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Management of Demolition Waste for the Purpose of Reuse & Recycle

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Abstract: Pune, a rapid urbanizing city, has seen a significant surge in redevelopment project driven by population growth, economic expansion, and the need for the modern infrastructure. Primarily redevelopment involves, transformation of aging and underutilized structures and areas into modern, efficient, sustainable, & technologically advanced structures. Pune's fast-growing suburbs facing challenges of increased waste generation due to increased redevelopment projects. The study evaluates existing policies, laws, and regulations governing waste management in Pune, identifying gaps in implementation and enforcement through the analysis of primary data from interview with professionals and secondary data sources, like research papers, reports, and websites. The research aims to analyze current Demolition Waste Management Practices & highlight the shortcomings of current practices and identify the scope of improvement. Data was sourced through interviews, research papers, books and analyzed by author. The analysis revealed that lack of awareness, lack of record & a smaller number of solutions for C&D waste management is creating more difficult for its execution. No policy or rules & regulations are carried out on ground zero. The findings suggest Pune should grow more focus on sustainable practices, especially for efficiently managing demolition waste and promoting a circular economy. More awareness should be created and new solution on a large scale should be made possible to apply in practical life.

Keywords: *Demolition Waste, Waste Management, Concrete and Masonry, Reuse and Recycle, Legislation and Guidelines, Circular Economy.*

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I. INTRODUCTION

Pune, having various developing suburb, has seen a remarkable urbanization & construction activity over past few decades. With this expansion comes the generation of construction & demolition waste, which creates environmental & logistical challenges. Demolition waste includes material like concrete, wood, metal, glass, & plastic generated during renovation, demolition of building for redevelopment or any untheorized construction, etc. The management of C&D waste is important for sustainable development. According to Pune Municipal Corporation (PMC) approx. 250 MT waste is generated. To tackle this PMC has developed a Detail Project Report (DPR) for understanding quantity, quality, source of waste, etc. & also included consultation with stakeholders to address their concerns but still not enough as intervention of government on ground level is practically zero. One of the key initiatives made by government is establishment of a 2 acres of C&D waste management processing facility at wagholi, with aim of diverting waste from landfill & recycling, which further is sort a of failure due to long distance transportation again leading to more money. One noteworthy technique involves the on-site separation & processing of demolition materials, reducing transportation costs & environmental impact. In addition to environmental benefits, effective C&D waste management can also have economic advantages. Recycling & reusing C&D waste can help in creating new job opportunities & contribute in local economy. On the other hand, it might not, as if the recycled material is costing then the virgin material, the stakeholders won't divert to recycled ones leading.

The papers present an in-depth study of construction and demolition (C&D) waste management in Pune, focusing on infrastructure projects, real estate redevelopment, and demolitions. It highlights the growing challenge of C&D waste in the city and explores methods for recovering and reusing these materials in new construction. Data is collated through interviews with respective professionals & secondary sources as research paper & books, government/organization sites. Currently practices followed in Pune on local level in case of redevelopment project are like the sign a contract to demolition contractor and get the clear site back. Monitoring on ground level is not done. Stakeholders are finding loopholes and neglecting the need of tomorrow. Building awareness & fostering a culture of sustainability within the community is crucial for compliance with regulations. C&D waste management has many scopes of improvement starting with creating awareness for finding alternate material for construction industry; creating recycled material market for encouraging community; imposing strict laws & implementing beneficial schemes to grab attention of stakeholders by government.

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➢ *Aim: to Analyze the Current Demolition Waste Management Practices.*

➢ *Objective:*

- To examine the increasing need for C&DW management.
- To analyze current practices and legislation.
- To identify areas for improvement.

➢ *Scope and Limitations:*

The scope of this paper includes various key areas, such as, waste sorting/segregation, policies and regulations, recycling/reuse with focuses on case studies, best practices, and technological innovations that contribute to effective waste management. With the growing demand for built spaces and the scarcity of land, there is a notable trend toward redevelopment projects. The site selection is confined only to Pune, a fast-developing city with numerous ongoing construction projects generating large amounts of waste leading to become a significant concern. The study focuses on examining current C&D waste management practices & identifying the areas of improvement, without delving into the economic analysis of waste management at this stage. The case study limits to redevelopment projects in Pune. Excluding urban infrastructures like roads, bridges, etc.

