

Analysis of Construction Waste Management in Rural and Urban Areas Based on C&D Waste Management Plan

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Abstract

This study presents an analysis of proposed environmental management plan (EMP) for construction waste management (CWM) in India. It gives the environmental effect analysis due to gradual increase in the rate of construction and waste generation. LCT plays a role in proper selection of materials and their efficient use dividing based on LCA and LCC, and it goes with the behavioural analysis of contractors and workers in the site. The EMP defines actions and activities for different phases and pinpoints the methods and procedures across the entire building process. Finally, it is applied to two groups of case studies showing the difference between CWM practices for Low budget buildings and High budget buildings. The outcome shows how the proposed plan can present a novel approach integrating environmental management and best practices for CWM. This shall facilitate complying with National standards and building rating systems for achieving environmental stewardships using waste management rules 2016 by Ministry of Environment Forest and Climate Change (MoEF&CC).

Keywords: Construction Waste Management; Environmental Management Plan; Life Cycle Costing; Life Cycle Thinking; Waste Management Hierarchy.

1. Introduction

When designing a building project, it is critical to identify what extra materials are likely to be generated and then focus on how those excess materials might be avoided or diverted from landfill. One strategy is to create a construction waste management plan. The primary goals of any construction waste management plan should be:

1. Reduce the amount of garbage generated because of the project.
2. Increase the amount of material delivered to reuse, recycling, or reprocessing.
3. Reduce the amount of waste delivered to landfills.

C&D trash is rapidly becoming one of India's major solid waste sources. Metal, concrete, mortar, brick and block, timber, and plastic are the most common types of C&D trash [1]. Because construction activities consume many natural resources, materials, and energy [2]. C&D waste is commonly recognized as being environmentally hazardous. Construction waste

(CW), renovation waste (RW), and demolition waste (DW) are the three categories into which C&D trash can be separated based on the phase of its generation. Numerous variables, including the degree of urban economic development and the scope of urban construction, influence the amount of construction and demolition debris produced [3]. As India comes under developing country, it needs more construction activities to satisfy the various living demands of people and requires the corresponding infrastructure to accompany its rapid economic development, urbanization and rising standards of living. However, enormous quantities of C&D waste are currently disposed of in India through simple landfilling or dumping, creating significant threats to regional ecological stability and sustainable growth [4]. Generation rate calculation method (GRC). This methodology has got a wide utilization in previous studies because it can be implied to estimate waste from all activities at both regional and project levels.

The fundamental of this methodology is to date [6]. First, they occupy large areas of land, which is already scared during a rapid urbanization process. Second, while most construction materials are inert, buildings may have used some materials which would absorb harmful elements [5]. Third, the massive volume of dumped C&D waste may result in safety hazards such as landslide [7]. It has been acknowledged that proper quantification of C&D waste is of great importance for establishing an effective management system at both project level and regional level [8]. Quantification at project level refers to forecast the C&D waste production in a particular project. Quantification at regional level refers to estimate the total C&D generation of all projects in a specified region [11-13].

1.1 Schemes and Regulations

1.1.1 Laws and Policies Framed in India Related to Pollution

- a) **Swachh Bharat mission (SBM):** A mission with the motto of “Clean India” initiated by the Ministry of Housing & Urban Affairs (MoHUA) in 2014. SBM is an India-wide campaign initiated by the Indian government in 2014 to manage wastes originating from domestic and C & D [13].
- b) **Target of the mission:** Planning of “deconstruction” activity, establishment of byelaws are included in the mission. Moreover, based on its importance the SBM doubled the awardable points to 100 [15].
- c) **Guidelines on environmental management of construction & demolition (C & D) wastes:** The central pollution and control board (CPCB) issued new rules that were published on 29th March 2016 by the Ministry of Environment, Forest, and Climate Change (MoEF & CC). Construction projects producing more than 20 tons of C & D waste in a day or 300 tons in a month need to draft and submit the site waste-management plan (SWMP) to the local authorities [16].
- d) **Guidelines for Sustainable Habitats (GSH):** The central public works department (CPWD) published a study titled "Guidelines on re-use of recycled C & D garbage" in 2014. The rules cover CDW recycling techniques and precautions, as well as the importance of deconstruction strategies. There is guidance provided for recovering valuable goods that can be reused without additional

processing. [17].

