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Key factors affecting construction wastes in Vietnam

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A B S T R A C T

As a developing country, Vietnam has a huge social demand for infrastructure. Ho Chi Minh City, where plenty of construction projects are made to cater to social needs, is seen as an economic center of preeminent importance. The development of construction projects in terms of quantity entails, among other things, the burden of construction wastes. In fact, the collection, classification, and treatment of wastes are not paid due attention by construction contractors. Furthermore, there remains a scarcity of enterprises investing in construction waste treatment plants and poor management of wastes. A major part of the waste is poorly treated, causing negative environmental effects. Hence, this paper identified factors affecting the management of construction wastes in Vietnam. A survey was used to collect the data for the analysis. The results illustrate that the critical factors affecting the management of construction wastes in Vietnam are: (1) Ecological design; (2) Optimization of design for reduction of material consumption and construction waste; (3) Recycling and reuse of construction wastes; (4) Workers' awareness of construction wastes; and (5) On-site waste sorting.

1. Introduction

While construction presents as a vigorous contributor to the national economy, it exerts adverse impacts on the environment (Nguyen et al., 2018a). Construction is hardly friendly to the environment, since it involves ground clearance, demolition, and building and renovation, thereby generating a significant amount of construction waste. According to Shen et al. (2007), construction typically is in the form of debris, rubble, soil, concrete, steel, wood and mixed crap from ground clearance, usually a mixture of inert and organic materials. It is estimated that in 1996, around 136 million tons of construction and demolition debris was generated in the US from dismantling and reconstruction at respective proportions of 48% and 44%. In the UK, the late 1990s saw about 70 million tons of construction materials and soil wasted, corresponding to the wastage rate in the construction industry of about 10-15% (Yuan, 2012). In Australia, the mid-90s statistics implied nearly one ton of solid waste to be landfilled per person every year and construction wastes were estimated to account for 16-40% of the waste amount generated. Meanwhile, Hong Kong suffered an increase by double of annual construction waste for 9 years from 1993 to reach 20 million tons in 2004 (Lu and Yuan, 2010; Poon et al., 2004).

Recent years have seen an emerging headline concern for the environment on a global scale. For developed nations, environmental protection has become mandatory in all production and business sectors. Especially, waste management and treatment is of constant paramount priority. Construction waste management is somewhat novel compared to other industries such as urban solid waste management. Reducing the generation of construction waste in an effective manner is a challenge to many economies around the world. Therefore, rational management of construction waste is critical to not only saving precious soil resources, but also for minimization of adverse environmental impacts. A fair response to this challenge would bring more than social benefits, as economic benefits would accompany them. That is why this paper defines factors affecting the management of construction wastes by contractors, owners, and project implementers in Vietnam, thereby addressing issues of concern to the management of construction waste, so as to support

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project stakeholders to make the right decisions when they implement policies. This also helps to avoid over mobilization and inefficient use of resources.

2. Research background

Construction waste management, which involves managing the entire useful life of a project, calls upon the responsibility of all stakeholders. Although the majority of waste is generated from building and demolition, the incurrence of construction waste must be taken into account in every stage over the project life cycle (Osmani et al., 2008). Therefore, the practice of construction waste management should emphasize the integration of an entire project's useful life. In other words, the overall effect of construction waste management will heavily rely on its related information and processes throughout the life of the project when integrated. The entire life cycle of construction waste management would receive the energetic participation of all stakeholders including, government, customers, contractors (including construction and demolition contractors), suppliers and management companies, and various departments (Nguyen et al., 2018b; Yeheyis et al., 2013). As construction waste management process should be done within the scope of project management, all stakeholders stand responsible for it. Responsibilities of project stakeholders (Gangolells et al., 2014) were shown in Table 1.

Table 1: Responsibilities of project stakeholders

Project Stage	Stakeholders	Responsibilities/ Obligations
Design	Customers, developers, architects, engineers and construction workers.	-To establish the coordination of parties; -To set out standards for supplies and recycling of supplies.
Planning	Customers, developers, architects, engineers and construction workers.	-To coordinate and set out a construction solid waste management plan; -To disseminate among site staff and implement the plan; -The contractors prepare the waste disposal site as planned.
Building	Project management, engineers and workers.	-To comply with the plan; -To train workers; -Extra commitment; -To forecast the situation.

