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Environmental Sustainability and Cost Benefit Analysis of Building Demolition Waste Management in Construction Projects for Nashik City

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Abstract: This paper presents the management practices for construction and demolition waste within the construction sector of Nashik city, focusing specifically on residential and infrastructure projects. The analysis of the potential for reuse and recycling was conducted using descriptive statistics. The study evaluates three different structures performing questionnaire survey and estimate before and after the utilization of construction and demolition materials. The generation of construction and demolition waste has escalated due to the rapid urbanization of towns and cities. Due to the increase in the economic growth after development and redevelopment projects in the country and subsequent increase in the urbanization in the cities has made construction sector to increase drastically, but also environmental impacts from building demolition waste are increasingly becoming a major issue in urban solid waste management. Environmental issues such as increase in the flood levels due to the illegal dumping of construction and demolition waste into the rivers, resource depletion, shortage of landfill and illegal dumping on hill slopes are evident in the metro cities. The main aim of this research is to reduce the environmental impact of C&D activities by promoting sustainable practices like waste minimization, reuse, and recycling. The report highlights the necessity of recycling construction waste, raising awareness about waste management challenges, and promoting the availability of recycling technologies.

This study concluded that effective management of construction and demolition waste presents a significant challenge in mitigating environmental risks, including air pollution, land degradation, and groundwater contamination. Recent developments indicate that federal stakeholders are increasingly cognizant of these issues, having implemented new policies, regulations, and programs to address them. At the level of Nashik city, progress has been minimal, and numerous obstacles remain. The rapid urbanization in India is expected to result in a significant rise in the amount of building demolition waste produced, alongside a shortage of resources for construction. Using construction and demolition waste effectively can lead to significant cost savings and environmental benefits. The result of residential project and infrastructure project shows that if we use construction and demolition waste materials in new construction then we can save 10.55 % cost in Laxmi Niwas, 11.98 % cost in CBS to Canada Corner – Model Road and 6.74% Sai Shraddha Bungalow. The case study highlights the critical need for effective construction and demolition (C&D) waste management. By optimizing waste reduction, reuse, and recycling processes, the study demonstrates significant environmental and economic benefits, emphasizing the importance of sustainable practices in the construction industry.

The case study underscores the detrimental impacts of improper C&D waste disposal, such as landfill overuse, resource depletion, and environmental pollution. By promoting recycling and reuse, the study showcases how C&D waste can be transformed into valuable resources, reducing the strain on landfills and preserving natural resources. Recycling and reusing construction and demolition waste materials reduces the need for new materials, lowers transportation costs, and minimizes landfill use, all contributing to a more sustainable and cost-effective approach to construction. Effective C&D waste management can minimize the volume of waste generated on construction sites, leading to reduced waste disposal costs. This can be achieved through strategies like selective demolition and careful material selection.

Keywords: Construction and Demolition Waste, Waste Management Practices, Reuse and Recycling, etc.

I. INTRODUCTION

Construction industry plays a vital role in contributing economic growth especially in developing countries. There are many mega project constructed in developing countries such as airport, high rise building, industrial area and harbour which contribute to generate huge amount of construction and demolition (C&D) waste. Hence, it gives negative impacts to the environment and health problems. In many countries, most of the C&D waste goes to the landfill. In Finland and Germany contribute 15% of the C&D waste and deposited in landfills. This practice increases the burden on landfill loading and shortens their lifespan. Therefore, more land is needed to deposit C&D waste. The land can be used for a good purpose rather than dumping the waste. It is very common to see huge piles of Construction and demolition (C&D) waste stacked alongside of major roads resulting in traffic jams, congestion and disruption & chocking of drains. It is one of the heaviest and most voluminous waste streams generated in the present scenario. Around 25% - 30% of all waste generated in the country comprises of Construction and demolition waste in developed countries. Construction and demolition (C&D) waste is generated from construction, renovation, repair, and demolition of houses, large building structures, roads, bridges, piers and dams etc. Construction and demolition materials included are steel, wood products, drywall and plaster, brick and clay tile, asphalt shingles, concrete, asphalt concrete etc. These estimates represent construction and demolition material amounts from construction, renovation and demolition activities for buildings, roads and bridges, and other structures. First of all, many of the materials used in the construction of buildings are produced in a non-sustainable way. The factories that make these materials, causes harmful CO_2 emissions. There is a huge environmental impact associated with the extraction and consumption of raw materials for production of building materials.

