CIVIL ENGINEERING (SUSTAINABILITY DEVELOPMENT)

Assessment of Construction Waste Generation and Resource Efficiency in Selected Infrastructure and Building Projects: An Empirical Case Study

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Published November 2026

Abstract

Construction and demolition waste reduces material productivity, consumes landfill capacity and represents a loss of resources when avoidable material losses are not controlled. This study assesses construction-waste generation and related resource-efficiency practices across five selected building and infrastructure projects associated with Shapoorji Pallonji and Company Private Limited (SPCPL). A descriptive case-study approach was adopted using project waste records, site observations and documented waste-management practices. Five material streams were examined: concrete/ready-mix concrete (RMC), reinforcement steel, autoclaved aerated concrete (AAC) blocks, mixed construction and demolition (C&D) waste, and bricks. The recorded average percentages were 2.04%, 2.91%, 4.25%, 2.34% and 6.14%, respectively. Bricks and AAC blocks showed the highest recorded averages, while project-wise results varied across all material categories. The study also considers material planning, storage, source segregation, reuse, recycling, 5S-based workplace organization, Just-in-Time practices and source-level controls. The findings support material-specific waste prevention rather than reliance on a single project-wide waste indicator. However, the original measurement denominators and reporting periods are not consistently established in the available records; therefore, the percentages are treated as reported descriptive values and are not aggregated or interpreted as fully standardized performance rates. Practical measures are proposed to strengthen project-level resource efficiency.

Keywords: AAC blocks; construction and demolition waste; construction waste management; resource efficiency; sustainable construction

1 Introduction

Construction activity relies on substantial quantities of concrete, reinforcement steel, masonry units and other materials. Losses can occur at several stages, including estimation, procurement, delivery, unloading, storage, cutting, fabrication, installation and finishing. These losses increase demand for virgin materials and create additional handling, transportation and disposal requirements. Construction and demolition (C&D) waste management is therefore not only a housekeeping or disposal issue; it is also a resource-efficiency and project-control concern.

The waste hierarchy places prevention and reduction ahead of reuse, recycling, recovery and disposal. Research has identified design decisions, procurement planning, material handling and site practices as important influences on construction waste generation [1], [2]. Studies also highlight the need to understand the causes and management routes of waste rather than focusing only on its final disposal [3], [4].

In practice, construction projects may report waste using different units and denominators. Concrete may be recorded by volume, steel and mixed C&D waste by mass, and masonry units by number. These measures cannot be added or compared directly without a consistent measurement basis. Material-specific monitoring is consequently important for identifying waste streams requiring further investigation.

This paper examines the recorded construction-waste profile of five selected projects and considers the operational practices documented in the underlying research. It focuses on concrete/RMC, reinforcement steel, AAC blocks, mixed C&D waste and bricks. The paper's contribution is a project-level descriptive comparison linked to practical material-management controls. It does not claim to establish causal relationships between individual practices and the recorded percentages.

2 Objectives and scope

The study has four objectives: (i) to examine recorded waste percentages for five material categories across five selected projects; (ii) to identify the project-wise range and material-wise pattern; (iii) to review documented practices relating to planning, storage, segregation, reuse and source control; and (iv) to propose practical actions for reducing avoidable material losses and improving resource efficiency.

The assessment covers Atrium Place, Gurugram; MSIL, Sonipat; LEH Airport; Joyville, Gurugram; and Trump Tower, Gurugram. The results are specific to these selected project records and should not be generalized to the wider construction sector.

3 Research methodology

3.1 Research design and case selection

A descriptive and analytical case-study design was adopted. Five projects associated with Shapoorji Pallonji and Company Private Limited were selected because project-level construction-waste information and related management records were available for the study. The projects represent selected building and infrastructure contexts; the paper does not treat them as a statistically representative sample of all projects.

