EXPLORING IMPLEMENTATION OF SUSTAINABLE DEVELOPMENT GOALS THROUGH CONSTRUCTION DEMOLITION WASTE MANAGEMENT FOR ENVIRONMENTAL SUSTENANCE USING NVIVO

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Abstract

The aim of this paper is to attain a relationship between Construction and Demolition waste, circular economy principle and SDG Goal 9, 12 through qualitative analysis. In Agenda 2030, "SDG Goal 9" (Industry Innovation and Infrastructure)" and "SDG 12 ""(Responsible Consumption and Production)" due relevance and importance in the rapid urbanization and industrialization. In Asia, Africa, and Latin America, where two third population shall live by 2050, (UN, World Population Prospects: The 2017 Revision, Key Findings and Advance Tables, United Nations, retrieved 1, 2017). Construction is a vital phenomenon in the upcoming urban areas. 50-60% of global GHG emissions and 75% of global primary energy is consumed by the cities. (UN-Habitat, 2018). Construction Demolition Waste (CDW) generated is unsustainable product and activity that deteriorates environment ((E. Mejía, 2015). The (CDW) can be utilized back to the forward supply chain in the project site working on the core principle of Circular Economy Reduce, Reuse and Recycle. The main objective of this paper is to understand the attributes using NVIVO for CDW Management, to develop a relationship between the two identified SDGs with CDW in the context of India. Using secondary data, exhaustive literature study and analysis through NVIVO software, thematic analysis to study the factors of successful implementation of CE in CDW management at project site for the attainment of Sustainability is attempted. The paper throws light on current schemes of CDW in Indian Scenario and what should be done for future for promoting sustainability through construction waste management among various stakeholders.

Keywords: Sustainable Development, Construction Waste, Construction Industry, Circular Economy, Environmental Management.

INTRODUCTION

Construction is of vital importance for the growth and development of world at large and Urbanization is a major phenomenon in both developed and developing nation. But in this rapid race of urbanization there is huge detriment that is caused to the environment at large.

In the developing markets of Asia, Africa, and Latin America, where two third of the population shall live by 2050, (UN, World Population Prospects: The 2017 Revision, Key Findings and Advance Tables, United Nations, retrieved 1, 2017). 50-60% of global GHG emissions and 75% of global primary energy is consumed by the cities. (UN-Habitat, 2018).

Huge construction results in larger generation of construction and demolition waste which generates different kind of pollution and causes a threat to sustainability at large. Construction Demolition Waste (CDW) produced in construction life cycle is considered an unsustainable product as well as activity that detoxicates environment ((E. Mejía, 2015).

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The total amount of CDW produced in world is 30 % of the world's solid waste of. (Clarence P. Ginga, 2020) This amount will be 2.2 billion tonnes doubling in 2025. (Fabris, 2018).

India accounts for 150 million tonnes of CDW every year out of which only 1 % is recycled according to Centre for science and excellence report (CSE). Thus, there is a dire need to study the utilisation of CDW back into the mainstream of construction project by Circular Economy methods not only to reduce the waste generated but also to lessen the burden on nature for utilisation of new material.

In agenda 2030, there are 17 goals which are set to promote sustainability.

This objective is to find out the way to foster (a) SDG Goal 9 (Industry Innovation and Infrastructure) (b) SDG 12 (Responsible Consumption and Production) by applying circular economy principle in the construction life cycle.

SDG 9 is to "Build Resilient and sustainable infrastructure, promote inclusive and sustainable industrialization, and foster innovation in achieving the objectives. (UN, The Sustainable Development Goals Report 2023, 2023)" It identifies the importance of Innovation, Infrastructure, and Industrialization 'in nurturing sustainable growth and development. (Nations, n.d.)

SDG 12 aims on sustainable consumption and production practices. It is to "enhance efficient use of resources, reduce waste and minimize the environment impact of consumption and production process". (UN, the Sustainable Development Goals Report 2023, 2023)

SDG 9 and SDG12 has relevance and importance in the era of rapid urbanization and industrialization. To achieve the SDG 9, SDG 12 needs collaboration from government authorities, academician, construction companies and individuals in implementing policies, practices, and technologies to promote CE principle of Reduce, Reuse and Recycle thought the construction projects.