As per the study conducted by Centre for Science and Environment of India, a new construction generates 40-60 kg of construction and demolition waste per sq. mt, then taking an average of 50 kg per sq. mt, building repair produces 40-50 kg per sq. mt. of waste. The waste produced per sq. mt. of demolition is 10 times that generated during construction. As per Technology Information Forecasting and Assessment Council (TIFAC), considering 300-500 kg of waste generation per sq. mt, India must have generated about 150 million tons (MT) of C&D waste in 2024.

A. Sustainability in Construction and Demotion Waste Management

Sustainable management of C&D waste involves consideration of environmental, economic and social aspects pertaining to overall development. Figure 1.8 shows the pillars of sustainable development. Among the seventeen Sustainable Development Goals (SDGs) formulated by UN in Agenda 2030, integrated waste management is the key to deliver all other global goals for sustainable development. C&D waste constitute to a considerable quantity of total waste that is generated globally; hence C&D waste management contributes significantly to overall sustainable growth.

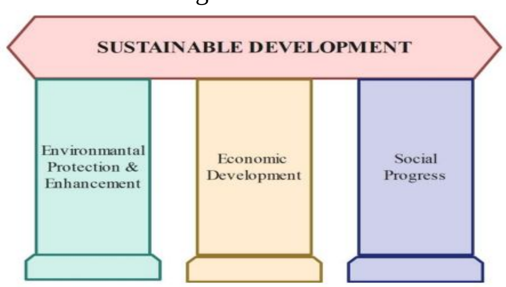

Fig. 1 Three Pillars of Sustainable Development

Environmental sustainability is the ability to maintain the qualities valued in the physical environment. There is extensive research in this area and it is based on the notion that the Earth's resources are limited and depleted natural resources cannot be renewed. As construction industry is one of the main contributors for pollution and environmental degradation, research has been done to examine the environmental effects of improper management of C&D waste and studies suggest the approach of reducing, reusing and recycling of waste for restoring and preserving the balance between natural and built environments. Social sustainability should ensure a better quality of life for people in present and in the future. Social acceptability and equity reflect how the community is receptive and supportive of the existing waste management options. The concern for health and safety of workers and public during C&D waste collection and recycling should be considered. Better quality of daily life, appropriate macro-policies for balanced development of various economic activities and creation of job opportunities, harmonious connections with the surroundings, preservation of local identity, effective public participation, and reasonable compensation and relocation plan are the components to be improved in waste management practices to ensure social sustainability.

II. METHODOLOGY

A. Problem Statement

The problem statement for construction and demolition (C&D) waste is that the industry generates large quantities of waste, a significant portion of which ends up in landfills, posing environmental and economic challenges. Proper management and waste reduction strategies are needed to mitigate the environmental impact and reduce costs associated with landfilling and material procurement.

B. Need of the Study

The generation of Construction and Demolition(C&D) waste is rising than ever before, while management of it is a major problem that has deleterious impacts on environment, economy and society. On the other side, there is rise in demand for construction materials which leads to natural resource depletion. This highlights the need for sustainability in management of C&D waste. Therefore, sustainable methods should be implemented in CDWM to:

1) Prevent predominantly practiced methods of landfilling and illegal dumping.
2) Promote an integrated approach to collect, transport, process and dispose C&D waste, where environmental management of C&D waste is given due consideration throughout the duration of the project.
3) Avoid mixing of C&D waste with other municipal solid waste as different processing techniques has to be followed.
4) To enhance of potential of recycling C&D waste and reduce the impacts on environmental.
5) To meet demand for aggregates in housing and road sector and reduce pressure on natural resources.