➢ *Methodology:*

- *Setting for study:*

The study in conducted in Pune, as constant increase in number of Redevelopment project.

- *Samples:*

Sites were identified based on parameters such as the level of urbanization (population and living standards, city growth rate, new development plans concerning land use, transit-oriented, the city's age, and construction patterns.

- *Method and Tools:*

✓ Section 1: Data Collection: The methodology involves collecting data and information through secondary sources such as research papers on C&D waste management, websites, various survey reports by agencies, and national authority websites.
✓ Section 2: Policy/Rules/Regulation: The analyses of current status of C&D waste management in terms of policies, laws, and regulations, ongoing waste management practices, technologies, and key stakeholder participation.
✓ Section 3: C&D Management (Buildings Case-Study): This data is sourced through primary sources like, interviews with professionals such as project managers, civil engineers, contractors. A questioner was circulated for analysis of current practices and checking awareness on need of management of demolition waste.
✓ Section 4: Technology of C&D waste Processing: Analysis of current technological advancement for waste management procedures.

II. LITERATURE REVIEW

The study from various research papers emphasizes the advantages of deconstruction over traditional demolition, as it allows for greater material recovery and waste minimization. The paper discusses strategies involving technological solutions, policy interventions, administrative frameworks, and legislation to improve waste management practices. The study reviews literature on C&D waste management practices worldwide, analyzing successful initiatives from various countries.

Few researchers identify best practices & policies that could be adapted to improve waste management in Pune. These include strategies for recycling C&D waste materials, particularly aggregates, to reduce project costs, lower pollution, and enhance sustainability in the construction industry & examines current C&D waste management practices in Pune's residential projects, analyzing disposal patterns and identifying gaps in existing systems. The paper presents a case study of a residential project in Pune, showcasing the ground report for waste reuse methods. This approach aims to reduce construction costs, improve profit margins, and encourage greener building practices. The study uses Life Cycle Assessment (LCA) methodologies to evaluate the environmental impacts of different concrete waste management strategies. By assessing the life cycle impacts, the research identifies the most sustainable alternatives for managing concrete waste. This approach addresses rising concerns about waste management and global carbon concentrations, aiming to reduce environmental impacts and promote a circular economy. Highlights the importance of policy frameworks, technological advancements, a legislative support in enhancing C&D waste management. It calls for stricter regulations, better enforcement, and incentives to promote recycling and reuse in the construction industry.

Overall, the papers provide a comprehensive analysis of C&D waste management in Pune, drawing on global best practices and local case studies to propose effective strategies for waste recovery, recycling, and sustainable construction. It emphasizes the need for a coordinated approach involving all stakeholders to address the environmental and economic challenges associated with C&D waste.

III. DATA COLLECTION & INTERPRETATION OF SURVEY FINDINGS

In recent years, there's a remarkable bloom in construction industry due to rapid increase in population leading urbanization and increasing economic aspirations. With every project a substantial amount of waste is generated. As per estimates, 150-500 MT per year, accounting for 35%-40% of the global C&D waste, and of its only 1% is recycled, stated by Center for Science and Environment, & 90% of it can be reused. A study by TIFAC in 2001 noted that C&D waste in India typically contain as shown in figure 1, but the composition varies region to region.

ISSN No: 2456-2165 https://doi.org/10.38124/ijisrt/25jul685

Table 1 Estimation of C&D Waste Generation

	Kg/sq.m	Type
Estimation of C&D waste generation	40-60	New construction
	40-50	Renovation/Repair
	300-500	Demolition of buildings

Solid waste generation in India is about 48 MT per annum out of which the construction industry accounts for 25% or 12 –14.7 MT per annum. The Union MoUD in 2000 estimates 10-12 MT of C&D waste annually. According to PMC, total generated waste is approximately 250 MT per day of C&D waste from various sources. To address the C&D waste, PMC has prepared a DPR to understand quantity-quality & sources of C&D waste, and doing consultation with various stakeholders and understanding their concerns.

