash contains a sizable amount of waste that can be recovered and reused. Bricks, tiles, wood and metals are recycled in India, but over 50% of the country's remains of construction and demolition concrete and masonry waste, which is currently disposed of in landfills. Waste material is asphalt, bricks, ceramic, clay, concrete, contaminants, fiber, glass, gypsum, plaster, metal ferrous, paper cardboard, plastics, soil, wood treated and untreated.

Construction Scenario in India: One of the biggest sectors in India is the construction sector. India is one of the Nations that is developing fast. With better technologies, urbanization is happening quickly. As the population of this Nation grows, so does the requirement for infrastructure and structures. There are numerous new civil structures under construction. There is also the demolition of smaller, older buildings to make room for larger, newer ones. These operations are causing quite a good quantity of waste derived from demolition and construction to be generated. As per research done at the Centre for Science and Environment of India, waste from demolition is created at a rate ten times greater than that of building waste, with new construction producing around 60 kgs of construction and demolition

garbage for every square meter, construction and demolition waste recycling facilities, such as those in Ahmedabad and Delhi, aid in the recycling and subsequent reuse of the materials. These efforts are surely reducing the amount of C&D waste that gets dumped in landfills.

The major components in the waste in India are cement concrete, bricks, cement plaster, steel from RCC, doors, window frames, roofing support, railing of staircases, rubble, stone, marble, granite stone. The minor components are iron plastics, GI pipes, electrical fixtures like copper, aluminum wiring, wooden baton, switches and wire insultation. Very frequently approx. 50% of construction and demolition waste is recycled or utilized again but the balance of 50% is sent to landfills. It is combined with municipal waste for most needed segregation but not done in India. In India, the remaining construction and demolition waste is usually dumped in landfills, with around 50% of it being recycled and used again. Municipal solid waste (MSW) and construction and demolition garbage are typically mixed. In India, most of the time, products and materials are not properly separated.

Infrastructure and new building construction are completed quickly due to population growth. People are moving from the countryside to the cities in search of employment. To live better lives, people are also relocating to cities. Cities are being burdened by these activities, which is why there is an increasing amount of civil structure construction. The aging infrastructure in older societies is a major factor in reconstruction. Over time, infrastructure such as roads, buildings and utilities may deteriorate and need upkeep, repairs, or replacement.

The 3Rs: reduce, reuse and recycle, can be used to manage construction and demolition trash. If applicable, incineration comes first, followed by landfill disposal.

Reduce: Reducing construction and demolition produced waste is an efficient strategy. This could be accomplished by using resources wisely, repurposing materials and avoiding placing excessive orders for virgin materials. The supplies need to be safely stored. Reduce repairs. Construction and demolition should be done only if it is unavoidable.

Reuse: Reusing some perfectly good materials instead of throwing them away is a smart way to manage construction and demolition waste. Repurposed materials might be applied to ongoing or upcoming projects. Reusing materials is cost-effective and contributes to trash reduction.

Recycle: Recycling is the act of taking a substance that would have been thrown away and sorting, collecting, processing, marketing and finally using it. Recycling is an attempt to keep valuable and usable items out of the landfill. Recycling is the process of converting waste that is still safe and can be recycled into new building materials. Sorting waste materials according to their categories is essential for successful recycling. Recycling contributes to resource conservation for the future, construction and demolition garbage frequently contains recyclable items such as metals, polymers, wood, glass, cardboard, plasterboard, bricks, tiles, concrete, stones etc. There is a market for many components found after demolition of buildings. Few commonly used construction and demolition materials include doors, hardware, appliances, fixtures. These can be donated. Wood cutoffs should be used for cripples, scrap of wood can be used to cover the ground. Gypsum in limited quantality can be used to add to soil. Bricks etc. can be used for driveways bedding. From the exterior wall, excess insulation can be used for the inner walls of the building. Leftover paint can be used for garage and other such places. Return the packing material to the supplier for his reuse.

Reusable Materials: The reduction in resources and power consumption that comes from producing fewer new materials is the primary benefit of material reuse. Take out fittings, such as doors and hardware, to be repurposed for other purposes or in the reconstruction process. Parts of wood can be used for blocks and cripples to avoid cutting one big piece of wood. For mulch or ground cover, scrap wood can be used. Similarly crushed gypsum can be added to the soil. Recycled concrete, masonry and brick can be used on site as subbase material, fill, or driveway bedding.