- e) **Bureau of Indian Standards (BIS):** The BIS oversees providing specifications and codes for recycled items. The amended IS:383(2016) specifies a 25% replacement with recycled aggregate in PCC, 20% in RCC, and 100% in lean concrete. [17].

1.2 Research Significance

CWM is regarded as a major environmental concern because it accounts for most of the municipal solid trash. Furthermore, garbage collection services are frequently inefficient and insufficient, onsite storage is inadequate, and collected waste is typically discharged to the nearest landfill. This makes it a growing issue with serious consequences for the environment and public health. As a result, it is critical to reduce municipalsolid waste throughout the earliest project phases by encouraging C&D waste reduction measures. Nevertheless, complying with and enforcing current standards is difficult when no tools are available. As a result, this study fills a knowledge gap by developing a proposed EMP for CWM. The proposed technique is designed to provide knowledge for applying LCT (Life cycle thinking) in accordance with the idea of avoided impact of material amounts.

2. Literature Review

Different literatures are collected and analysed to know the proper cause and situation of construction waste generation throw-out the world and our country and managed to know different strategies which were involved in reduction of waste. CWM strategies vary in different countries depending on the existing potentials and challenges of the construction industry and the local market. Nevertheless, many developing countries lack the financial and technological means to appropriately manage C&D waste, which may be to blame for the dearth of studies in this field [4,9,10].

2.1 An Environmental Management Plan for Construction Waste Management

Published on: March 2023, by Walaa S.E. Ismaeel, Nada Kassim.

First review on Egypt documentation which is based on implementing construction waste management using method of division of analysis based on EMP. If the project is following environmental management plan, how it helps to reduce waste and its effectiveness in maintaining sustainability in construction. If the

project did not follow the environmental management plan, where does the waste is disposing and how it can be reduced with other methods of reduction. In Egypt, CWM is considered a primary environmental concern because it accounts for about half of all municipal solid waste [14]

2.2 Environmental Management of Construction and Demolition Waste in Kuwait

Published on : December 2004, by Nayef Al-Mutairi.

Second review on Kuwait documentation which is based on construction and demolition [C&D] waste management. This paper presents the status of C&D waste disposal system in Kuwait and identifies the potential problems to the environment, people, and economy. It investigates alternative solutions to manage and control this major type of waste in an economically efficient and environmentally safe manner. Next, the paper describes the feasibility of establishing a C&D waste recycling facility in Kuwait. It concludes by highlighting the major benefits and bottleneck problems with such a recycling facility [19]

2.3 Implementing Construction Waste Management in India: An Extended Theory of Planned Behaviour Approach

Published on: February 2022, by Swarna Swetha K., Tezeswi T.P., Siva Kumar M.V.N.

Third review on Indian documentation, it investigates the workforce motivators for implementing construction waste management (CWM) in India. A theoretical model based on theory of planned behavior (TPB) is fundamentally structured by including constructs like knowledge and perceived utility. The analysis results conclude, perceived behaviour control is consistently crucial construct for predicting

behaviour intention in comparison with attitude and subjective norm [17].

2.4 Construction and Demolition Waste Management in China Through The 3R MARK Principle

Published on: September 2017, by (B. Huang).

In fourth review on China documentation, a literature review and personal interviews were conducted to analyze the current barriers to CDW management. Three groups of stakeholders most relevant to the CDW industry were interviewed; they were (1) scholars/researchers (11 persons); (2) operators from building design (5 persons), construction (5 persons) and demolition companies (9 persons); and (3) CDW treatment/recycling companies (10 persons). These interviewees were selected based on the availability and their familiarity with the CDW industry [18].