This research tries to find solutions for different requirements in C&D waste management sector. Nashik being the chosen study area that lacks CDWM facilities, it is necessary to take steps to enhance CDWM as a whole. CDWM includes collecting, transporting, processing and disposing C&D waste, where collection and transportation of bulky and voluminous C&D waste contributes significantly to economic and environmental impacts. Transfer station (TS) being a link between various waste management facilities, plays a paramount role in collection and transportation of waste. Transfer stations that are strategically placed will make it easier to achieve waste management goals and also other goals including material and energy acquisition, environmental preservation and social justice. Also, it is crucial to manage waste regionally in order to be a part and contribute to overall sustainability.

C. Aim of the Study

The main aim of this research is to reduce the environmental impact of C&D activities by promoting sustainable practices like waste minimization, reuse, and recycling. This involves maximizing the use of recycled materials in construction projects and ensuring proper disposal of hazardous waste.

D. Scope of the Study

The research will mainly cover the reutilization of construction and demolition waste generated from new construction, demolition and renovation in building practices with a focus in Indian context. Ongoing practices of construction and demolition waste management and advantages of reusing this waste will be presented to support the topic.

1) *Reduction of C&D Waste:* Less waste leads to fewer disposal facilities, this leads to less environmental issues. Rehabilitate an existing structure in place of planned demolition. Use deconstruction techniques rather than demolition of a building.
2) *Reuse of C&D Waste:* It does not require any further processing to convert into a useful product. The items which are usable directly to be screened out from the debris and put into the possible use without further processing.
3) *Recycling of C&D Waste:* Once the waste generated from construction and demolition activities has been segregated and reusable items are taken out, the leftover is available for further processing i.e., recycling into next useful stage.
4) *Re-buy of processed material*: Purchase recycled-content building materials by authorized contractor. In each new construction 10% material (minimum) should be used recycled C&D waste materials.

E. Objectives of the Study

The objectives of this research are:

1) To perform questionnaire survey on construction site in Nashik city for the type of construction waste that can be generated,
2) To estimate different projects of Nashik city before and after use of construction and demolition waste materials,
3) To analyze different case studies on construction and demolition waste management in different cities,
4) To implement the use of recycling materials of construction and demolition in different construction projects in Nashik city.

F. Methodology of the Work

The different phases of this project of work are shown in the following diagram. The figure simply describes the experimental strategy of this study step by step.

1) Review the existing literature and identify different construction projects,
2) Select different projects from Nashik city for conducting study on construction and demolition waste management,
3) Estimating cost of construction projects before use of construction and demolition waste materials,
4) Estimating cost of construction projects after use of construction and demolition waste materials,
5) Analyzing different case studies on construction and demolition waste management in different cities,
6) Implementation of use of recycling materials of building demolition in different construction projects in Nashik city,
7) Performing questionnaire survey on construction site,
8) Interpretation of results and conclusion.

G. Different Construction Projects for the Study in Nashik City

The following different construction sites are selected for the study.

TABLE I
DIFFERENT CONSTRUCTION PROJECTS FOR STUDY IN NASHIK CITY

Project No.	Building Name	Type of Structure	Location
Project 1	Laxmi Niwas	Residential Project	Parijat Nagar, Nashik
Project 2	CBS to Canada Corner – Model Road	Infrastructure Project	CBS, Nashik
Project 3	Sai Shraddha Bungalow	Residential Project	P&T Colony, Nashik

III. PERFORMANCE ANALYSIS

A. Data Collected from Questionnaire

The chosen study area is Nashik, the city does not have a recycling facility and the C&D waste generated is collected are just sent to landfills. Data collection was done for a period of three months. The study area generates around 50 to 100 tons of C&D waste per day. The Construction and Demolition Waste (C&DW) generated by Nashik district is about 9187.25 MT/Annum. The construction waste which is not usable or cannot be recycled is to be placed at the dumping ground as identified by the municipal corporation. The list of dumping grounds in all six divisions will be given to the contractor beforehand. There are six divisions of the municipal corporation Nashik East, Nashik West, Nashik Road, Satpur, Cidco and Panchavati. The Public Works Department (PWD) of the NMC has selected a few locations across all six divisions for dumping the debris.