REVIEW OF LITERATURE

Construction and Demolition Waste in India

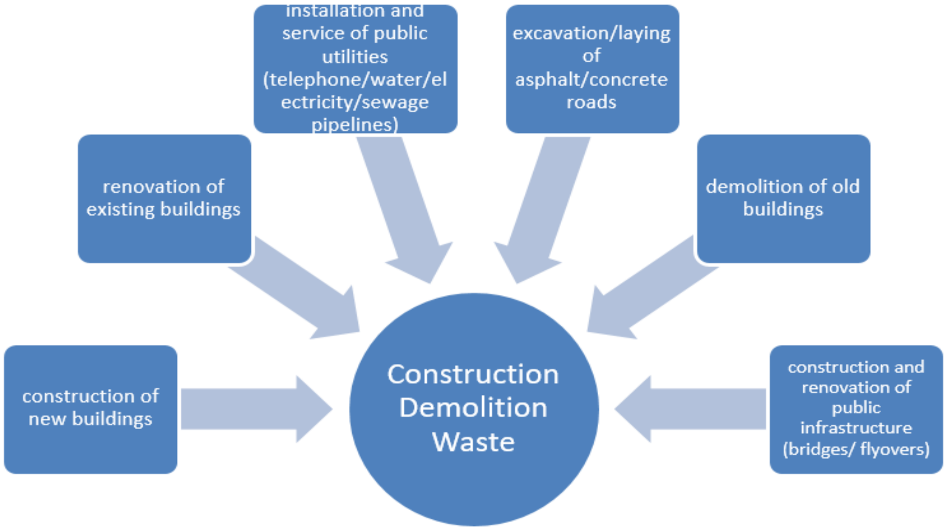
India is one of the fastest developing economies is beholding rapid infrastructural development, urbanization. Construction is the backbone as it is considered third among, economic sectors with 12-15 % contribution to GDP and second largest employer generator. (Statista, n.d.).

However, these progressive strides have arrived at a significant environmental health and natural resource depletion cost. It's high time to use CDW as not waste but a resource.

Since the primary material like sand, soil, limestone, wood coal is facing disruption so use of secondary recycled CDW material needs active usage and promotion.

According to Shen et al., "C&D waste is as a combination of surplus constituents generated from construction, renovation and destruction activities such as site clearance, land excavation and roadwork and demolition". (RK, 2018)

CDW generating activities are:



The CDW waste composition is city and project specific and varies with the urbanization rate, development pace and city redevelopment [1].

As per Construction Demolition Waste Rule 2016, It is is defined as 'any waste comprising building materials, debris and rubble resulting from construction, remodelling, repair, and demolition of any civil structure' " (Environment, 2018). CDW as shown in Fig 1 is an inert waste compromising of Rubble, Sand, Metal, Building Material, wood etc which can be reused and recycled, but it varies from region to region.

Table 1: Origin and Causes of Construction Waste

Origin of Waste	Causes of Waste
Contractual	• Incorrect contract documents • Inadequate and • Incomplete contract papers
Design	• design changes • Design and construction detail errors • Unclear description • Incorrect management and communication
Procurement	• Order errors • budgets overshoots • suppliers' fault
Transportation	• Damage due to transportation • Inadequate unloading and lack of protection while unloading
planning and site management	• Lack of wa material control and waste management strategies on-site • Lack of supervision • Insufficient planning.
Material storage	• Damage due to Inadequate site storage . • materials storage at an extreme distance from the of usage point
material handling	• Loose supply of materials • Improper resource handling
Site operation	• Accidents due to negligence • Inadequate workmanship Equipment malfunction. • Time pressure

Source: (Canadian SA, 2014)(2

Need for CDW management

CDW deterioratesenvironment (The decrease in the usage of natural aggregates and enhancing the use of CDW as raw materials shall promote sustainability in the construction industry. (Rodrigues, 2013). = Threats caused by CDW (environmental pollution, landfill depletion natural resource usage, and) are a threat to environment (Roussat, 2008) There is harmful impact of CDW to the environment in various ways some of which are

a) Urban flooding during rains due to clogging of routinely dumbed waste in open.

b) The aquatic ecosystem and hydrology is disrupted by dumping of CDW in wetlands, riverbeds etc one of the example is in Minnesota where the groundwater is affected by construction debris (Fabris, 2018)

c) Leaching of hazardous substance as paint, asbestos , oil degrades land and cause ground and water pollution

d) Heterogeneous CDW mixes with Municipal waste causing difficulty in segregation of the municipal waste

e) CDW causes dust pollution for example we all are aware of the precarious situation due to construction dust in Delhi NCR that worsens in winter season. Study suggests 38 % of Delhi, 71 % of Mumbai, 23 % of Bangalore and Chennai air pollution is due to construction activities.