3. Methodology and Approaches

The latest data on construction and demolition waste generation of several ongoing projects in local vicinity were collected through a set of questionnaires from different governmental and private organizations [19]. It is extremely complex to quantify the C & D waste that is being generated in India. Currently in India the C & D waste which is being generated onsite is cleared with the help of local vendors (LV) (Figure 1). The LV, charge a nominal amount to clear the site and the LV intern trade the material to the individual in need. Thus, the existing scenario, makes the recycling targets, processing, and quantification estimations of CW tougher. As part our research we went through some project in the part our methodology to collect real time responses from project executers about construction waste generation and its reduction strategies followed by them in sense of reducing environmental impact.



Figure 1 Describes the Methodology

3.1. Survey Approach

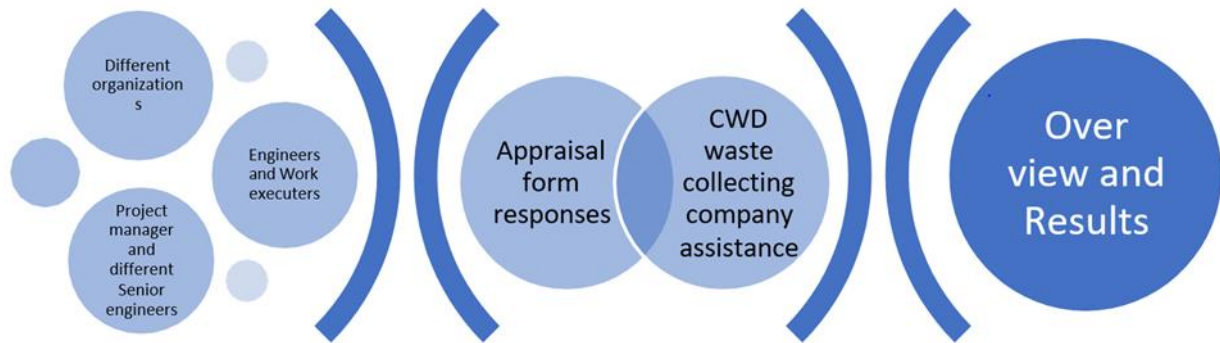


Figure 2 Describes Stages of Survey

The described ideas are considered for elaborating the survey questionnaire and interpreting the results (Figure 2). It is vital to collect feedback from many stakeholders before implementing or improving CDW management programs. These stakeholders have various levels of jurisdiction (regional, local, and construction site), and they can be from the

public or private sector, regulators, project management teams, construction companies, managers or resident engineers, or CDW collection companies (Hyderabad); all of these stakeholders were included in the questionnaire and consulted during this research (Table 1 & 2).

4. Data Collection

4.1 Examples of Selecting Projects & Survey About Project

Table 1 Survey Projects & Their Details

| PROJECTS | COMPANY NAME | TYPE OF CONSTRUCTION | DURATION OF PROJECT | COST OF PROJECT | CONSTRUCTION WASTE GENERATION (%) |
|---------------------------------|--------------------------------------|----------------------|---------------------|-----------------|--|
| Lecture Hall | JCR Engineering & Infra | New project | 12 Months | 13 Cr. | Steel – 10% Concrete and dead mortar-12% Brick bats - 2% |
| Skill Development Building | JCR Engineering & Infra | New project | 9 Months | 7 Cr. | Steel-3% Concrete and dead mortar - 5% Brick bats – 2% |
| City Centrum of Pulivendula | KPC Projects Ltd. | New project | 18 Months | 87 Cr. | Steel- 4% Concrete and dead mortar- 5% Brick bats- 5% |
| YSR Medical College Pulivendula | DEC Infrastructure (India) Pvt. Ltd. | New Project | 30 Months | 369 Cr. | Steel- 10% Concrete and dead mortar- 5% Brick bats- 6% |
| Gurukulam | Rayalaseema constructions | New Project | 12 Months | 40 Cr | Steel-5% Concrete & Dead mortar- 4% Brick bats- 6% |