Cause: 77% of India's tall buildings are found in Mumbai, the financial hub of the Nation, according to a CBRE South Asia report, which ranks the city 17th globally. The primary forces behind supply and building growth are the State government's premium discounts to builders, the increase in FSI and the growth of the housing market in the Mumbai Metropolitan Area. Redevelopment is motivated by people who want to live better lives.

Debris Dumping: Massive reconstruction has led to debris dumping arising from the falling old buildings. According to BMC officials, the debris mafia routinely dumps waste of construction and demolition in the city's neighborhood and the area around the Anik depot. The material was discovered by BMC personnel during unexpected inspections. People's complaints are similar in the city and the Mumbai metropolitan area. The rapidly expanding pile of waste being disposed of inside the forest, around the trees, has been observed by the public and the BMC officials.

Review of Literature

According to Bertaud[1], Mumbai residential uses 2.9 square meters of floor area on an average per person. This is the area per capita which is the lowest on the globe. But in recent years, Mumbai has become a regional economic powerhouse, boasting a sizable middle class and a highly skilled workforce. Mumbai residents employ little area due to four reasons: challenging topography, inadequate land use regulations, unclear property rights and inadequate infrastructure. Nonetheless, the most detrimental aspect is the harsh FSI reduction enforced by poorly thought-out land

use laws. Mumbai's average forced savings index (FSI) is likewise the lowest globally.

Hasanbeigi et al[4] stated that over the coming decades, there will be a rise in cement production worldwide. Although it is anticipated that China's cement output will slow down, more cement will be needed in developing Nations like India and others in Asia and Africa as they expand their infrastructure. This projected rise in demand and production may result in higher emissions of greenhouse gases (GHGs), other hazardous emissions and criteria air pollutants within the current regulatory and technological environment. Air pollution has several harmful effects on health.

As per Reddy[9], even though they make up less than 1% of the planet, metropolitan regions are home to more than 50% of all people. Due to the increased demand for resources and the resulting production and consumption, population growth and human activity put significant strain on the environment. Therefore, it is critical to comprehend how resources enter the city, how they change and what waste and products emerge as a result. Assessing the effectiveness of resource use can be done, for example, by looking into urban metabolism.

Petroche et al[7] observed that the most often utilized substance in construction is concrete, with water coming in second. The primary ingredient in concrete is cement. The cement industry contributes 8% of worldwide CO_2 emissions, the primary greenhouse gas that causes global warming. Assessing the environmental profile of local construction material manufacturing is crucial since reducing the environmental impact of buildings is a pre-requisite for combating climate change. The life cycle assessment methodological framework is used in this study to evaluate the environmental sustainability of Ecuador's cement and concrete sectors.

According to Power[8], for more than a century, people have argued over whether historic housing should be demolished or renovated. From the first approval by the Government in 1880 of the Statutory destruction of unsanitary slums, it has been a focus of active policy. Repulsion extent of "demolition blight" and fresh construction in the 1960s prompted a reevaluation and significant redevelopment in inner-city neighborhoods with older housing. With its recommendations for extensive clearing and construction, the Government's Sustainable Communities Plan of 2003 has heightened discussion about demolition and new construction during the previous five years.

Joshi[5], described how plants can be used to monitor dust in urban areas and how they can help to reduce dust pollution. A thorough method of employing a dust chamber to choose plants for creating green belts in metropolitan areas is covered. The qualities that make certain plants in a city ideal for mitigating dust pollution are listed, along with the plants that make good phyto monitors. As per Patankar[6], one of the biggest megacities in the world, Mumbai, has been severely affected by air pollution because of growing vehicle traffic, increased industrial and commercial activity and population expansion. Planning for increased productivity and guaranteeing a higher standard of living for people hence require examining the health effects of urban air pollution. The purpose of this study is to investigate the relationship between Mumbai's air pollution and morbidity. The study aims to quantify the concentration-response (CR) coefficients to determine the occurrence of health outcomes for changes in air pollution concentrations and compute the cost implications of these occurrences.