3.2 Data sources and collection

The research draws on project waste-generation records, site surveys, direct observations, waste logs, available weighing and recording arrangements, project documentation and observations of waste-management practices. The source methodology describes recording and classifying waste by material category, identifying management routes such as reuse, recycling, recovery or disposal, and comparing the available project information. The underlying records identify concrete/RMC with concreting activities, steel with reinforcement work, AAC blocks with masonry/blockwork, mixed C&D waste with various construction activities, and bricks with masonry, demolition and salvage activities.

3.3 Material categories and measurement

Five waste streams were included: concrete/RMC, steel/reinforcement, AAC blocks, mixed C&D waste and bricks. The underlying research framework identifies different original measurement units for

these streams, including cubic metres, metric tonnes and number of units. The project comparison table available for this paper reports percentages. Because the original denominator and reporting period are not consistently established in the consolidated records, the percentages are reproduced as supplied and treated as descriptive values only.

3.4 Analytical procedure and data limitations

The analysis compares each material category across the five projects and calculates the reported average and observed minimum-to-maximum range. The averages are reproduced from the research dataset. Percentages across different material categories are not added, and no composite project waste rate is calculated. The available dataset does not isolate project type, construction stage, procurement method, material specification, design decisions or record completeness as explanatory variables. Consequently, observed differences are not attributed to a particular cause without supporting evidence.

4 Results and discussion

4.1 Project-wise construction-waste profile

Table 1 presents the recorded percentages for the five material categories across the selected projects. Variation is visible within each category. The table should be read horizontally within each material stream; values from different material columns should not be added because their measurement bases may differ.

Table 1. Recorded construction-waste percentages across selected projects.

Project	RMC (%)	Steel (%)	AAC (%)	Mixed C&D (%)	Bricks (%)
Atrium Place	2.70	1.89	4.68	2.06	6.90
MSIL	1.67	2.45	3.75	4.08	5.25
LEH Airport	1.03	2.13	2.05	2.01	4.15
Joyville	1.42	3.26	4.28	1.89	7.60
Trump Tower	3.38	4.82	6.51	1.67	6.80
Average	2.04	2.91	4.25	2.34	6.14

Source: Compiled by the researcher from project-waste-generation records. RMC = ready-mix concrete; AAC = autoclaved aerated concrete; C&D = construction and demolition. Values are reproduced as reported; source denominators and reporting periods require confirmation.

4.2 Material-wise variation

Concrete/RMC waste ranged from 1.03% at LEH Airport to 3.38% at Trump Tower. This spread indicates that concrete-related losses warrant project-specific review of quantity estimation, ordering, delivery, placement and recovery arrangements. Project records also identify concrete-pump hopper tray arrangements as a source-level control intended to contain spillage. The available evidence does not quantify the reduction attributable to this measure.

Steel/reinforcement waste ranged from 1.89% at Atrium Place to 4.82% at Trump Tower. The Steel scraps are a recoverable material stream; organized collection, segregation and storage can preserve its recovery value and prevent mixing with the general wastes. Reinforcement detailing, cutting

optimization, fabrication planning and inventory control are relevant areas for project-level investigation, but the dataset does not establish which factor explains the observed differences.

AAC block waste ranged from 2.05% at LEH Airport to 6.51% at Trump Tower. Recorded variation highlighting the importance of accurate quantity take-off, suitable storage, careful unloading and handling, planned cutting and reuse of usable off-cuts where technically gets appropriate. Brick waste ranged from 4.15% at LEH Airport to 7.60% at Joyville and had the highest recorded average of the five categories (6.14%). The research records identify reuse of suitable salvaged bricks for minor repair and patching works as an existing practice.

Mixed C&D waste ranged from 1.67% at Trump Tower to 4.08% at MSIL, Sonipat. Mixed waste can reduce the potential for material recovery when recyclable streams become contaminated. Source segregation, clearly identified collection points and controlled transfer to authorised recovery or disposal routes are therefore important. The recorded average values rank bricks highest (6.14%), followed by AAC blocks (4.25%), steel/reinforcement (2.91%), mixed C&D waste (2.34%) and concrete/RMC (2.04%). This is a descriptive ranking of the supplied percentages, not a ranking of environmental impact, financial loss or overall project performance.