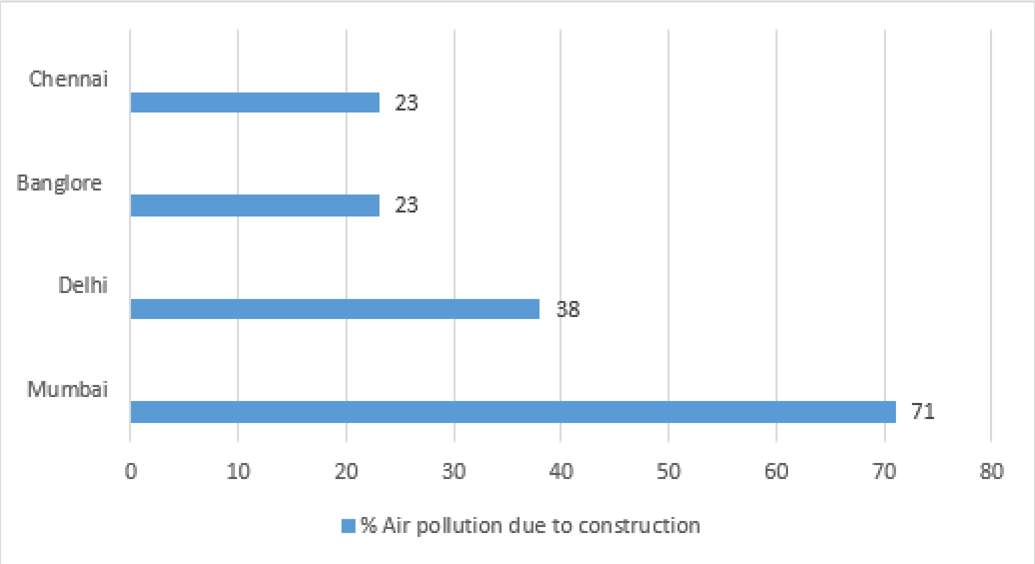


Fig 1: Air Pollution in various cities due to CDW source (Environment, 2018)

There are many cardiovascular diseases (heart attacks, strokes), respiratory (asthma, bronchitis) and even lung cancer because of presence of silica and asbestos are some of the health hazards of construction dust. (Contributor, 2019)

f) CDW blocks the traffic and pedestrian ways causes jams and even accidents example In Shenzhen, China more than70 people were killed by a landslide created by a pile of construction debris (Fabris, 2018) f) Unfenced Broken glasses, wood logs, ceramics rusted metal create a hazardous environment.

Circular Economy (CE) principle

Circular Economy can be an promising profitable system based on “Take -Make -Dispose” from the existing linear model in Construction It is based on “Reuse, Recycle and Recovery”. (Ghisellini, Ripa, & Ulgiati, 2018). The CE transforms waste into value enhancing the sustainability. (Nobre & Tavares, 2021). There are various literature studies as Tazi, et al. (Lederer, Gassner, Kleemann, & Fellner, 2020)reviewed the circularity of inert building materials for the French abode r by Material Flow Analysis (MFA). Variables as location, total floor area, number of dwellings, market variables and end-of-life scenario. In Vienna, Austria, Lederer, et al. (Hoang, Ishigaki, Kubota, Yamada, & Kawamoto, 2020) carried a case study ffor evaluation of recycling possibility of chiefly mineral in CDW. It used Material Flow Aanalysis to measure four inert CDW viz bricks, concrete, asphalt and , gravel,

Objective and Research Methodology

The paper aims to achieve two objectives through comprehensive literature study and secondary data.