Yu et al[10] opined that China generates a large amount of waste from construction and demolition every year, but it rarely considers the potential environmental consequences on the nearby areas. With a focus on metals, this study described the metal concentrations and related environmental issues in construction and demolition waste. Samples of construction and demolition waste were collected in Shenzhen City, China, from building demolition sites, redeveloped areas, landfills and recycling companies.

India is a significant global producer of greenhouse gases and the country's cement usage is main source of polluting environment according to Dongare[3]. The industry's use of innovative technologies will have a hugely beneficial effect on the environment. It is time to include technological breakthroughs to mitigate green gases, as the average carbon footprint of Mumbai city is 1.76 tons CO_2/ capita and the building industry is growing with new projects to extend the metropolis.

Chaurasia et al[2] stated that the level of air quality situation of Rajasthan, India, is presented in this research effort. The New National Ambient Quality of air Standard was used to evaluate the air quality. The criteria that were used were PM10, SO2, NOx and SPM. Near the coal mill and power plant, the average PM10 value was found to be higher than the allowable limit.

Research Design: Research design is well crafted for the study. Apart from case study method, the researchers used Bloomberg data and interviewed 30 professionals form Ultratech cement company and the 25 builders and few lawyers. The following techniques are proposed to be used for the study of predictive and prescriptive analytics for sustainable development in cement industry. Data was sourced from case studies, Bloomberg terminal, Websites of the regulators in India and global level. Policies of major cement corporates in driving sustainability agenda in India were observed.

Green House Gases: Approximately 8% of greenhouse gas emissions connected to energy are now attributed to cement and concrete and the industry possesses the means and capacity to minimize these emissions swiftly and economically. The manufacturing, pressing and distribution

of cement are expected to release 37.55 billion tons of CO_2 in 2023. As per the International Energy Agency, by 2030, emissions must decrease by an average of 3% per year to catch up with the near zero emissions (NZE) scenario. The use of low-carbon fuels, the replacement of clinkers, increased energy and material efficiency and creative near-zero emissions production methods will all be essential in reaching this goal. The emissions from concrete manufacturing should be cut by 60% by 2030 when paired with the decreases in consumption in this scenario.

China, India and aviation are expected to be the main drivers of the 398 million metric tons annual increase in global emissions in 2023, according to apnews.com. Emissions from fossil fuels climbed by 458 million metric tons in China, 233 million metric tons in India and 145 million metric tons in aircraft over the previous year. According to the University of Stanford, researchers estimated that worldwide CO_2 emissions would surpass 40 billion tons in 2023, with roughly 37 billion tons originating from fossil fuels

Research Questions

1. Does redevelopment of buildings in metro cities like Mumbai impact pollution?
2. Are there any solutions to control pollution along with redevelopment of the buildings?
3. How do we achieve sustainable development?

The study is essential because redevelopment of the buildings and roads cannot be halted, which will impact redevelopment of the living standards and development of the cities. The study will investigate the solutions to control the pollution caused by redevelopment. The industry of cement is a major cause of pollution and carbon dioxide. We need to have proper SOPs and if necessary proper regulations to ensure sustainable redevelopment.

Discussion

As demonstrated by SDC case studies and the German experience, renovation is feasible in most situations. It initiates a positive cycle of rejuvenation. During redevelopment, by measures used to water usage judicially, utilizing renewable energy sources and retrofitting older structures with energy-efficient technologies, redevelopment can promote sustainability.

Green Cement Cheaper than Traditional Cement: The latest advancement in building technology is called "green concrete," and it provides an environmentally friendly and sustainable alternative for building materials. The huge amount of carbon dioxide that is released by the cement used in ordinary concrete, is bad for the environment. The idea behind "green concrete" is to replace some or all the cement with different elements that are either recycled trash or byproducts of the manufacturing of other materials. To create green concrete, fly ash which is produced by burning pulverized coal in power plants is used to replace some of the cement in the design. Glass powder and demolished waste collected from the construction site and ground into fine powder are used to replace fine aggregate entirely.

To support the use of green concrete as a sustainable building material, a cost/benefit analysis has been conducted and a comparison of the qualities of conventional and green concrete was made. The outcomes of the experiment demonstrate that green concrete is a novel and promising material that can take the place of regular concrete. Even though the results do not seem to differ much in terms of the qualities of the two types of concrete, green concrete is more economically priced and if it is made in copious quantities, the difference could be even greater. Additionally, green concrete uses leftover materials from other businesses, serving as a sink for these substances that would otherwise be a nuisance to the environment. Replacing green cement instead of traditional cement can reduce pollution.