Construction waste management involves the elimination, reduction, and reuse of construction waste. Solid waste management has addressed waste reduction, recycling and reuse as necessary for the sustainable management of resources. The 3R principle refers to the three desired strategies of reduction, reuse, and recycling, which are placed in the hierarchy of importance as follows (Tam and Tam, 2006): (1) Reduction is deemed as the most powerful and effective method of construction waste management, since it fills two needs with one deed by preventing the production of construction waste and reducing the cost of waste transportation, disposal, and recycling; (2) Reuse concerns the use of construction materials more than once for the same function, for instance, reusing formwork, and for new functions such as using the cutting angle of a steel bar to support brackets; (3) Recycling provides benefits for mitigated resource demands, reduced transportation costs, and saved production energy, and allows the use of waste that might be buried otherwise.

The outcomes of 3R practice as a solution for environmental protection in many parts of the world have proven its effectiveness and significant socioeconomic benefits. Thanks to 3R application, the waste amount would be reduced, which invites environmental quality improvements and tremendous economic benefits.

Wastes from building and demolition are majorly attributed to mistakes in design, material procurement and planning, inefficient processing of material, raw material redundancy, and unexpected design changes. Some improvements carried out onsite and with respect to construction design might greatly help reducing waste. Yeheyis et al. (2013) listed various categories of construction waste and their reusability, as shown in the Table 2.

The past three decades has seen the huge Chinese construction industry paired with rapid economic growth, which has greatly increased construction waste. The bulk of construction waste is caused by poor treatment, hence severe damage to the environment. Lu and Yuan (2010) has addressed seven important factors for the addressed 7 important factors for the success of construction waste management, namely: (1) regulation of waste management, (2) waste management systems, (3) awareness of construction waste management, (4) construction technologies of low-waste footprints, (5) reducing changes in design, (6) research and development of waste management, and (7) vocational training in waste management. The study also broadens understanding of how to reduce the adverse environmental consequences of construction activities in fast-growing economies.

By investigating the hindrances to construction waste management in Vietnam, Ling and Nguyen (2013) proposed recommendations to effectively improve the management of construction waste in the country, for instance: (i) using subcontractors capable of managing wastes; (ii) training in conduct and awareness of waste concerns; (iii) tightly auditing and supervising subcontractors and workers; (iv) serial operations to mitigate damage to completed works; (v) setting limits on wastage; and (vi) enforcing reward and sanction policies.

In another research, Saez et al. (2013) concluded on the need to emphasize the elaboration of regulations on making technical recommendations for the use of recycled materials in construction, since only 8% of asked agents acknowledged using recycled materials. This is a measure for a significant reduction of construction waste from demolition. Through a series of analytical procedures, the research has defined three powerful practices at the design stage:

1) Using precast or industrial technologies or systems of low waste,
2) Overlay-planning for existing workplaces, and
3) Setting aside spaces for precise construction waste management within the work area.

In addition, the 5 most effective practices on site include:

1) Waste management contracts,
2) Onsite waste sorting,
3) Distribution of small containers in workplaces,
4) The use of construction waste containers, and
5) Reducing unnecessary packaging upon procurement of raw materials.

Table 2: Category of construction wastes and their recyclability

Wastes	Recyclability	Biodegradation	Landfill	Incinerability
Concrete	Synthetic recycled for road pavement and concrete	No	Yes	No
Steel	Degenerated into steel material	No	No	No
Bricks and blocks	Landfilled, synthetic recycled	No	Yes	No
Thermal insulation materials	Reused for roof heat-insulation or inner wall soundproofing	No	No	Yes
Glass	Degenerated into pure glass for cement manufacture	No	Yes	No
Bricks	Recycled into raw materials and concrete raw aggregates	No	Yes	No
Aluminum	Degenerated into aluminum	Some	No	No
Plastic	Recycled in any form	Some	No	Yes
Paint	Reused as paint or concrete additives	Yes	No	Yes
Wood	Recycled into plywood, pulp	Yes	Yes	Yes
Plaster board	Recycled into new boards, crushed into chips that can be made into new boards	Yes	No	No
Packaging, cartons	Recycled into organic fertilizers, fuel, paper	Yes	Yes	Yes

Effective management of construction waste is indispensable to the sustainable development of infrastructure. So far, generous effort has been made to assess construction waste management. However, most such endeavors have focused on construction waste management from only a narrow or specific field like economics. Meanwhile, little attention has been paid to social and environmental aspects, which are in fact naturally a must for promotion of construction waste management. Yuan (2013) from a holistic perspective identified 30 key indicators affecting the overall effectiveness of construction waste management. He also proposed a framework to evaluate the effectiveness of construction waste management, which is based on the integration of key indicators as defined (Chang and Tsai, 2015). This evaluation framework not only gives further insight into the effectiveness of construction waste management, but also lays the ground for future research on evaluating the effectiveness of construction waste management.