a) To identify the attributes for Construction Demolition Waste (CDW) Management and analyse its dominance using NVIVO

b) To develop a relationship between the two identified Sustainable Development Goals (SDG) (SDG9, SDG 12) with CDW to promote sustainability through Circular Economy (CE)

c) To understand different challenges and future implication of CDW

Using secondary data, integrated literature study and practical problem the research objectives were accomplished. Credible online scientific databases like Science Direct, Google Scholar, and Scopus were used to access the appropriate material. Analysis through NVIVO software, thematic analysis factors of successful implementation of CE in CDW management at project site for the attainment of Sustainability is attempted. The paper throws light on current schemes of CDW in Indian Scenario and what should be done for future for promoting sustainability through construction waste management among various stakeholders. The search of the literature using the keywords used are “SDG”, “Sustainable Development”,” Construction Waste”, “construction industry”, “Circular Economy” was done. The operator “AND” was utilised. There were no limits in the number of years, but the study paper is from 2020-2024 i.e., in the recent years only which further strengthens the need for the study. In the first run a total of 451 and 211 were identified in Scopus and Woos. The same key words were used in Google Scholar. After manual reading of title, abstracts and paper **48** peer reviewed journal were found in totality. The articles were further limited to Engineering, Environmental Science and Business Management and language was limited to English articles only. Thematic analysis of separate 20 papers were conducted. The paper indicates vital factors that effects the usage of CDW waste towards more Sustainability.

The major challenges which were identified are as below by various literature.

- Lack of enforcement regulation
- Heterogenous waste
- Nonawareness among stakeholders

- Laclk of confidence among buyers
- Temporal difference
- Location constraints
- Poor Economic Viability
- Policy Road Block

Heterogeneous waste- the nature of waste is so much diverse as wood, cement, and ceramics. In nature that segregation, Temporal difference India is a vast country geographically the waste produced at seashore is different from that at sub-zero temperature.Location constraints. It is difficult to collect the waste from already difficult terrain geographical sites. To attain profit minimum economies is required to generate profit. Nonawareness among stakeholders. The various clients as well as contractors are unaware about CDW recycled material to design in forward supply chain. Need for enforcement regulation there are week and nascent policies and no stringent rules in case of non-adherenceto CDW management rules. Policy roadblocks that existed. Extremely weak national laws on CDW, Lack of legal framework, inadequate buyer confidence in Delhi and Ahmedabad recycled plants. There is poor economic feasibility of recycled product as no tax relaxation

DATA AND METHODOLOGY

This is a qualitative study. It gathers and works with non-numeric data. The present study identifies paper during 10 years from 2013-2023 thatfocus on CDW factors, its relevance and way forward. A total of 20 papers were analysed using NVIVO software for thematic analysis. After that for individual factors, one with highest weightage were analysed and tabulated. An overall study of 30 papers abstract was also done to study the word map, cluster analysis, tree map

Analysis and findings:

The analysis done using NVIVO without any exclusivity on individual papers., the word cloud was generated (Fig 2)

Fig 2: word cloud frequently mentioned words

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Fig 4 shows the Tree Map of all research papers. The hierarch factors are waste in construction generated and the factors are proper management of waste, building materials reuse and policy establishment. This shall further affect the sustainability and energy generated. The recycling practices aids the sustainability. Again, research in the domain, aids the economic, development and building sustainability. The analysis of demolished material like cement, asphalt, steel, iron are some other important points.