The type of construction waste that can be generated in Nashik city is as follows:

TABLE III
CONSTRUCTION AND DEMOLITION WASTE MATERIALS CATEGORIES AND SOURCES

Waste Material	Construction & Demolition Source
Asphalt	Roads, bridges, Parking lots, Roofing materials, Flooring materials
Brick	Masonry building equipment white goods, Appliances installed equipment
Ceramics/clay	Plumbing fixtures, tile
Concrete	Foundation, reinforced concrete frame, sidewalks, parking lots, driveways
Contaminants	Lead-based paint, Asbestos insulation, Fibre glass, Fuel-tanks
Fiber-based	Ceiling systems materials, insulation
Glass	Windows, doors
Gypsum/Plaster	Wall board, interior partitions
Metals, Ferrous	Structural Steel, pipes roofing, flashing, iron, stainless steel
Metals, Non-Ferrous	Aluminium, copper, brass, lead
Paper/cardboard	N/A
Plastics	Vinyl siding, doors, windows, signage, plumbing
Soil	Site-clearance
Wood, treated	Plywood: Pressure or creosote-treated, laminates
Wood, untreated	Framing, scraps, stumps, tops, limbs

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The different constituents of C&D waste generation in Nashik are as follows:

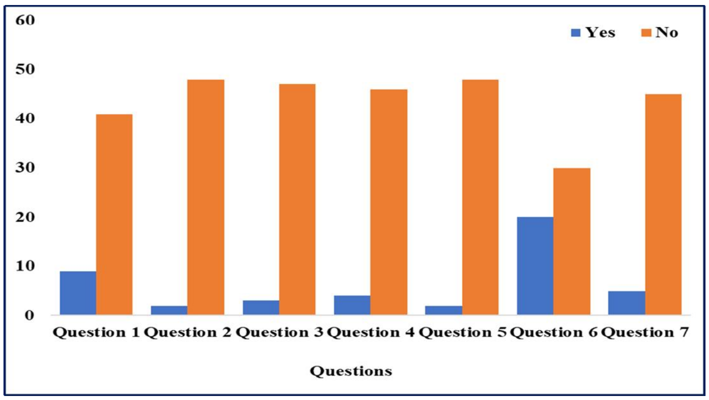
TABLE IIIII
DIFFERENT CONSTITUENTS OF C&D WASTE GENERATION IN NASHIK

Constituent	% of C&D Waste Distribution
Building	45-50
Roads	15-20
Bridges	8-10
Power	5-8
Railway	8-10

B. Results of Questionnaire Survey for Contractors for use of Construction and Demolition Waste on Construction Site

Responses noted from different peoples from different construction sites.

Total Responses: - 50



Graph. 2 Results of Questionnaire Survey

C. Project 1: Laxmi Niwas, Indira Nagar, Nashik: Residential Project

1) Name of Project: - Laxmi Niwas
2) Name of Contractor: - Shree Hari Krushna Developers
3) Location: - Parijat Nagar, Nashik.
4) Type of Structure: - G+1 Structure
5) Construction Year: - 2024