By reviewing the available literature at home and abroad, the authors have grounds to propose factors affecting construction waste management in Vietnam as in the Table 3.

3. Research methodology

The research process consisted of the following three steps:

- **Step 1:** Literature review: After determining the research objective, the authors consulted past studies and opinions of experts to preliminarily identify the factors affecting construction waste management.
- **Step 2:** Empirical survey: After a factor model was proposed, a questionnaire was designed. Then the questionnaire was piloted, and the trial survey results were analyzed. Next, the questionnaire was revised and the official questionnaire went live on a mass scale.
- **Step 3:** Analysis and conclusions: After the survey data were collected, data analysis started. Based on the analysis results, conclusions were drawn and recommendations were made.

Data collection was done by questionnaire survey. The questionnaire was designed to gather data for probing the importance of factors affecting the construction waste management process. A 5-level Likert scale was used, addressing levels from 1 "very minor" to 5 "very important" (Huynh et al., 2019). The questionnaire then entered an official stage, where it was distributed in masse to engineers with projects in Ho Chi Minh City. The survey results were gathered by direct interview or via email.

To minimize and summarize the data, the authors conducted an Exploratory Factor Analysis (EFA). This analytical method is used when the relationship between observed variables and latent variables is ambiguous and uncertain. The first key requirement of this method is that the KMO (Kaiser-Meyer-Olkin) value must be between 0.5 and 1. For the analysis to be conducted, Principle Components Analysis is used as the extraction method together with Varimax rotation. Hair et al. (2014) stated that factor loading implies the practical significance of EFA. A practical significance is implied by a factor-loading indicator being greater than 0.5.

Table 3: Summary of factors affecting the management of solid construction waste in construction projects

Factors	Source
Fewer design changes	Lu and Yuan (2010), Yuan (2013)
Waste management regulations	Lu and Yuan (2010)
Lifecycle waste management	Lu and Yuan (2010)
Improving communication amongst project participants	Lu and Yuan (2010), Esa et al. (2017)
Practitioners' awareness of construction waste	Lu and Yuan (2010), Yuan (2013), Esa et al. (2017)
Vocational training in waste management	Lu and Yuan (2010), Esa et al. (2017)
Onsite construction and demolition waste sorting	Lu and Yuan (2010), Wang et al. (2010), Saez et al. (2013)
Construction and demolition waste recycling and reuse	Lu and Yuan (2010)
Optimize design sections to reduce the amount of material used, and as a consequence the construction and demolition waste generation	Saez et al. (2013)
Designating a waste management plan coordinator who is responsible for ensuring that the plan is followed onsite	Esa et al. (2017)
All the stakeholders are involved in the coordination of the waste management plan	Esa et al. (2017)
Eco-design	Esa et al. (2017)
The amounts and types of construction waste are estimated for each of the construction activities conducted	Esa et al. (2017)
Market for recycled materials	Wang et al. (2010)
Safety of operatives in conducting construction and demolition waste management	Yuan (2013)
Consideration of construction and demolition waste reduction in design	Yuan (2013)

4. Results and Discussion

In total 85 engineers engaged in projects in Vietnam were surveyed, of which 35 participants came from contractor companies (41%), 17 from design consultancy units (20%), 14 from supervisory consultancy units (17%), 11 from project management units (13%), and 8 from investors (9%). The groups of critical factors in construction waste management are ranked by the descending order of mean values, as shown below in Table 4.