4.2 Relative Important Index

Table 2 Relative Index

| S.no | Statements | Agree | Partially agree | Partially disagree | Disagree | Total | Total number(N) | *N | II | Ranks |
|------|---|-------|-----------------|--------------------|----------|-------|-----------------|-----|------|-------|
| 1. | Construction waste causes land pollution. | 0 | 39 | 8 | 1 | 8 | 25 | 100 | 0.68 | 5 |
| 2. | Dumping of construction waste causes changes in properties of landfill areas. | 4 | 9 | 20 | 1 | 4 | 25 | 100 | 0.74 | 4 |
| 3. | Local projects don't consider environmental consequences | 2 | 36 | 18 | 2 | 8 | 25 | 100 | 0.68 | 5 |
| 4. | All the projects follow construction waste management plan. | 4 | 18 | 16 | 4 | 2 | 25 | 100 | 0.62 | 7 |
| 5. | All the projects don't follow construction waste management plan. | 2 | 12 | 18 | 7 | 9 | 25 | 100 | 0.49 | 9 |
| 6. | Construction waste increases with the time and causes drastic effects on environment. | 6 | 21 | 4 | 1 | 2 | 25 | 100 | 0.82 | 3 |
| 7. | Construction and demolition waste (CDW) has become the major environmental problem. | 0 | 18 | 26 | 1 | 5 | 25 | 100 | 0.65 | 6 |
| 8. | All the materials of construction waste can be recycled. | 4 | 45 | 6 | 6 | 1 | 25 | 100 | 0.61 | 8 |
| 9. | Maximize the efficient use of resources while minimizing the wastage. | 4 | 0 | 6 | 0 | 0 | 25 | 100 | 0.90 | 2 |
| 10. | The most effective environmental solution may often be to reduce the generation of waste. | 4 | 0 | 6 | 1 | 1 | 25 | 100 | 0.91 | 1 |

4.3 In Urban CW&D Waste Managing Units

4.3.1 Their IEC Activities

One Zonal in charge, along with 15 Field Officers assigned to each circle and a dedicated Command ControlCentre, have been established to streamline operations. Raising awareness about C&D waste services involved distributing pamphlets and stickers door-to- door for each (Refer Figure 3 & 4)

household within the respective circles. Additionally, a toll-free number has been promoted across various platforms such as Twitter, Facebook, Instagram, etc. Letters have been dispatched to builders and building demolition contractors to inform them about thenewly introduced C&D waste services (Table 3 & 4).