During the production process, green cement can cut carbon emissions by up to 80%, which can aid in lowering pollution. Utilizing innovative methods and cost-effective byproducts including silica of fly ash, slag of blast furnace and iron, green cement is created with less waste. Additionally, green cement has a carbon emission intensity that is 60% lower and requires less thermal energy than regular Portland cement (OPC). A low-carbon substitute for conventional cement, green cement can contribute to the goal of net-zero emissions by 2070. Around 7% of the world's CO_2 emissions, making it one of the industries with the greatest emissions, are caused by cement. Green cement is usually less expensive than regular cement since it is mostly made of waste resources like fly ash and blast furnace slag.

However, premium green cement products might cost up to three times as much as ordinary cement. Pozzo CEM is one such product that is made completely of fly ash. Most of the industry's abandoned waste is used as one of the primary raw materials to create green cement. Fly ash and blast furnace slag are the two main components used in the manufacturing of green cement. This also explains why green cement is far less expensive than regular cement. It is strongly recommended to use green cement. The faster are the change and use of green cement, the earlier will be reaching the sustainability in the construction industry.

Standard Operating Procedure (SOP)s Pollution Control Guidelines laid down by BMC for construction sites violating the laws: New rules were released by the Brihanmumbai Municipal Corporation (BMC) with the intention of lowering air pollution coming from construction sites in Mumbai. The new rules mandate the installation of sensor-based pollution monitors at sites of building constructions and respond quickly if pollution levels exceed the allowable limits. To minimize dust pollution, the builders, need to put a 35 feet high metal sheet around the construction site and must encircle the perimeter of under-construction structures higher than 70 meters. BMC has

asked the builders to shut down the work if SOPs are not followed. The move will help a severely struggling city to reduce the pollution that comes with development. 2024 saw the most current release of the revised regulations.

According to a ward assistant commissioner, the authorities have strictly asked either to reduce the dust pollution or shut down the work at site. When SOPs are not followed, numerous active building sites in Mumbai face a collective penalty of Rs 82.5 lakhs from the local administrative body, BMC, which announced the guidelines on October 25, 2023. The SOP dealt with containing the growing amount of air pollution. 139 construction and demolition sites were fined for burning rubbish, 537 people were punished for disposing of construction and demolition waste without authorization and 1,572 work sites were fined Rs 48 lakh for neglecting to keep their properties clean. The BMC has published 27 new, severe standards for dust mitigation that all work sites, including government projects, must follow within 30 days.

The BMC Deputy Municipal Commissioner examines the stock ward level to identify any noncompliant sites. A penalty is assessed and notice is given. Cement mixers blasted dust as scroll drove into the city's construction site. Although a metal sheet encircled the area, it was just a few feet high. Few residents, who live in a flat in the same building, are afflicted with respiratory conditions. Residents remarked that they had had a persistent cough for several weeks. CT scan and X-ray showed that lung tissues were scarred, showing pulmonary fibrosis. This indicates the serious health hazards created by pollution of redevelopment of buildings in the city. Huge clouds of dust billowed as uncovered trucks drove to and from the location to pick up the ready concrete.

Conclusion

The Suggestion to Overcome Pollution: Green cement, sometimes referred to as a cement which is sustainable, is a kind of cement produced with environmentally friendly materials and procedures. It is created by substituting waste byproducts from other industries like fly ash, slag, or silica fume for a part of the standard Portland cement. Because of its environmentally friendly qualities and sustainable qualities, green cement has become increasingly popular in recent years. Green cement has many advantages for the environment. It can decrease both the use of non-renewable resources and carbon emissions. Infrastructure that is long-lasting, ecologically beneficial and sustainable can be built with green cement. By adopting sustainability achievers like solar panels and rainwater harvesting saving features, it can be used to construct green houses.