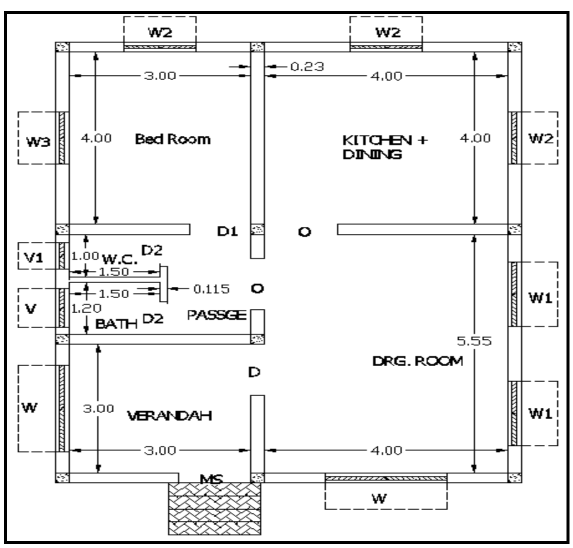


Fig. 2 Proposed Plan of Laxmi Niwas

D. Project 2: CBS to Canada Corner – Model Road, Nashik: Infrastructure Project

The pilot Smart Road stretch is from CBS to Canada Corner – Sharanpur Road, measuring about 1.1km. This project is about transforming chaotic road image to a smart road. Proposed features of the smart road are uniform standard carriage way width from one junction to another, properly designed footpaths, bicycle lane, road intersection development, infrastructure utility ducts below footpaths, road marking, proper storm water drainage and landscaping to increase overall aesthetics of the road.

Features of Project 2 are as follows:

1) Name of Project: - CBS to Canada Corner – Model Road
2) Name of Contractor: - Sampanna Developers
3) Location: - CBS to Canada Corner – Model Road
4) Type of Structure: - Infrastructure Project
5) Construction Year: - 2024-25 (to be completed up to November 2025)

Fig. 2 Demolition of CBS to Canada Corner – Model Road

E. Project 3: Sai Shraddha Bungalow, P&T Nagar, Nashik: Residential Project

1) Name of Project: - Sai Shraddha Bungalow
2) Name of Contractor: - Patil Developers
3) Location: - P&T Colony, Nashik
4) Type of Structure: - G+ 2 Structure
5) Construction Year: - 2025