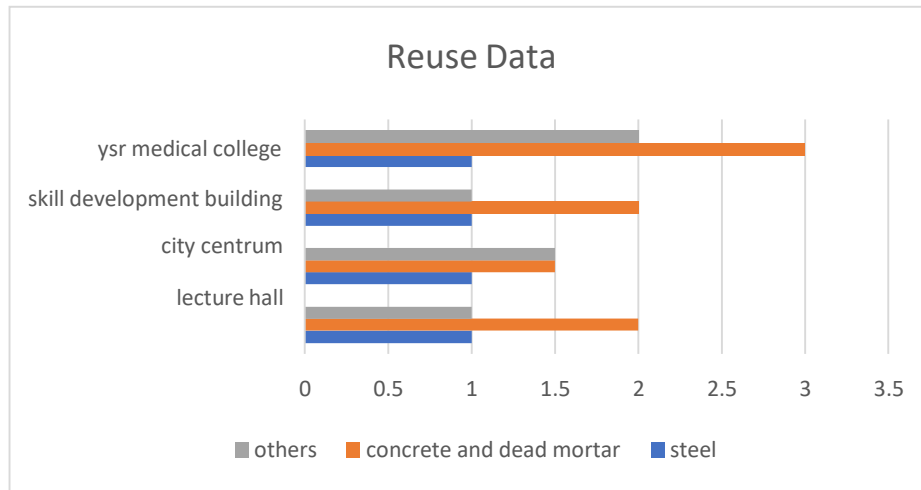


Figure 3 C&D Waste Processing Plant

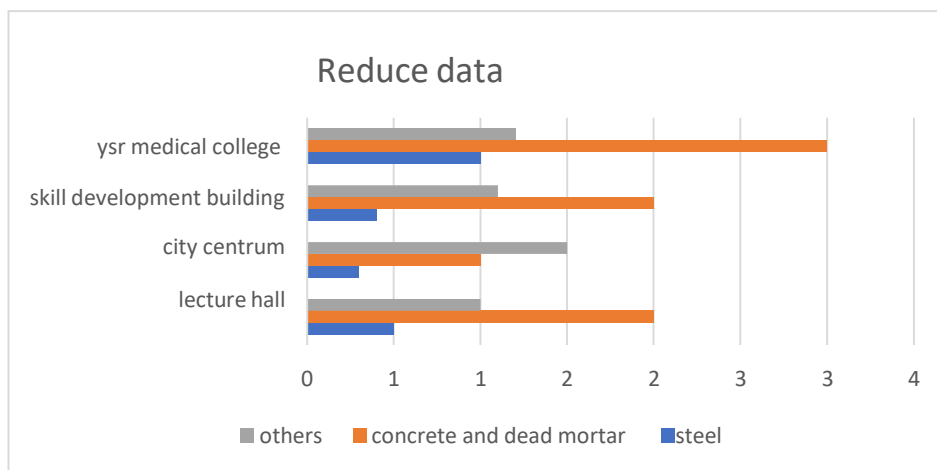


Figure 4 Sand & Aggregates Prepared from C&D Waste

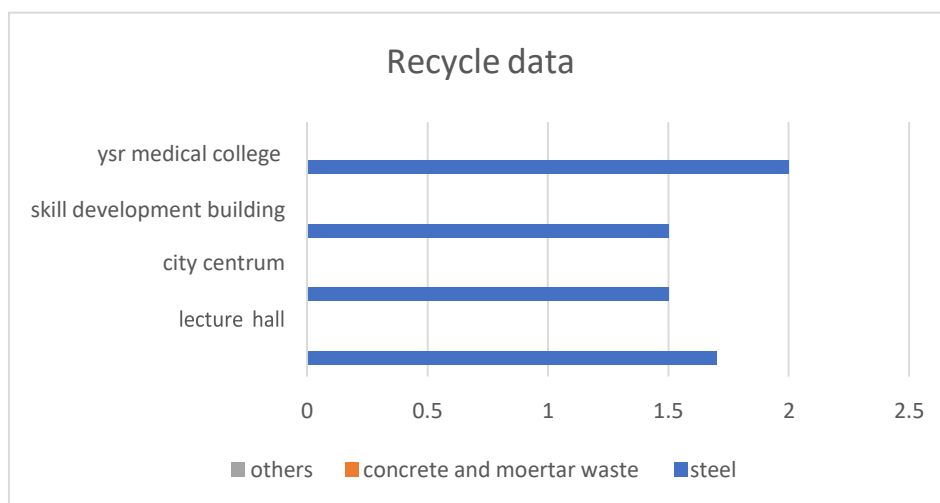
4.4 Graphic Representation of 3R Conditions in Rural Areas Without C&D Waste Processing Unit



Graph 1 Describes the Re-Use Data of the Survey Projects



Graph 2 Describes the Reduce Data of the Survey Projects



Graph 3 Describes the Recycle Data of the Survey Projects



Figure 5 Y.S.R. medical college Pulivendula



Figure 6 Lecture Hall, JNTUACEP



Figure 7 City Centrum, Pulivendula

5. Results & Discussions

5.1. Waste Reduction Strategies

Most of the literatures studied in this study emphasized the importance of waste management in