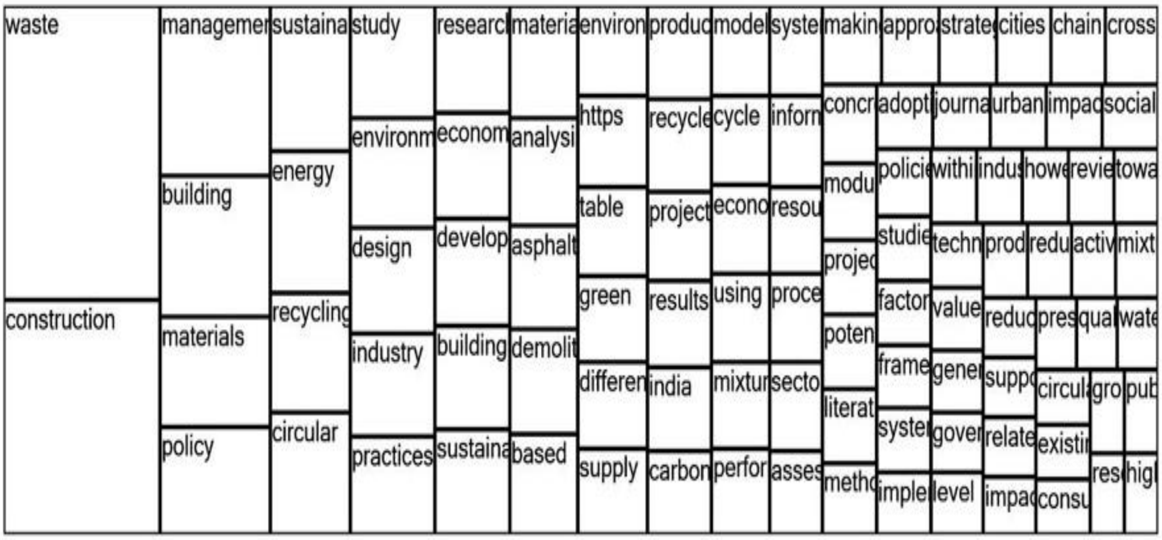

Fig 3: Tree Map of all Research papers showing the relationship of different factors

The percentage and weightage of different factors are in Fig 3 and Fig 4. As it is clearly visible the main attributes are Waste, sustainable, products, construction material, energy, building, management, use, industry, consumption, development, research, urban, concrete, strategies, systems, study, sector, innovation in decreasing order.

More than 2.5 %is of that construction waste produced. Sustainability factors are 2.25 % and sustainable products are 1.75 %. The material and energy generated is 1.4 %. The management of construction waste and green building performance are percentage above. The decreasing factors are effective use, construction industry.

Fig 4: Percentage factors of all research papers for codes generated. Fig 3 -Tree Map of all Research papers showing the relationship of different factors. The percentage and weightage of different factors are in Fig 3 and Fig 4.

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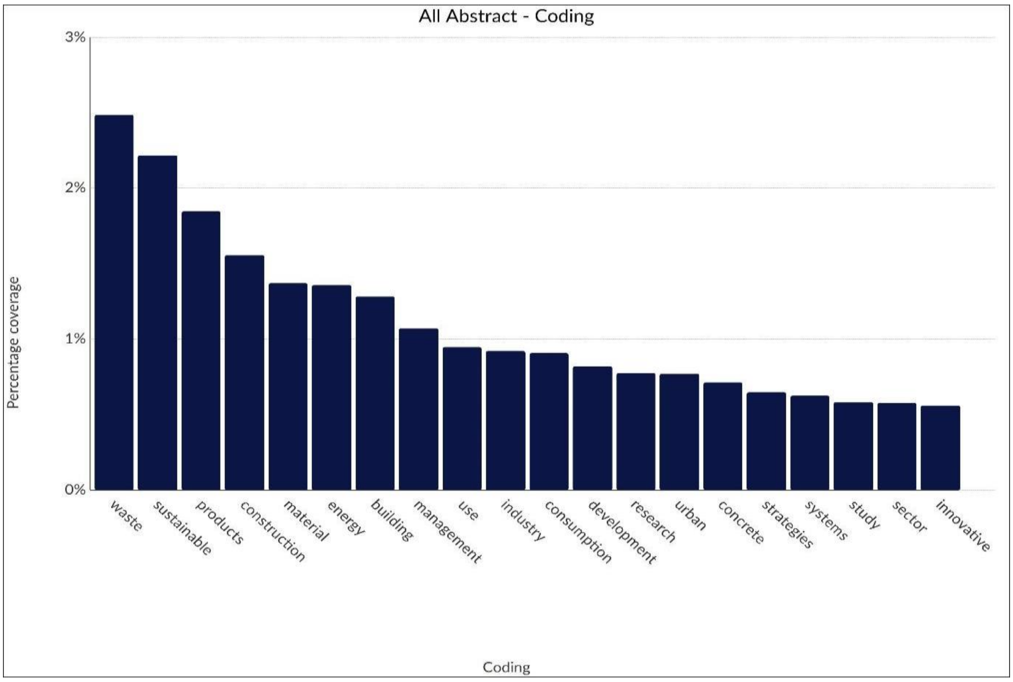

Fig 4: Percentage factors of all research papers for codes generated.