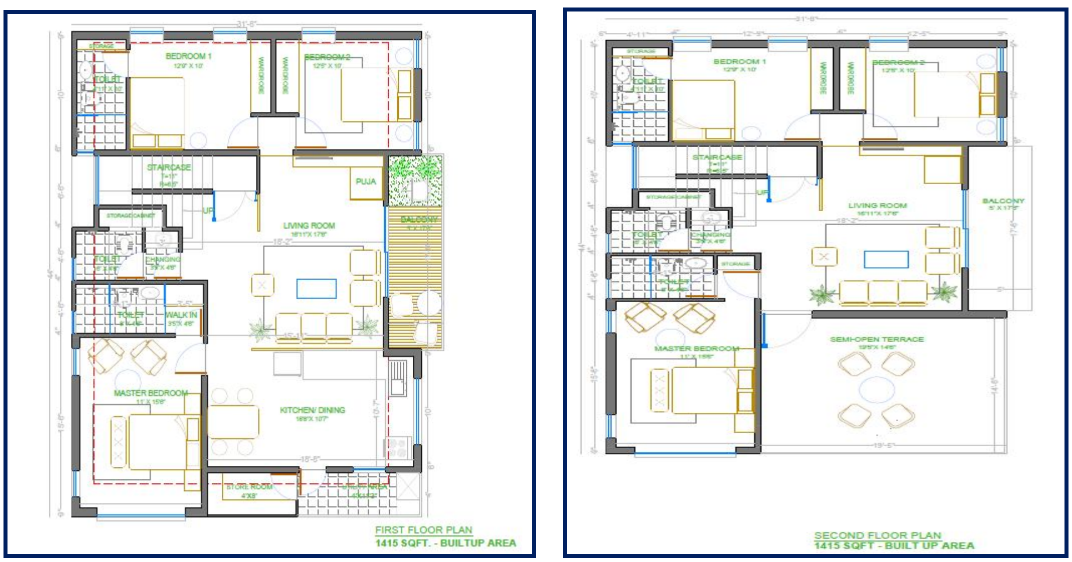


Fig. 2 Proposed Plan of Sai Shraddha Bungalow

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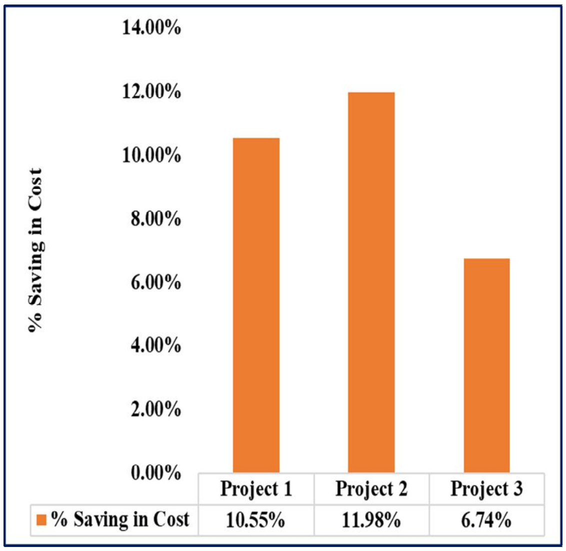
TABLE IVII
SUMMARY OF SAVING IN COST OF PROJECT

Sr. No.	Item	Project 1	Project 2	Project 3
1	Estimating Cost before Use of Construction and Demolition Waste Materials	29,77,981/-	24,95,88,622.72/-	88,63,697/-
2	Estimating Cost after Use of Construction and Demolition Waste Materials	26,63,708/-	21,96,80,678.97/-	82,66,367/-
3	Saving in Cost	3,14,273/-	2,99,07,943.75/-	5,97,330/-
4	% Saving in Cost	10.55 %	11.98 %	6.74 %



Graph. 2. Summary of Saving in Cost of Project

F. Case Studies of Different Construction and Demolition Waste Management Practices

1) L&T – CIDCO Housing Project, Ulwe, Navi Mumbai.

L&T has bagged the contract from CIDCO to construct 23,432 dwelling units at various locations in Navi Mumbai. This project, under the Pradhan Mantri Awas Yojana (PMAY) envisages construction of dwellings for the Economically Weaker Section (EWS) and Low-Income Group (LIG). A large part of this project is precast concrete and L&T has set up a PEB factory at Ulwe, Navi Mumbai where the precast concrete would be produced. Recycled concrete aggregates were proposed to be used for the PEB Grade slab (M 20) and for lean concrete (M 10).

Demolished concrete from Mumbai Metro project, Line no:5, Thane city was recycled at Metro waste handling Private Limited plant at Kalyan Phatta, set up for the Thane Municipal Corporation. It was decided to use RCA fine aggregates A detailed sampling and testing schedule was prepared beforehand and testing of the recycled aggregates were conducted at a third-party laboratory before dispatch. Based on the physical properties of the RCA, the mix design was suitably modified. RCA was used at 100 percent for lean concrete, while 50% of the fine aggregate was replaced with RCA for grade slab concrete (M 20). A total of 268 MT of RCA was supplied to the site and close to 500 m3 of concrete produced. 150.5 m^3 of M 10 lean concrete and 342.55 m^3 of Grade slab concrete M 20 was produced with this RCA. The concrete was cohesive and the compressive strength was comparable to the concrete produced with fine aggregate from natural stone.

2) SINTEF Pilot projects of Construction waste recycling in India Godrej Construction Materials; Mumbai

The Construction Materials business under Godrej Construction operates an RMC plant, a crushing unit for dry recycling of concrete debris and a fully automated concrete block and pavers manufacturing plant in Vikhroli, Mumbai. The recycling plant has a capacity of 300 TPD and the blocks and pavers plant have the capacity to produce 36,000 solid blocks per day and 54,000 Pavers per day. Marketed under the Godrej Tuff brand, these blocks and pavers are produced totally with recycled aggregates from Construction and Demolition waste. The objective of the project is to demonstrate the added value of using concrete blocks with recycled aggregates. This means to document the technical performance of the pilot in each stage – from the source of the demolition to the placing of the blocks and evaluate the net greenhouse gas emission for concrete pavement products by including the natural CO_2-binding in the Environmental Product Declaration (EPD) by life cycle analysis. The project, using a third-party testing house, systematically covered sampling, testing and documenting each stage of the whole cycle of demolition, recycling, block making and laying the recycled concrete block back into the prestigious Mumbai Metro construction project in the Aarey-Goregaon (E) station building. This also included testing a concrete block made with the recycled concrete in the SINTEF lab in Norway for evaluating the CO_2 binding properties and the resultant positive impact on lowering the carbon footprint. The project report is currently being analyzed and compiled for publication.

