# Optimization of Main Factors Affecting Construction Waste by the Supply Chain Management

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***Abstract*— A survey report of the Vietnam Urban Environment and Industrial Zone Association reveals that every day in 2009, about 1,000 tons of construction waste were generated in Hanoi and 2,000 tons Ho Chi Minh City in Vietnam. It is forecasted that the coming years would see a vigorously growing amount of construction waste as a result of the plan to dismantle and renovate old apartment buildings in major cities. So, in this research we developed a supply chain management strategy for the waste controlling in the construction industry. While the bulky volume of construction wastes poses a great environmental threat to urban areas, response to it remains meager. Hence, this paper presents four primary factors affecting the management of construction wastes in Vietnam using fuzzy logic.***

***Keywords*—** *construction waste, environmental management, supply chain management, fuzzy logic, Vietnam.*

## 1. Introduction

Statistics in 2013 of the Department of Natural Resources and Environment points out more than 7,200 - 8,100 tons of solid wastes being discharged every day in Ho Chi Minh City in Vietnam. In particular, 6,400 - 6,700 tons of wastes was gathered and buried, along with about 1,200 - 1,500 tons of non-hazardous industrial wastes, 250 - 350 tons of hazardous industrial wastes, 14-18 tons of hazardous medical solid wastes, 900 - 1,200 tons of construction wastes ( e.g. debris). Domestic solid wastes mainly consist of highly biodegradable food left over (at low heat and high humidity), which accounts for 55-65% of waste weight. The rest is paper, plastic, rubber, etc., which are high heat and recyclable.

Industrial solid wastes (hazardous and non-hazardous) and non-hazardous medical solid wastes are diversely composed, highly degeneratable and can make high market values. At present, construction solid wastes are primarily used for leveling and provides an abundant source of raw materials for manufacturing unburnt bricks adapting to climate change. A major part of waste is poorly treated, causing negative environmental effects. Therefore, management of construction waste is critical to not only saving precious soil resources, but also for minimization of adverse environmental impacts. this paper presents four main factors affecting the management of construction wastes in Vietnam using fuzzy logic.

## 2. Research Methodology

The following steps present the evaluation process of the weights of four main factors affecting the management of construction wastes in Vietnam using fuzzy decision analysis approach [5-8, 12, 14].

Step 1. The pairwise comparison matrices can be obtained by using construction experts input. Step 2. We calculated the elements of the synthetic pairwise comparison matrix by using the geometric mean method suggested by Buckley [3]:

$$\tilde{a}_{ij} = (\tilde{a}_{ij}^{1} \otimes \tilde{a}_{ij}^{2} \otimes \tilde{a}_{ij}^{3} \otimes ... \otimes \tilde{a}_{ij}^{n})$$

where $\tilde{a}_{ij}$ is the fuzzy comparison value of criterion *i* to criterion *j*.

Step 3. The fuzzy weights of four main factors affecting the management of construction wastes in Vietnam were calculated by [2-4, 9]:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \tilde{a}_{i3} \otimes ... \otimes \tilde{a}_{in})^{1/n}$$

Moreover, for the weight of each criterion:

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \tilde{r}_3 ... \oplus \tilde{r}_n)^{-1}$$

where $\tilde{w}_i$ is the geometric mean of the fuzzy comparison of the $i^{th}$ criterion, which is indicated by a triangle fuzzy number $\tilde{w}_i = (Lw_i, Mw_i, Uw_i)$. $Lw_i$, $Mw_i$ and $Uw_i$ stand for the lower, middle and upper values of the fuzzy weight of the $i^{th}$ criterion, respectively.

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Step 4. For defuzzified the fuzzy weights, we applied the following CoA method [17]:

$$BNP_{w_i} = [(U_{w_i} - L_{w_i}) + (M_{w_i} - L_{w_i})]/3 + L_{w_i}$$

where $BNP_{w_i}$ is the Best Nonfuzzy Performance value of the fuzzy weights of the $i^{th}$ criterion.

## 3. Results and Discussion

Workers should be considered a factor of top concern since this factor has the highest important weight (38.1%). A successful implementation of waste management measures requires the joint efforts of all project stakeholders, especially workers, who play a momentous role in construction waste management. Indeed, waste can be avoided by changing the attitude of engaged workers. How much construction waste is reduced, reused, and recycled heavily depends on how the workers' behavior is changed. This is completely consistent with Yean Yng Ling & Song Anh Nguyen research. The authors indicated the importance of on-the-job training and close supervision of construction waste management due to a large proportion of unskilled workers in the construction labor force. In addition, the wastage by subcontractors is in fact due to their lack of training, economic practices, and waste treatment operations. These should be attributed to wrong perceptions about waste and inadequate judgment of material value [18-20].