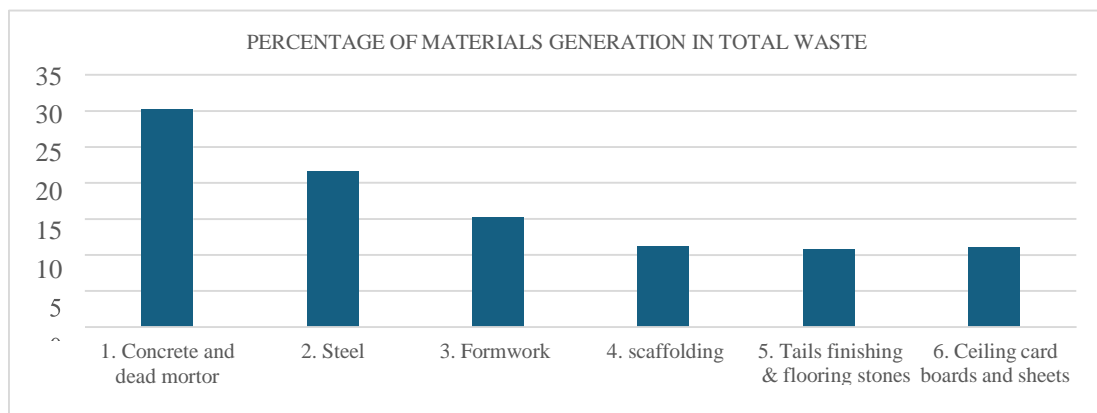
sustainable construction [4]. In most cases, produced waste is reduced in the earliest stage through source and material quality control (Figures 5 to 7). Later, the debris generated during construction was used as filler material in ramps and stages. As the total budget of the construction increases, CW is normally lowered, thus they were employing the created waste if it was possible to some works like brick bats for subterranean sumps and soak pits. In most circumstances, recycling methodology is not implemented in rural areas because the factories are too far away, putting a strain on the budget for transportation, but only in the case of steel are they sent to scrap. Therefore, the most practical approach to minimizing the effect of waste on the environment is to prevent generating waste [10,11,12]. Compared the CWM of the four projects across different project phases following the proposed EMP. The data were obtained based on the project's documentation and team members' assistance. Further, the EOL (End of Life) scenarios were assumed based on the project's team members' expectations. For those answering with 'No', survey participants indicated that C&D waste was often handled by a waste collector who was hired by the contractor to remove the waste from the construction site. Waste haulers usually adopted a range of disposal techniques, disregarding their long-term environmental impact, and landfilling was perceived as the least expensive option. Also, the waste reduction strategies were seldom considered during early project phases, and they were later considered in the construction stage. They added that tracking the quantities of C&D waste was performed in the form of weight or volume without considering their environmental impact. Additionally, specifying and procuring.

Conclusion

Based on the above survey reports we can see that there is less amount of waste generating in the projects which follows environmental management plan (CWMP). If the amount of waste generates more than limits the project will suffer economical problem and environmental pollution. That's why they follow environmental waste management plan in stages to reduce waste generation during construction. Results are shown in Graph's 1 to 5.