4.3 Operational practices and resource efficiency

The project records describe several practices relevant to construction-waste prevention and resource efficiency. 5S-based workplace organization supports orderly storage, identification, housekeeping and segregation. Just-in-Time (JIT) principles can support planned material delivery and reduce unnecessary accumulation, handling and deterioration. These practices are useful management approaches, although the available study data do not provide before-and-after measurements to quantify their individual effectiveness.

Material-specific controls are also required. For concrete or Ready Mixed Concrete (RMC), suitable pumps hopper trays and controlled discharge arrangement can prevent spillage at the point of generation itself. For reinforcement steel, designated scrap collection and organized storage support recovery. For the AAC blocks and bricks, accurate quantity estimation, the protected storage, carefully handling and planned cutting can reduce the breakage. For mixed C&D waste, segregation at source is essential to preserve recyclable fractions. Reuse should be subject to technical suitability and applicable project requirements.

4.4 Project-level priorities

The results indicate that a single project-wide waste percentage would conceal differences among material streams. For example, Trump Tower recorded the highest values for concrete/RMC, steel and AAC blocks, while MSIL recorded the highest mixed C&D percentage and Joyville recorded the highest brick percentage. These observations can guide targeted reviews of the relevant material-management processes. They do not, by themselves, establish that one project performed better or worse overall because the underlying denominators, project characteristics and reporting periods are not fully standardized.

5 Recommendations

Based on the observed material-wise patterns and documented practices, the following actions are recommended for construction projects:

1. Establish a material-wise waste register that records input quantity, waste quantity, unit, measurement method, reporting period, destination and responsible person. Define and apply a consistent denominator before comparing projects.
2. Integrate waste prevention into design review, quantity estimation, procurement and work planning. Review high-loss materials before purchase orders and before each major work package.
3. Strengthen storage and handling controls through designated, protected storage areas; safe unloading; clear stacking limits; the material identification; and routine inspection of damage or deterioration, etc.
4. Apply material-specific controls: the concrete-pump trays and controlled discharge for RMC; cutting schedules and segregated scrap storage for steel; measurement and cutting optimization for AAC blocks; and careful stacking, handling and salvage/reuse of bricks.
5. Segregate C&D waste at source using clearly marked collection points. Keeping recyclable material streams separate and maintain traceable records of reuse, recycling, recovery and final disposals.
6. Use 5S and JIT as supporting site-management practices. Monitor implementation through routine inspections, toolbox communication and corrective-action tracking.
7. Introduce project-level indicators such as material-wise waste percentage with a defined denominator, quantity reused, quantity recycled, mixed-waste proportion, and closure of identified corrective actions. Compare trends only where measurement boundaries and reporting periods are consistent.

6 Conclusion

The study examined construction-waste generation across five selected projects using five material categories. The recorded averages were 6.14% for bricks, 4.25% for AAC blocks, 2.91% for steel/reinforcement, 2.34% for mixed C&D waste and 2.04% for concrete/RMC. The project-wise results varied across all categories, indicating the need for material-specific monitoring and controls rather than reliance on a single project-level measure.

The research records identify practical approaches including 5S-based workplace organization, JIT-supported material movement, source segregation, organized steel-scrap storage, reuse of suitable salvaged bricks and concrete-pump hopper trays. These measures provide a basis for strengthening resource efficiency, although their individual waste-reduction effects were not quantified in the available dataset.

The principal limitation is that the original measurement denominator and reporting period are not consistently established for all reported percentages. Further research should standardize material input and waste measurement, verify project-level records, and collect baseline and follow-up data to assess the effectiveness of prevention measures. Subject to these improvements, material-wise waste monitoring can support better procurement, site control, resource conservation and sustainable construction.

Acknowledgment

The authors acknowledge the support of the research supervisor and the project teams whose available records and documented practices contributed to the study. Selected internal project records of Shapoorji Pallonji and Company Private Limited were used as research material.

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