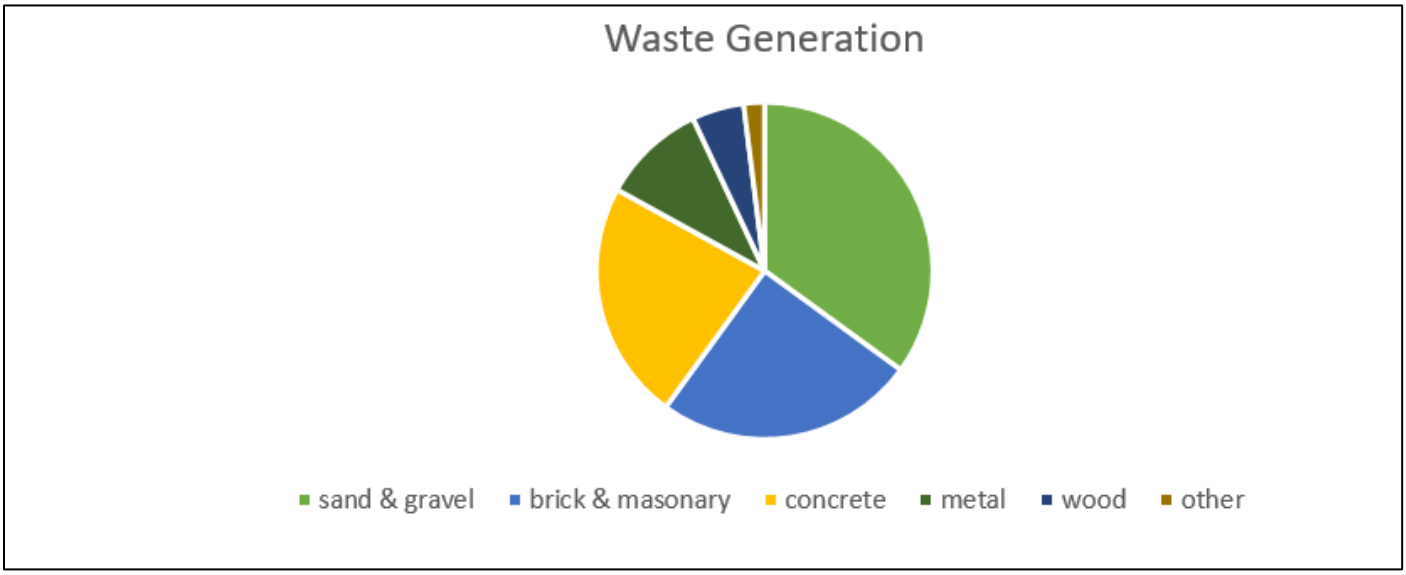

Fig 1 Waste Generation

➢ *Policy:*

Indian Standards: The Bureau of Indian Standards (BIS), 2014 set up the Panel for Aggregates from other than Natural Sources to fast-track inclusion of recycled C&D waste as legal substitute of natural aggregate in concrete mix.

IS 383 categorizes Recycled waste into: Recycled Aggregate (RA) and Recycled Concrete Aggregate (RCA)

- National Building Code of India: 'Approach to Sustainability' was added as the 11th chapter to NBC in 2015 as follow.
- The Ministry of Environment, Forest and Climate Change (MoEFCC) notified the C&D Management in 2016.

➢ *Key Highlights:*

C&D Waste Management Rules, 2016:
Overview of Demolition waste:

Table 2 Overview of Demolition Waste

Features	**Demolition Activity**	**Remark**
Activity awarded by	Development Authority/Housing Board/Slum Clearance Board/Private company	All factors depend on the size of the project / encroachments to be removed. Main Pollutants: NOISE & DUST generation
Activity executed by	Outsourced to private contractors	
Nature of activity	Manual & mechanized	
Waste generation/sqm	Very high	
Fees/Rates for lifting wastes	Demolition: Rates for lifting demolition waste are fixed per cu.m or cu.ft by the concerned department after assessing the salvageable waste; most local bodies have empaneled contractors for executing demolition activities	
Common equipment developed at site	Concrete breaker machines, JCB, earth moves, pneumatic breakers	
Wastes that can be salvaged (Re-usable/Recyclable wastes)	Concrete breaker machines, JCB, earth moves, pneumatic breakers	