Table 3 Survey Results on Major Sources of Waste

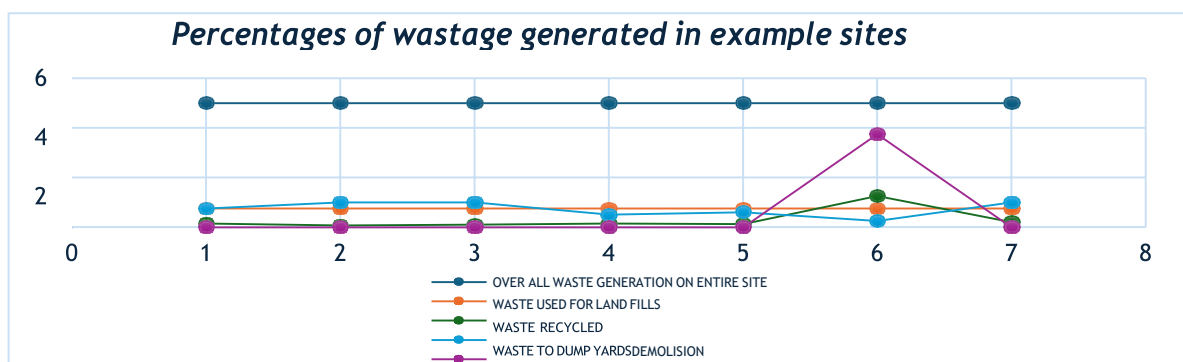
| S.No. | Materials | Percentage of Materials Generation in Total Waste |
|-------|-----------------------------------|---|
| 1 | Concrete and dead mortar | 30.25% |
| 2 | Steel | 21.55% |
| 3 | Formwork | 15.25% |
| 4 | Scaffolding | 11.22% |
| 5 | Tails finishing & flooring stones | 10.75% |
| 6 | Ceiling card boards and sheets | 10.98% |



Graph 4 Percentage of Materials Generation in Total Waste

Table 4 Waste is Generated in Different Ways According to the Survey

| Projects | Overall Waste Generation On EntireSite | Waste used for land fills | Waste recycled | Waste to dump yards | Demolition waste |
|------------------------|--|---------------------------|----------------|---------------------|------------------|
| Y.S.R medical college | 5 | 0.75 | 0.15 | 0.75 | 0 |
| City centrum | 5 | 0.75 | 0.075 | 1 | 0 |
| Lecture hall | 5 | 0.75 | 0.1 | 1 | 0 |
| Skill development hall | 5 | 0.75 | 0.15 | 0.5 | 0 |
| Gurukulam | 5 | 0.75 | 0.125 | 0.6 | 0 |
| GHMC waste management | 5 | 0.75 | 1.25 | 0.25 | 3.75 |
| Kvm constructions | 5 | 0.75 | 0.2 | 1 | 0 |



Graph 5 Percentages of Wastage Generated in Example Sites

After all the discussions we had with the authorities on sites we conclude that Construction and waste generation are influenced by a multiple factor.

1. Scale of the Project

The scale of a construction project plays a crucial role in determining the volume of materials used and the complexity of construction activities. Larger projects inherently involve higher material volumes and more intricate processes, resulting in increased waste generation. This is due to the need for more extensive excavation, structural work, and finishing, which collectively contribute to a larger waste footprint.

2. Contractor Profit Margins

The profit margins of contractors significantly influence waste management practices on construction sites. When profit margins are tight, contractors may prioritize speed and cost-efficiency over waste reduction measures. This can lead to practices that generate more waste, such as over-ordering materials to ensure project deadlines are met or opting for cheaper but less sustainable construction methods.

3. Construction Methods and Technologies

The choice of construction methods and technologies can greatly impact waste generation. Modern construction techniques offer opportunities to minimize waste through efficient material and process utilization. For instance, prefabrication and modular construction methods can reduce material waste by optimizing cutting and assembly processes. Similarly, advancements in technology, such as Building Information Modelling (BIM), enable better material management and coordination, further reducing waste.

4. Material Selection

Material selection is a critical factor influencing waste generation. Certain materials are more recyclable or reusable than others, directly affecting the overall waste footprint of a project. Additionally, using materials with higher durability and longevity can reduce the need for frequent replacements, thus decreasing waste generation over the project's lifecycle.

5. Compliance with Regulations and Policies

Compliance with regulations and policies, including government mandates and industry standards, shapes waste management practices in the construction sector. Adherence to waste disposal regulations and environmental guidelines ensures proper handling and

disposal of construction waste, minimizing environmental impact and promoting sustainability.