Table 4: Top five critical factors affecting construction waste management

Critical factors	Mean	Rank
Ecological design	3.98	1
Optimization of design for reduction of material consumption and construction waste	3.92	2
Recycling and reuse of construction waste	3.91	3
Workers' awareness of construction waste	3.74	4
On site construction waste-sorting	3.69	5

Ecological design was the most critical factors influencing construction waste management in Vietnam. A variety of technologies and innovative solutions have been incorporated into the ecological design to help better manage resources. Ecological design technology has been widely applied in the industries of waste conversion, architecture, landscape design, environmental protection, and restoration. It was concluded by Keys et al. (2000) that services and products of design and construction companies are more and more inclined to the pursuit of safety, ecological friendliness, and wastage reduction. By emphasizing the concentration of waste at the design stage of projects and construction development, wastage reduction focus would be transferred from the "construction site" to a "design concern". This prompts stakeholders in the design and construction process to deepen their relationships with construction waste managers, who can prove innovative solutions for minimization and recycling of waste instead of waste treatment (Azevedo et al., 2014; Phong et al., 2018). This approach gives designers and construction waste managers a chance to reduce waste on a more holistic scale.

Green Building Guidelines have become a powerful tool to promote waste reduction strategies and practices in construction (Potbhare et al., 2009). Among the top pre-eminent green building rating systems is the US's Leadership in Energy and Environmental Design (LEED). LEED covers the rankings of different building types ranging from new constructions, existing buildings, commercial interiors, core and shell, schools, retail, health care, homes, and neighborhood development. Regardless of the differences in construction methods, the prerequisites and credits of the ranking system are divided into six areas:

(1) Sustainable sites;
(2) Water efficiency;
(3) Energy and atmosphere;
(4) Materials and resources;
(5) Indoor environmental quality; and
(6) Innovation in design.

Among the 6 credit categories, water efficiency and materials and resources definitively address the concern of construction waste management in building operations. Some other concrete elements of LEED system highlight the points that can be probed by effective waste management during the construction stage.

Previous studies have shown that construction waste management has not been a priority in the design process. Moreover, architects seem to attribute the bulk of construction waste to onsite activities and almost nothing to the design phase. However, in substance, about one-third of construction waste can arise from design decisions. Osmani et al. (2008) conducted a study to investigate how architects stand on the sources of design waste and waste reduction design practice in the United Kingdom as well as barriers against waste reduction. The research reveals that most architects were reluctant to integrate waste reduction strategies into their projects. Architects are willing to work with consultants and contractors in reducing design waste only when customers require and agree to give bonuses for waste research and minimization. Eliminating waste in the design phase is considered an advanced or exceptional aspect rather than a core of the building design process. On the other hand, architects insist on some obstacles in reducing waste by design, particularly waste awareness and unknown essential causes of design waste, customer requirements, and non-identification of responsibilities. In contrast, laws and rewards are seen as major incentives that can greatly impact design waste minimization. In bottom lines, waste elimination in design phase requires a comprehensive assessment of design waste, which helps assessing the impacts on changes in a waste reduction design model. Therefore, architects should assume a decisive role in the reduction of construction wastes in all phases by concentrating their efforts on design waste reduction. To maximize their role, architects need to be aware of the chances for prevention of wastes and necessary means to improve waste reduction.

Classification of wastes at construction sites may help boost the rate of reuse and recycling of construction waste while reducing waste transportation and treatment costs. Construction waste is isolated and classified into different groups on the site in correspondence with their characteristics and compositions for them to be reused or recycled. To prevent the mixing of types of waste, workers would isolate the waste at the source.

Yuan (2013) addressed four basic types of onsite waste: domestic waste, inert construction waste, active construction waste and chemical waste. Waste should be properly managed at the source where they are generated during the construction process, so that ordinary construction processes are not interrupted. Specific in-place classification methods vary by the type of project and waste combinations. For example, as just a little active construction waste is generated from infrastructure projects, waste management plans mainly target soil and sludge. Thus, onsite classification of waste is rarely recognized in infrastructure projects.

Another worthy concern with respect to onsite waste classification is the management effort and behaviour of stakeholders. Site layout is also not least important, as it may obstruct the practice of waste classification at construction sites. Meanwhile, labor force and costs have only a minor impact on the local classification of waste. Projects of all types tend to treat construction waste in place as an indispensable part of the construction process.

5. Conclusion

Construction waste management will help with increasing the efficiency of material consumption, decreasing pollution, and creating a green construction environment. The primary purpose of this study is to identify factors affecting construction waste management. The study has addressed 16 factors governing the effectiveness of construction waste management. Among of them, the 5 main factors in high need of concern include ecological design, optimization of design for reduction of material consumption and construction waste, recycling and reuse of construction wastes, workers' awareness of construction waste, and onsite waste sorting.

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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