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➢ *Material and Cash Flow:*

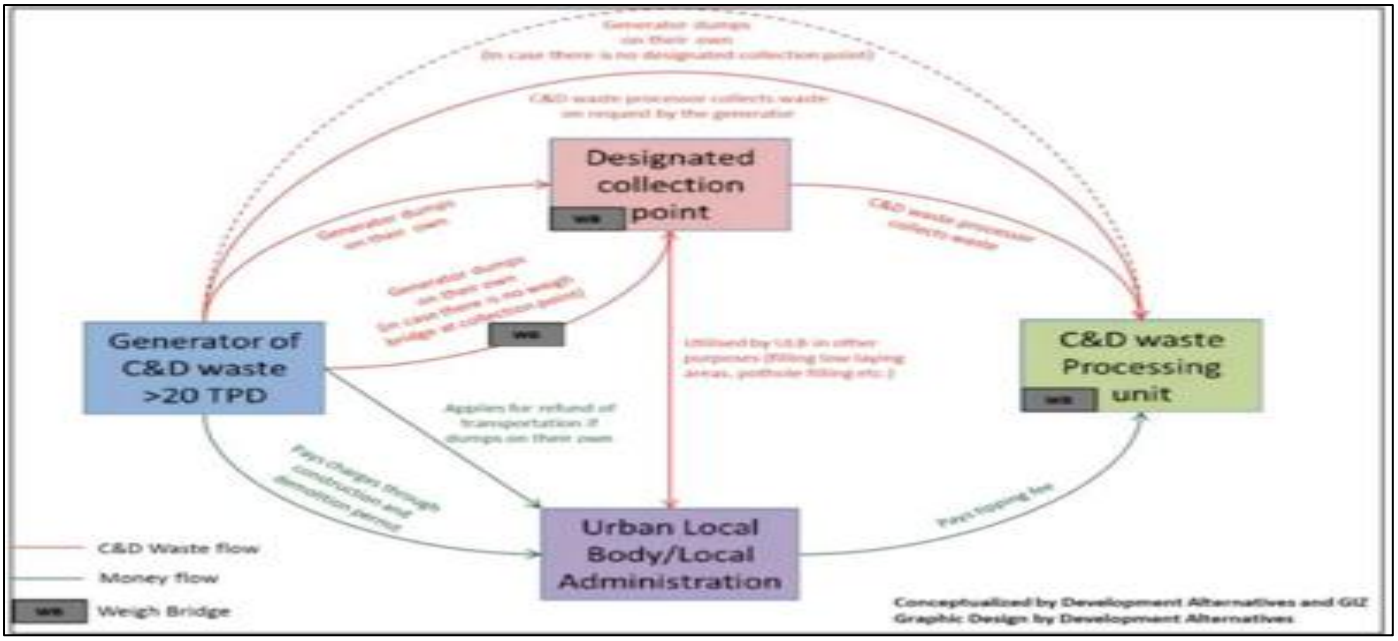

Fig 2 Material and Cash Flow in Standardized C & D Waste Management Model in a City With Processing Unit