6. Labor Efficiency

Labor efficiency is essential for minimizing waste on construction sites. Skilled labour and efficient project management contribute to waste reduction by ensuring proper handling and installation of materials. By reducing errors and material wastage, efficient labour practices play a significant role in mitigating unnecessary waste generation.

7. Client Preferences and Requirements

Client preferences and requirements can indirectly influence waste generation by impacting design choices and construction methods. Clients may prioritize certain materials or construction techniques based on aesthetic preferences, functionality, or sustainability goals, all of which can influence the amount and type of waste generated during the construction process.

8. Site Conditions

Site conditions, including factors such as location, accessibility, and environmental considerations, have a significant impact on waste generation and management practices during construction. Adverse site conditions, such as limited space or difficult terrain, may necessitate additional waste management measures to ensure safe and efficient waste handling. Furthermore, environmentally sensitive sites may require stricter adherence to sustainable construction practices to minimize ecological impact, thereby influencing waste generation levels.

Annexure – 1

Questionnaire and Responses

Appraisal form

Does the construction company apply CWM plan?

If yes...

- When is the plan was set?
 - Planning stage
 - Construction stage
- Which project phases integrate this plan?
 - Initiation
 - Construction
 - Design
 - Operating and maintenance
 - End of life
- Who is responsible for setting and implementing the plan?
 - Design team
 - Construction team
 - Contractor
 - Quantity-control
 - Project management
- Does the plan specify diversion rates?

Yes No

5. Does the plan specify diversion targets?
Yes No
6. How much amount of waste is recycled?
a) 0 – 15% b) 15 – 30% c) 30 – 50%
7. Does the plan consider...
a) Environmental plan b) Economical c) Both
8. Does the plan consider life cycle thinking, such as LCA or LCC of materials?
LCC (Life Cycle Costing)
Yes No
LCA (Life Cycle Assessment)
Yes No
9. How much amount of construction waste is generating approximately?
a) < Five percent of project b) 5 – 10% of project c) >10% of project
10. How much amount of construction waste is disposed to landfills?
a) 0 – 15% of total waste b) 15 – 30% c) 30 – 50% d) Above 50
11. Is there any demolition waste before construction? If yes, what is the amount of demolition waste?
a) 0 – 15% of total waste b) 15 – 30% c) 30– 50% d) Nil
12. Is there any material separation method followed to dispose demolition/construction waste? _____

- a) On site sorting b) Manually c) Mechanically
d) Another Methods
13. What are the approximate methods in the field to estimate waste based on plinth area? _____
a) Plinth area method b) Grade of material
c) Any other method

Does the construction company apply a CWM plan?
If no...

- Who manages managing construction waste?
a) Planning team b) Site in charge c) Contractor
- How is construction waste managed?
a) By using 3R's b) By following EMP
- Is there a system functioning to divert construction waste?
Yes No
- Is waste reduction taken into consideration during design, material specification, procurement, and construction?
Yes No
- Is there a system in place to track the amount of construction waste generated?
Yes No
- Where does the waste is disposed?
a) Dump yards b) Landfills c) Open areas
- How much amount of construction waste is disposed to landfills? _____

Annexure - 2

| S.No. | Statements | Agree | Disagree | Partially Agree | Partially Disagree |
|-------|---|-------|----------|-----------------|--------------------|
| 1. | Construction waste causes landpollution. | | | | |
| 2. | Dumping of construction wastecauses changes in properties of landfill areas | | | | |
| 3. | Local projects don't consider environmental consequences. | | | | |
| 4. | All the projects follow constructionwaste management plan | | | | |
| 5. | All the projects don't follow construction waste managementplan. | | | | |
| 6. | Construction waste increases withthe time and causes drastic effects on environment. | | | | |
| 7. | Construction and demolition waste(CDW) has become the major environmental problem. | | | | |
| 8. | All the materials of constructionwaste can be recycled. | | | | |
| 9. | Maximize the efficient use of resources while minimizing the wastage. | | | | |
| 10. | The most effective environmental solution may often be to reduce the generation of waste. | | | | |

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