For the analysis of the paper the top 10 are considered waste, construction, management, building, material, policy, sustainable and energy are taken since they are the most frequently appearing word. These are then compared and analysed on the 20 papers.

Research studies conducted by shows that construction waste has 1.47 %, the construction practices account for 1.18 %, management perspective in various .60 %, building orientation and dynamics is impacting 0.5 % of the total weighted average of the attributes, the recycled material, correct policy implementation, sustainability of the product of the urban areas, the circular economy principles are all below .33%.

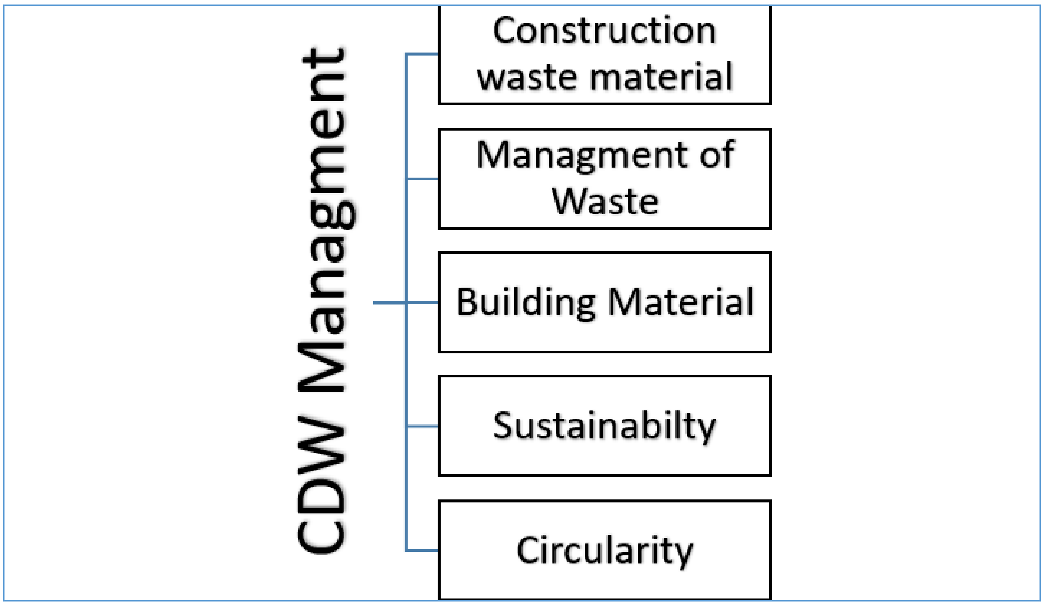

Fig 5: The themes identified under different papers were broadly classified into following categories

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Table 3: Thematic analysis based on Individual Papers

Paper No	Paper Title	Top 10 words based on the thematic coding	
1	The co-evolution of business models and public policies in transitions - A system dynamics perspective	waste	1.49
		construction	1.16
		management	0.62
		building	0.49
		policy	0.40
		materials	0.37
		recycling	0.33
		sustainable	0.33
		energy	0.33
		circular	0.31
2	Optimizing Energy Use, Cost and Carbon Emission through Building Information Modelling and a Sustainability Approach: A Case-Study of a Hospital Building	waste	1.52
		construction	1.17
		management	0.62
		building	0.49
		policy	0.38
		materials	0.37
		energy	0.33
		recycling	0.33
		sustainable	0.32
		circular	0.31
3	Understanding the relationship between institutional pressures, supply chain integration and the adoption of circular economy practices	waste	1.58
		construction	1.19
		management	0.64
		building	0.43
		policy	0.40
		materials	0.38
		recycling	0.34
		circular	0.32
		sustainable	0.30
		practices	0.28
4	Optimizing recycled asphalt mixtures with zeolite, cottonseed oil, and varied RAP content for enhanced performance and circular economy impact	waste	1.74
		construction	1.31
		management	0.67
		building	0.48
		policy	0.44
		materials	0.42
		recycling	0.37
		sustainable	0.31
		design	0.29
		energy	0.29
5	Demonstrating circular life cycle sustainability assessment – a case study of recycled carbon concrete	waste	2.16
		construction	1.61
		management	0.84
		building	0.59
		policy	0.55
		materials	0.45
		recycling	0.39
		sustainable	0.39
		energy	0.35
		design	0.34
6	SDG 11: Sustainable cities and communities in the Indian Context	waste	2.40
		construction	1.68
		management	0.84
		building	0.67
		materials	0.49
		energy	0.41
		sustainable	0.39
		design	0.39