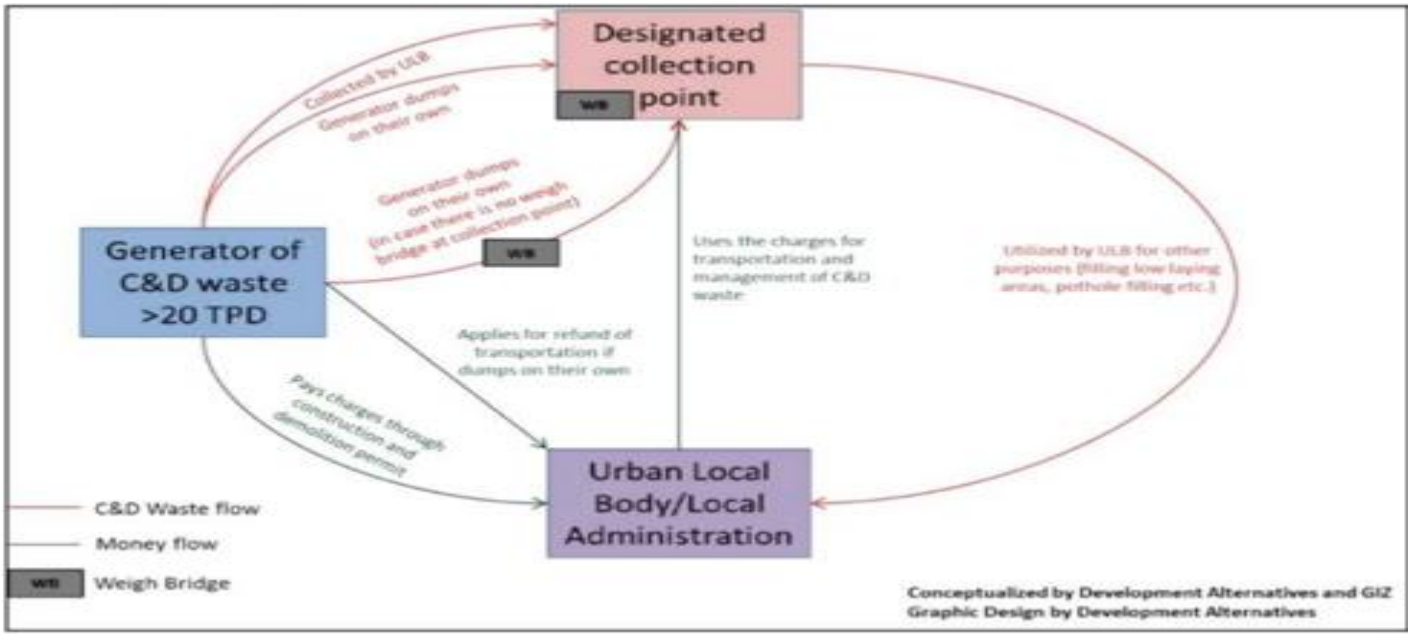

Fig 3 Material and Cash Flow for Standardized C & D Waste Management Model without a Central Processing Unit

➢ *Duties of Stakeholder:*

Table 3 Overview of Demolition Waste

Stakeholder	Duties and Responsibilities
Waste generator	a) Properly collect and store waste within their premises ensuring no spill over or mixing with MSW. b) Deposit waste in designated locations as notified by local authority. c) Submit waste management plan and get approval before starting construction/demolition work. d) Pay respective charges.
Utility service providers and their contractors	a) Prepare comprehensive waste management plan. b) Collect and store waste securely by avoiding local disruption or pollution. c) Arrange with urban local authority for disposal paying the relevant charges.

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Local authority	a) Main actor responsible for waste management. b) Should do a feasibility study before finalizing management plan. c) Pass by-laws mandating C&D waste management and fix relevant charges and penalties Designate intermediate collection points and site for processing facility, if needed in collaboration with state agencies. e) Examine and approve waste management plan of generators and collect relevant fees. f) Make arrangements for collection, transportation and processing, in contract with private party.) Create incentives for use of recycled products including through preferential purchase agreements in municipal contracts.
State Pollution Control Board/Committee	a) Monitor all implementation. b) Authorize C&D waste processing facility and monitor environmental compliance. c) Prepare annual reports for CPCB.
State Govt.	a) Prepare policy document for C&D waste management. b) Help cities identify land for waste management where necessary. c) Facilitate preferential procurement of recycled materials by all state agencies.
CPCB	Prepare guidelines for C&D waste management & analyze data collected by SPCBs and prepare annual compliance report for central government.
BIS/Indian Roads Congress	Prepare standards for suitable utilization of recycled products from C&D waste in construction and in roads.
Central Govt.	a) Compliance facilitation by MoHUA, MoRD. b) Review of implementation by MoEFCC.