Climate change is the effect of Conventional Portland cement, accounting for about 7% of worldwide CO_2 emissions. Green cement manufacturing, on the other hand, uses less energy and produces less greenhouse gas emissions, making it a far more sustainable choice. These ingredients, which take the place of some of the conventional Portland cement in the mixture, are fly ash, slag and silica fume. There are several benefits to employing green concrete in building projects. First, using Supplementary Cementitious Materials (SCMs) lowers the quantity of traditional cement used, hence lowering the concrete's carbon impact. Second, using SCMs makes waste management more ecologically friendly and sustainable by lowering the quantity of waste that is dumped in landfills.

The longevity of green concrete is an additional advantage. Green concrete provides superior long-term strength and durability than conventional concrete since SCMs are used in its production. Because it can tolerate huge weights and frequent use, this makes it a great option for high-traffic places like roadways, tunnels, flyovers and airports. Around the world, green concrete has been employed in several construction projects. By adding fly ash and slag to the mix, the amount of Portland cement utilized in the green concrete was lowered by 70%. Nerite is a better sustainable friendly and substitute to standard concrete for building homes and other structures since it is created with 90% less water and 70% less cement. Green cement can be used for building pavements, foundations, high rise buildings, bridges, dams and tunnels.

Exceptional Topography of Mumbai: Mumbai's small peninsula, which was a desirable location for a port when the city was found, is now a liability that limits the city's potential to expand economically and physically. To assess the extent of Mumbai's topographical limitations, we will examine the proportion of land covered by water in three major Asian cities: Seoul, Jakarta and Mumbai. Only 15% of Jakarta's land is available like Mumbai due to its geographic location, despite Jakarta being a seaport. Reforming the land use policy will allow for i) More intense land use; (ii) More efficient land use through the clarification of property rights; and (iii) The expansion of available land area through improved access to the hinterland through the development of infrastructure. The fact that Mumbai's current infrastructure is inadequate and would prevent increased densities is one of the primary justifications for FSI.

References

1. Bertaud A., Mumbai FSI conundrum: The perfect storm: the four factors restricting the construction of new floor space in Mumbai, 1-11 **(2004)**

2. Chaurasia S., Ahmad I., Gupta A. and Kumar S., Assessment of air pollution emission from Cement Industries in Nimbahera, Rajasthan, India, *International Journal of Current Microbiology and Applied Science*, **3(3)**, 133-139 **(2014)**

3. Dongare A.P., Reduction of Carbon Footprints of Mumbai City-Using Civil Engineering Technology, *International Research Journal of Engineering and Technology (IRJET)*, **8(6)**, 1399-1403 **(2021)**

4. Hasanbeigi A., Bhadbhade N. and Ghosh A., Air Pollution from Global Cement Industry: An International Benchmarking of

Criteria Air Pollutants Intensities, Mumbai: Global Efficiency Intelligence **(2022)**

5. Joshi N., Dust Pollution and Plants: A Case Study of Mumbai, Maharashtra, India, In Desai N., Patil M. and Pawar U., Plant Metabolites under Environmental Stress: Mechanisms, Responses and Adaptation Strategies, New York, Apple Academic Press, 85-115 **(2023)**

6. Patankar A.M., Health Effects of Urban Air Polution: A Study of Mumbai, Mumbai, Indian Institute of Technology, Bombay **(2009)**

7. Petroche D.M. and Ramirez A., The Environmental Profile of Clinker, Cement and Concrete: A Life Cycle Perspective Study Based on Ecuadorian Data, *Buildings*, 1-18, https://doi.org/10.3390/buildings12030311 **(2022)**

8. Power A., Does demolition or refurbishment of old and inefficient homes help to increase our environmental, social and economic viability?, *Energy Policy*, **36(12)**, 4487-4501, https://doi.org/10.1016/j.enpol.2008.09.022 **(2008)**

9. Reddy B., Metabolism of Mumbai - Expectations, impasse and the need for new beginning, Mumbai: Indira Gandhi Institute of Development Research, Retrieved 10 12, 2024, from http://www.igidr.ac.in/pdf/publication/WP-2013-002.pdf **(2013)**

10. Yu D., Duan H., Song Q. and Li X., Characterizing the environmental impact of metals in construction and demolition waste, *Environmental Science and Pollution Research*, 13823-13832, doi:https://doi.org/10.1007/s11356-018-1632-z **(2018)**.

(Received 26th December 2024, accepted 05th March 2025)