“Designs” is ranking second important factor (30.2%). The findings of Begum et al. also showed that those contractors having their workers trained in construction waste management would gain a more positive attitude toward waste management than those not receiving such training [2]. Tam and Tam found the necessity for appropriate training and coaching to change workers' attitude towards the application of precast technology as a way to minimize construction waste [16]. The lack of trained and professional workers is a huge obstacle to construction environmental management. Worker rewards and incentive policies would encourage workers’ efforts to reduce construction waste. These policies should be formulated focusing on raising awareness, broadening knowledge and promoting contractors engaged in environmental and waste management [2, 11]. In the practice of construction waste management, the safety of workers must be also noticed.

Minimizing waste in Phase 1 of design is an important strategy for effective reduction of wastes. Some historical studies concluded that a considerable volume of construction waste originated from the non-conformity of construction outcomes against the designs. A variation of construction design is undoubtedly intended to fix design errors, to add value to customers, or to meet new design specifications. Additionally, in response to the increasingly rapid development requirements in the construction industry and the pressure of contractual schedules, the design of a construction project is often deployed in haste at the expense of thorough consideration.

Another reason for overdone changes in design during the construction process is that customers fail to perform a complete market analysis before embarking on a project. Hasty design and incomplete market surveys probably lead to changes in design in the construction phase, which in turn possibly causes excessive costs and more construction waste. Osmani, Glass, and Price estimated about 33% of waste on construction sites was related directly or indirectly to project design [10, 13]. Waste generation in the construction phase would be minimized if appropriate strategies or practical methods for waste reduction are provided in the design—for example, design standards for construction materials, or application of precast structural blocks or materials. Nonetheless, construction waste management is given almost no priority in project design. Therefore, it is important to consider the potential to reduce waste in the design phase given the total amount of waste generated by construction projects. This shows how important the role of engineers or architects is with respect to construction waste reduction.

The weight of management factor equals 24.3%. Arif, Bendi, Toma-Sabbagh, and Sutrisna realized the lack of importance to be attached to construction waste management in developing countries, and pointed out the crucial role of governments in training for enhancement of awareness [1, 21]. By enforcing policies across the entire industry, the government undeniably plays a vital role in promoting the practice of construction waste management. The biggest headache comes from the fact that most current state policies are not detailed enough to guide and execute construction waste management. The government should demonstrate some operations under construction waste management policies to effectively guide the classification, reduction, reuse, recycling, and disposal of wastes. Construction waste management units are now challenged in assessing whether their construction waste management practice conforms to regulations and specific standards. For sheer regulation of construction waste management, local authorities need to build their own specific regulations and standards.

The final indicator is recycling factor (17.1%). The majority of contractors did not isolate the waste at its sources, reduce sources of waste, reuse or recycle waste onsite or dispose of construction waste at landfill sites. The reasons for this are cost, narrow knowledge of consequences of waste, and the scope for reduction and reuse of waste. Poon, Yu, and Jaillon underlined the need for separating construction wastes and disassembling waste compositions before transferring them to landfill sites or public dumps for disposal [15]. Begum et al. pointed out the benefits of reuse and recycling of wastes, including a saving of some 2.5% of the total project budget [2]. To reduce the amount of construction waste to be disposed at landfill sites as well as to motivate contractors to isolate or minimize waste at source, reuse, and recycle them, the government should raise construction waste treatment fees. A higher treatment fee allows the government to provide additional incentives to encourage waste-sorting, reduction, reuse, and recycling. This also strengthens waste management practices among construction contractors. Furthermore, project managers believe that in the present context, a developed market for recycled materials would promote onsite waste-sorting.

## 4. Summary

This paper concluded four main factors affecting construction wastes by the supply chain management in Vietnam projects, including (1) design, (2) management, (3) workers, and (4) recycling. It also proposes a quantitative approach to ranking main factors affecting the management of construction wastes in Vietnam by using fuzzy decision-making method. This approach can reflect uncertainty in the evaluation of civil engineering and construction experts by using the Best Nonfuzzy Performance calculations.

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