The disposal of C&D waste often results in dumping in unauthorized locations, leading to environmental degradation and missed opportunities for resource recovery. Primary source of dust pollution. Dumped on streets and footpaths majorly leading to result in traffic congestion and accidents. Usually gets mixed up with other municipal solid waste during the process of transfer or at the collection site, making difficult for MSW management. Filling up existing landfills, resulting in need for more. Chemical particles degrade the soil, leading to land and groundwater pollution. Especially hazardous components like paints, oil and asbestos sheets. Dumped in open drains, wetlands, riverbed and water channels, disrupts the hydrology and destroys the aquatic ecosystem and leading to flooding during rains due to clogging. Hazardous materials like broken glass, boulders, broken wooden logs, rusted metal, broken ceramics, etc., create a hazardous environment when dumped in open places.

➢ *Case Studies:*

Work flow/Coordination between Builder, Engineer & Demolition Contractor:

- *Material Extracted:*

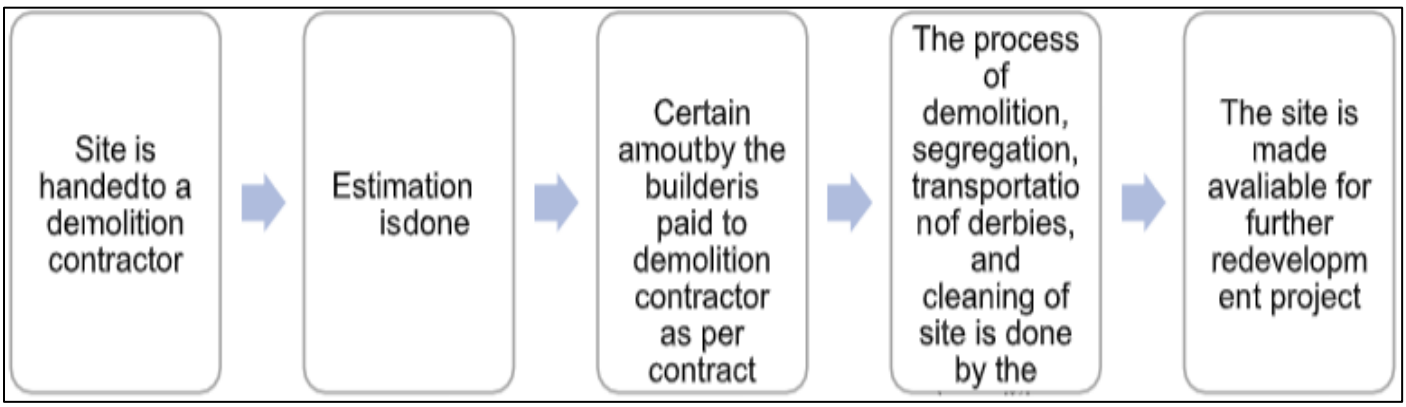

Fig 4 Workflow

Source: Author

- Concrete/Bricks – the debris are used for land filling purpose instead of murrum for plinth level filling, as builder as to royalty for the murrum filling.
- Steel Reinforcement – steel is sold to scrape market, in Chakan.
- Timber – sold to timber market & further furniture are made from it.
- Door/Window – door & windows are sold in timber market.

Chakan has a big scrape market were on-going project contractor sell their metal scrap, further it is up-cycled. Concrete is either used in plinth filling or dumped in landfilling at extreme end. On average 0-25% material goes to landfilling. After having survey with the respective

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stakeholders of the concern project, a conclusion was drawn that government as 0 intervention waste management process as of current condition. No regulations are audited by local body authorities.

Fig 4 Furniture Made at Timber Market With Left over Wood or Waste Sourced from Demolition Site. – Source: Author

Fig 5 Scrap Market in Chakan - Source: Author

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- *Material and its potential use:*