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		recycling	0.37
		buildings	0.35
7	Attitude and behavioural factors in waste management in the construction industry of Malaysia	waste	2.50
		construction	1.73
		management	0.87
		building	0.53
		materials	0.50
		recycling	0.39
		sustainable	0.38
		design	0.37
		energy	0.37
		demolition	0.35
8	Waste effectiveness of the construction industry: Understanding the impediments and requisites for improvements	waste	2.28
		construction	1.71
		management	0.81
		building	0.56
		materials	0.53
		recycling	0.41
		sustainable	0.40
		energy	0.40
		demolition	0.36
		buildings	0.35
9	Global Housing Technology Challenge- India (GHTC-India): Government of India Ministry of Housing and Urban Affairs (MoHUA)	waste	2.47
		construction	1.41
		management	0.86
		materials	0.56
		building	0.55
		energy	0.43
		sustainable	0.43
		recycling	0.43
		demolition	0.39
		India	0.36
10	A recommendation system for energy saving and user engagement in existing buildings	waste	2.57
		construction	1.44
		management	0.88
		materials	0.57
		building	0.57
		energy	0.46
		sustainable	0.45
		recycling	0.43
		industry	0.35
		demolition	0.34
11	Maximising the construction waste reduction potential – how to overcome the barriers	waste	2.96
		construction	1.46
		management	1.00
		building	0.65
		materials	0.64
		recycling	0.49
		energy	0.49
		demolition	0.40
		design	0.38
		industry	0.37
12	Advantages and barriers of modular construction method in constructing buildings	waste	2.72
		construction	1.42
		management	0.81
		building	0.74
		materials	0.70
		energy	0.62
		design	0.41
		demolition	0.39
		recycling	0.37
		sustainable	0.37

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13	Construction and demolition waste generation in cities in India: an integrated approach	waste construction building materials energy management sustainable demolition economy circular	1.97 1.25 0.79 0.73 0.72 0.52 0.42 0.42 0.39 0.35
14	Construction Industry and Its Contributions to Achieving the SDGs Proposed by the UN: An Analysis of Sustainable Practices	waste construction building materials energy management demolition sustainable economy circular	2.06 1.23 0.81 0.76 0.76 0.54 0.44 0.43 0.40 0.37
15	Solid Waste Management in the Construction Sector: A Prerequisite for Achieving Sustainable Development Goals	energy building green buildings sustainable construction carbon design sustainability model	1.67 1.59 1.09 0.92 0.80 0.78 0.77 0.73 0.73 0.61
16	Conceptualising the Circular Economy Potential of Construction and Demolition Waste: An Integrative Literature Review	waste construction management building materials policy sustainable energy recycling circular	1.47 1.18 0.60 0.50 0.38 0.38 0.38 0.36 0.32 0.32
17	Economic, Environment & Legal analysis of Construction &Demolition (C&D) waste plant in North Goa: A comparative study of India with International experience	waste construction environment demolition management recycling table impact recycled recycle	3.33 1.35 0.92 0.86 0.86 0.86 0.71 0.69 0.61 0.58
18	Understanding the relationship between institutional pressures, supply chain integration and the adoption of circular economy practice	waste construction materials building demolition management definitions economy energy circular	2.52 1.32 0.97 0.68 0.59 0.58 0.52 0.50 0.49 0.46
19	Construction and Demolition waste, Centre for Science and Environment	waste construction	3.30 1.50

		materials	1.28
		demolition	0.78
		definitions	0.71
		management	0.70
		economy	0.68
		circular	0.62
		recycling	0.61
		material	0.51
20	Post occupancy evaluation for green school building	waste	1.47
		construction	1.18
		management	0.60
		building	0.50
		materials	0.38
		policy	0.38
		sustainable	0.38
		energy	0.36
		recycling	0.32
		circular	0.32