G. Materials Reused from Building Demolition

1) *Concrete:* BIS permits the use of RCA as both coarse and fine aggregates up to 20% in reinforced concrete in grades up to M25 and up to 25% replacement in plain concrete. Further, it allows 100% use of both RCA and RA in lean concrete below M15 though RA is permitted only in the form of coarse aggregate. This is a major step in promoting the use of recycled aggregates in concrete. Although use in higher grades is currently not permissible, it must be noted that more than 50% of the concrete made in the country is grade M25 and below. Hence there is significant potential for using recycled aggregates within the current regulations. To further encourage and enhance use of RCA in concrete, it is important to test the properties of RCA. Compared to natural aggregates, the water absorption values of RCA are typically higher and exhibits greater variability. This is due to the presence of hydrated cement paste in the RCA. There is a resultant decrease in the specific gravity and increased porosity leading to higher water absorption. Both these properties (specific gravity and water absorption) have an impact on the concrete behavior and therefore, the mix design has to be suitably modified while using RCA. Other characteristics that need to be monitored are the permissible values for free chlorides and sulphate. Thus, a proper testing regime, preferably through a third-party testing agency needs to be implemented to enhance transparency and confidence of all market players.
2) *Precast Concrete Products:* One of the most common and effective use of recycled aggregates is in the pre-cast concrete industry, especially for the concrete blocks, bricks and pavers. As mentioned previously, India will require an estimated 600 billion number of concrete blocks and bricks annually. Since these applications are non-structural in nature, recycled aggregates can completely replace natural aggregates. Many existing C&D processing plants also have concrete blocks and paver manufacturing activities co-existing to manufacture value-added products ensuring seamless consumption of the recycled aggregates. Other pre-cast products that can be produced are concrete floor and wall tiles, kerb stones, concrete fence posts, drain covers, garden furniture, benches and a host of related concrete products.
3) *Granular Sub-Base for Roads:* **-** Recycled aggregates are an excellent replacement for natural aggregates in the construction of sub-base for roads. The crushing characteristics of hardened concrete are similar to natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates produced from original concrete can be expected to pass the same tests required of conventional aggregates. RCA can be used in granular sub-base and lean concrete sub-base. For example, as per IL&FS Environment (2017), the Delhi Development Authority has used close to 5 lakh MT of recycled aggregates as sub-base for roads. Indian Road Congress has permitted the use of produce of C&D waste processing and has issued IRC: 121-2017 "Guidelines for use of construction and demolition waste in road sector".

IV. CONCLUSIONS

The following summarizes the conclusions of the study.

1) Effective management of construction and demolition waste presents a significant challenge in mitigating environmental risks, including air pollution, land degradation, and groundwater contamination. Recent developments indicate that federal stakeholders are increasingly cognizant of these issues, having implemented new policies, regulations, and programs to address them. At the level of Nashik city, progress has been minimal, and numerous obstacles remain. The rapid urbanization in India is expected to result in a significant rise in the amount of building demolition waste produced, alongside a shortage of resources for construction.

2) Using construction and demolition waste effectively can lead to significant cost savings and environmental benefits. The result of residential project and infrastructure project shows that if we use construction and demolition waste materials in new construction then we can save 10.55 % cost in Laxmi Niwas, 11.98 % cost in CBS to Canada Corner – Model Road and 6.74% Sai Shraddha Bungalow.

3) The case study highlights the critical need for effective construction and demolition (C&D) waste management. By optimizing waste reduction, reuse, and recycling processes, the study demonstrates significant environmental and economic benefits, emphasizing the importance of sustainable practices in the construction industry. The case study underscores the detrimental impacts of improper C&D waste disposal, such as landfill overuse, resource depletion, and environmental pollution. By promoting recycling and reuse, the study showcases how C&D waste can be transformed into valuable resources, reducing the strain on landfills and preserving natural resources.