Table 5 Material and Potential

C & D waste	Potential use
Concrete	75% of concrete is made of aggregates. Opportunity: The quantities of demolished concrete can easily recycle as aggregate & used in concrete, but waste and quality of raw material produced being site specific, tremendous inputs are necessary if recycled material has to be used in construction for producing high grade concrete.
Bricks	Broken bricks can be used for refilling or as debris paver blocks or debris blocks.
Stone	Stone can be reused for plinth formation, masonry construction, landscape purpose, ledges, platforms, window sills, coping etc. depending upon the form and size.
Timber, Plywood and other timber- based boards	Timber elements from deconstructed building may have aesthetic and antique value. Plywood and other timber-based boards can be either reused for interior works in new construction. Opportunity: Whole timber from construction/demolition works can be utilized easily.
Gypsum	In India, over 10 about of waste gypsum such as phosphor-gypsum, Fluro-gypsum etc., are being generated annually.
Metals / metal alloys & Nonferrous metal	Ferrous Metals are the most profitable and recyclable material. Scrap steel is almost totally recycled and allowed repeated recycling. Nonferrous metal from construction/demolition sites are aluminum, copper, lead & zinc.
Debris	Construction debris can be recycled to manufacture paver blocks used for light traffic areas and masonry blocks. Other uses of processed debris include use in lean concrete for leveling purpose, as mortar & bedding mortar for pavement tiles & for land filling materials is comparable with new materials.
Composite materials	The plastic wastes are best for recycling if these materials are collected separately. Plastic may be recycled & used in products specifically designed for the utilization of recycled plastic, such as street furniture, roof and floor, PVC window noise barrier, cable ducting, panel. Composite materials like thermoplastics are not only using non- renewable resources, they are non-biodegradable products. PVC-U sourced mostly from window and door fabricators is being recycled into wiring accessories and cable management systems including skirting and trucking. These can be down-cycled.

IV. CONCLUSION

Management of C&D waste is still a huge challenge for local government bodies and other stake holders. Even government agencies like PWD invite bids for demolition based on what contractors would pay for recoverable. The recoverable of secondary market value, like metal rods, pipes and fixtures, wooden frames, etc., are salvaged by the informal sector, typically from demolition sites, leaving behind the "rubble" composed of bulky materials. A small fraction of rubble is used for back-filling in construction projects, both for private and public works, and the same demolition contractors arrange for its transportation to sites where it is needed. The remaining fraction of C&D waste is disposed, either in designated landfills/dump sites or often in unauthorized places such as road sides, river beds and low-lying areas causing a host of nuisance, safety and environmental problems. Challenges face is shortage of land, lack of monitoring capacity & experience in C&D waste management, concern about business & finance case, urgency/priority, confidence in recycled products and poor economic viability resulting in low involvement of government and engagement by public construction agencies. Issue is more complicated by poor waste management practices and a lack of data, making it even more difficult to address the concern. Even though legal reform is taking a long time, several architects have already taken steps to reuse waste in their buildings.

➢ *Steps by India:*

- School in Rajkot in Ahmedabad, has been built from the debris formed during Bhuj earthquake.
- A Building built effectively in Gurgaon has recycled its own construction waste.
- In fact, the attempt to use recycled material from the Burari center in New Delhi, during the Commonwealth Games faced opposition as these materials are not backed by standards as yet.
- Architect and Engineer Vinu Daniel creates award-winning buildings with help of waste materials and earth.

But these are limited steps and they will have to be encouraged with policy and financial support. Globally, the strength of these materials has been proven; and being used in case of infrastructure necessary for development such as roads, flyovers, pavements, etc.

Currently in Pune, the wood scrape collated after the demolition of the structure is sold to timber market while the whole metal scrape is sold to scrape market in Chakan. And further metal is upcycled and resold. And the remaining derbies i.e. concrete is either used as plinth level filling or resulting in mismanagement, as illegal dumping, clogging of drains, or dumping nearby water bodies, with zero intervention of government. Hence, intervention of

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government should be increased and Implementing tax policies to reduce waste generation and prevent unsafe disposal will further support environmental sustainability. Workshop & campaigns should be conducted to educate builders, contractors, & residents about the importance of proper management. Collaboration between government bodies, private enterprises & research institute is essential to create a sustainable ecosystem. Encouraging efficient management practices to minimize waste and the use of alternative materials in infrastructure is important. Economy analysis plays a vital role in C&D waste management, while awareness and social impacts highlight the importance of stakeholder's involvement and education. One of the biggest hurdles to effective C&D waste management is lack of market demand & trust for the recycled material. While undergoing the remarkable growth we are moving closer to extinction of primary resources and the need of secondary materials should is increased. Creating market for C&D waste material is important for encouragement of the stakeholders, as to make invest in C&D waste management. It is essential to fast-track the creation of BIS codes for recycled materials and promote the use of alternative building materials. By contributing few efforts, we can be successful to create a sustainable system that reduces the ecological footprint of construction activities and contributes to a better circular economy & environment.