Table 4: The main themes are having different attribute as

Construction Industry	Management of waste	Building Material	Sustainability	Circularity
Construction Practices	Management practices	materials	Environment	Circular principle
Demolition	Waste management	building	Impact on humans	recycling
Green Building	Economic Viability	Industry	Study	Save Energy / Renewable Energy
Sector	Policy in place	Analysis	Practices	Research
Projects	Supply chain	Asphalt	Development	Model
Technology	Assessment	Modular	Carbon	Approach
Implementation	Strategies	Make	Cities	Journal
	Framework	Concrete	Urban	
	System		Social	
	Reduction			

By 2050, unparalleled progression because of inhabitants growth, urbanization will cause more pressure on natural resources. Construction is a vital phenomenon in the upcoming urban areas. 50-60% of global GHG emissions and 75% of global primary energy is consumed by the cities. (UNHabitat, 2018). Between 1980 and 2010, India's material intake has augmented by 200% making it the third-largest consumer of materials in the world. Indian stake is 7% of global material depletion. If the same trend continues India's segment of raw material requisites might reach up to 15 bn tons by 2030 and 25 bn tonnes by 2050 (GIZ, 2018).

The major stakeholders are CDW plant owners, government policies, Contractors, and project clients. As we have seen there are multiple challenges and blocks in the adoption of CDW management some of the solution for CDW management can be adhered to are:

(i) supervision of the market by local governments as in India Municipal Corporation,

(ii) Purchasing recycled products by contractors to be mandated by the government projects or by national international developers and producing high-quality products.

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(iii) Violation punishments are more than the extra cost of following implementation policies.

(iv) As in China, this can be done by subsidizing CDW recycling plants as land rent subsidy tax deduction, loan discounts (Taxation)

(v) Implementation of green building certificates for green building products and related award or reward

(vi) Quality and price of recycled product, adoption, and market growth is slow and slows down the development of the CDW market (Oyedele, 2014) therefore contractors are resistant to buying recycled product and go for virgin material. Only non-structural members such as recycled products are used. (viii) Regulatory mechanism Waste sorting and technical level shall have huge impact on the quality of recycled product ad needs extra cost from labor and machineries. As per CSE, India generates 150 m tonne of CDW every year, but the recycling capacity is only 1% i.e., 6500 tonnes / day. Also, out of the 53 cities that should have had CDW plant only 13 cities have till 2020. (Earth, 2020) The largest CDW is upcoming in Delhi at Jahangir Puri with a capacity 2000 Mt/ day (ET, 2023)

IMPLICATIONS

The study shall donate to the current perception of the behavior, necessity, and collaboration of various stakeholders in the CDW recycling market and provide important management, organization and implications to promote the CDW recycling practice to enhance sustainability. One of the practical implication is to seek the attention of likeminded industrial experts and small and big business owners in the private sector and public authorities and to add value CDW plant. The social implication is better CDW plant management that shall boost the sustainability of the overall built environment this creating positive impact on society.

CONCLUSION

In meeting the socio-economic needs of individual, society and nation construction projects create air, water, noise and land pollution (Hendrickson, 2000) In addition, the construction industry also devours substantial amount of energy and natural resources (Ding, 2018.) greatly challenging the SDG. To reduce and eliminate the amount of humungous unwanted CDW dumbed, CE is the solution to enhance Sustainability. The CE framework of material recovery, recycling, processing. The literature review and recent studies shows the challenges, limitations, feasibility, and usability of CDW. The integrated literature review and secondary sources advocates the use of CE which is not happening due to various challenges and is a two-dimensional loss. The in-depth summarizes three main barriers to CE adoption: high CE costs, Failure to meet local market demands, and users low awareness of CE.

Not at all like green structure and metropolitan restoration issues, which have been controlled by government mediations and expected to be remembered for the building regulations, the job and situating of CDW the board and CE is marginally muddled. Opportune change of modern approaches and mitigation of the organization's monetary strain will be significant targets for the execution later on. Second, there is a general absence of consciousness of CE among the partners as open, project individuals, and clients. (Pei-Hsuan Lee a, 2023)

Footnote

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