4) Recycling and reusing construction and demolition waste materials reduces the need for new materials, lowers transportation costs, and minimizes landfill use, all contributing to a more sustainable and cost-effective approach to construction. Effective C&D waste management can minimize the volume of waste generated on construction sites, leading to reduced waste disposal costs. This can be achieved through strategies like selective demolition and careful material selection.

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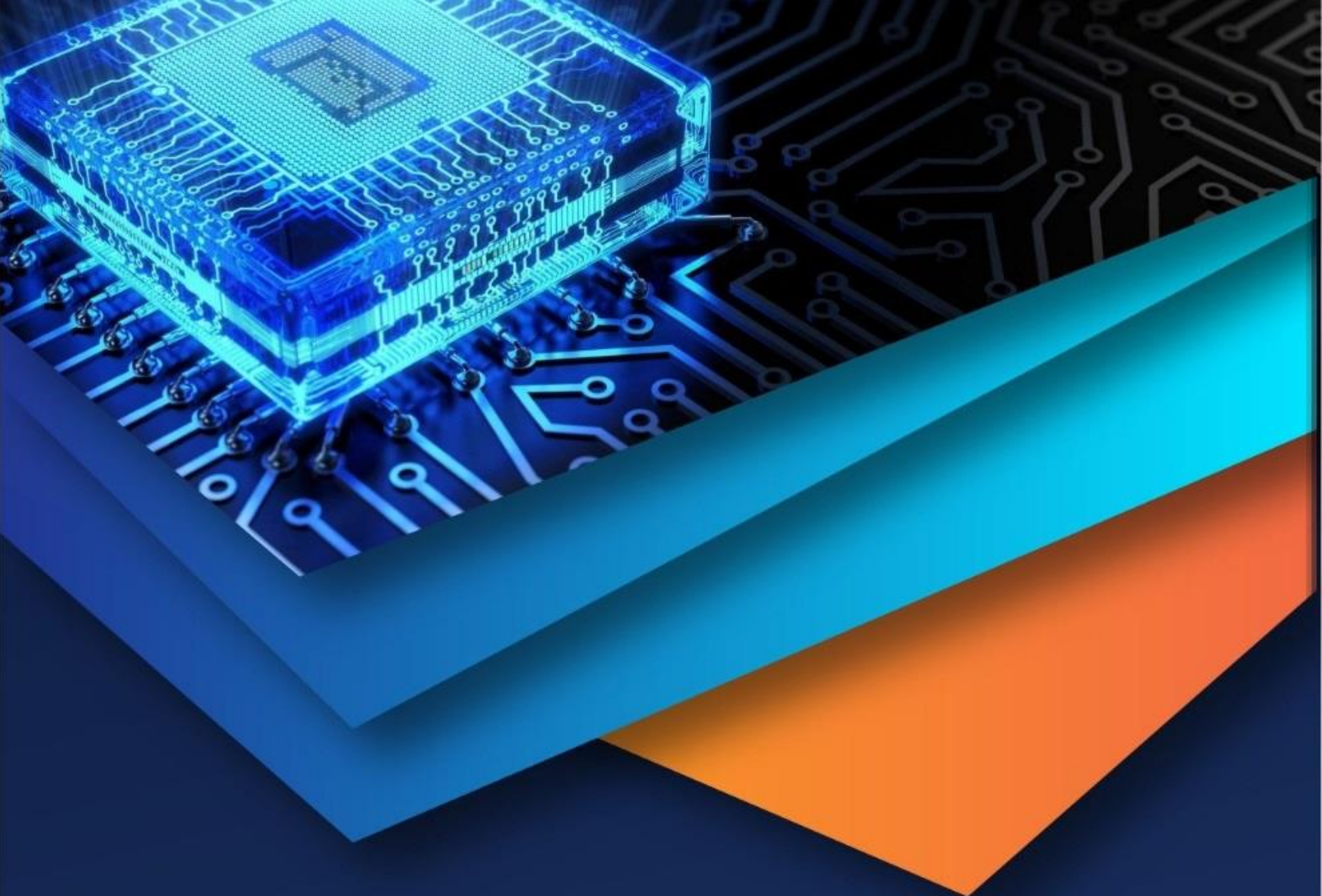

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