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ANNEXURES

ANNEXURE A

Abbreviation:
BIS – bureau of Indian standards
C&D – construction and demolition

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DPR – detail project report
FSI – floor space index
IRRAD – institute of rural research & development
LCA – life cycle assessment
MSW – municipal solid waste
MoEF – ministry of environment and forest
MoEFCC – ministry of environment, forest & climate change
NBC – national building codes
PMC – pune municipal corporation
PWD – public works department
RA – recycled aggregate
RAP – recycled asphalt pavement
RCA – recycled concrete aggregate
R&D – research & development
SWM – solid waste management
TPD – tonnes per day
TTIFAC – technology information, forecasting & assessment council

ANNEXURE B

➢ *Questionnaire Prepared:*

This survey aims to understand current practices and challenges in construction and demolition (C&D) waste management. Your responses will be anonymous and will be used to improve C&D waste management strategies.

- What is your primary role in the construction industry?

✓ Architect
✓ Engineer
✓ Contractor
✓ Waste Hauler/Recycle
✓ Other (Please specify): _____

- What is the average size of your construction projects (square footage)?

✓ ≤5,000 sq ft
✓ 5,000 - 25,000 sq ft
✓ 25,000 - 100,000 sq ft
✓ ≥100,00 sq ft

➢ *(OBJ 1)*

- On avg., what percent of your construction &s demolition waste is diverted from landfill?

✓ 0-25%
✓ 26-50%
✓ 51-75%
✓ 76-100%

- What are the top 3 types of C&D waste you generate? (Select all that apply)

✓ Cement, Concrete blocks and brick masonry
✓ Wood – carpeting, cabinets, timber and timber-based boards, door and window frames and shutters, panels
✓ Drywall
✓ Metal – structural steel, framings
✓ Asphalt
✓ Stone
✓ Ceiling and flooring tiles
✓ Landscaping materials
✓ Appliances and Hardware - bathroom & lighting fixtures, insulation, pipes, PVC water tanks, roofing sheets, fabric of tensile structures etc.

- In your opinion, how important is C&D waste management in the construction industry? (Open ended)

➢ *(OBJ 2)*

- Which of the following C&D waste management practices do you currently implement? (Select all that apply)

✓ Source reduction (e.g., material selection, efficient cutting)
✓ Reuse of materials on-site –

▪ Bricks cleaned off mortar and sold to sold to slum dwellers.

✓ Recycling of C&D waste –

▪ Reinforcing steel sold as scrap
▪ Concrete for road filing

✓ Landfill disposal
✓ Other (Please specify): _____

- How familiar are you with the regulations for C&D waste disposal in your region? (Open ended)
- Do you have a designated person on your team responsible for C&D waste management? Y/N
- Are you aware about green rating system in your region? Y/N
- Have you participated in any training programs related to C&D waste management? Y/N

➢ *(OBJ 3)*

- How important is government intervention (e.g., subsidies, regulations) in promoting better C&D waste management practices? (Open ended)
- In your opinion, what role can technological advancements play in improving C&D waste management? (Open ended)
- What are the biggest obstacles to implementing effective C&D waste management on construction projects? (Select all that apply)

✓ Lack of knowledge or awareness
✓ Limited resources (time, manpower)
✓ Infrastructure limitations (sorting facilities)
✓ Unclear or complex regulations
✓ Other (Please specify): _____

- What are the biggest challenges you face in managing C&D waste on your projects? (Select all that apply)

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- ✓ Lack of awareness about C&D waste regulations
- ✓ Cost of recycling and hauling
- ✓ Lack of readily available recycling facilities
- ✓ Difficulty in sorting and separating waste onsite

- What improvements would encourage you to divert more C&D waste from landfills?

- ✓ Government subsidies for recycling programs
- ✓ Lower costs for hauling and processing C&D waste
- ✓ Increased availability of local recycling facilities
- ✓ Educational programs on C&D waste management
- ✓ Clearer regulations and enforcement for C&D waste disposal
- ✓ Other