

## Original Article

**A Study Identifying Causes of Construction Waste Production and Applying Safety Management on Construction Site**Ali Asghar Najafpoor<sup>1</sup> Asma Zarei<sup>2</sup> \*Farideh Jamali-Behnam<sup>2</sup> Mohammad Vahedian-Shahroudi<sup>3</sup> Ahmad Zarei<sup>4</sup>

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**Abstract**

**Background and purpose:** In a recent century, the amount of construction waste has increased significantly. Although the building industry has a considerable role in the development of a society, it is regarded as an environmentally destructive. Source reduction is the highest goal in the waste management hierarchy and is in priority. It also has economic benefits by reducing costs associated with transportation, disposal or recycling of wastes. The present study is aimed to identify activities generating the wastes in design, transportation and storage and procurement of building materials.

**Materials and Methods:** This was questionnaire survey. A total of 94 professionals in the construction industry were attended in this study. To determine the validity and reliability of the instrument, content validity method and Cronbach's alpha coefficient (0.79) were used. Data were analyzed using SPSS for Windows. Frequencies, percentage, mean and standard deviation were determined in this research.

**Results:** The results showed that handling and storage have been chosen as the most causative factor of waste production in construction activity. Improper material storage was identified major factor in producing waste in handling and storage phase. Usage of low-quality material in design stage and material price changes in procurement were recognized as major causes of waste production in these stages.

**Conclusion:** All studied phases in this research were identified as causative factors in producing of waste. Identifying causes of construction waste production will help us decide better how to control this sort of wastes.

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**Key words:** Construction Waste, Handling and Storage, Procurement, Design Phase, Source Reduction

## 1. Introduction

In a recent century, the growth of waste generation, particularly construction and demolition wastes have attracted considerable attention (1, 2). Although construction activity has an important role in developing of cities, it contributes to the degradation of the environment. Some of negative impacts of this phenomenon include lack of enough area for land filling of wastes, energy consumption, water usage, dust and gas emission (3).

According to the studies, a major amount of municipal solid wastes about 35% in developed countries and 50% in developing countries belong to construction wastes (4). Research in some European countries showed that the amount of construction waste is different from country to country. For example, the wastage rate in Australia, Denmark, Germany and the Netherlands were 300, 500, 2600, and 900 kg/cap. year, respectively (5). As construction industry is increasing in the UK, reducing of waste in all stages of construction is necessary (6). Amount of C and D in Iran comparing to developed countries is very high. Data available for Tehran, Iran Waste Management Organization indicated daily production of C and D wastes nearly 4.46/capita (7). another study in Bushehr, Iran showed that most of municipal solids of this city is related to C and D, which is 42.49% of the total amount of generated wastes (8).

Increasing trend of C and D generation, and also lack of land fill area for disposal of them has made the management of these wastes more difficult that requires a high cost for management. Having knowledge about quality and quantity of waste generation, defining a modeling methodology and use of it for other construction projects are the fundamental requisites for setting up an ideal waste management system. Four methods for C and D waste management are: source reduction, reuse, recycling and land filling (9, 10). Among the mentioned methods, source reduction is the

highest goal in the waste management hierarchy and is in priority. Source reduction also has economic benefits by reducing costs associated with transportation, disposal or recycling of wastes (11).

Daily, 11,000 tons of construction waste is generated in Mashhad, Iran that causes major environmental issues in the area. This city is located in north-east of Iran with a population more than 2 million people. The area of this city is 288 km<sup>2</sup> (12). There are some countries in the world that have area and population nearly to Mashhad and need to manage their C and D waste generation. Use of applicable ways to reduce amount of generated wastes require knowledge about factors affecting waste generation. Source reduction is influential when factors affect generations of wastes are clearly defined. The present study is aimed to identify activities generating the wastes in design, transportation and storage and procurement of building materials.

## 2. Materials and Methods

In this descriptive study, non-probability sampling was used. Therefore, the research team was sent to engineering organization of Mashhad and 94 persons of supervisors, architects, designer engineers and contractors who fulfill the following characteristics were selected as study group:

- 1- Diploma or higher degree in an engineering field related to construction projects.
- 2- Have a role in construction projects.
- 3- Have at least 1 year work experience in the field.

Data collection was done by preparing questionnaires with four sections. The first, second, third and fourth sections were prepared with questions about demographic information, 13 questions about factors, which affect amount of wastage in design stage, 11 questions about factors, which affect amount of waste produced in transfer and storage

stage and 4 questions about procurement of building materials, respectively. In the questionnaire, the respondents were requested to assign an appropriate rating on a scale of 1-5, where 5 denotes extremely high and 1 extremely low. Content validity was confirmed by some environmental health engineering experts. The questionnaire was pre-tested and pilot-tested upon twenty samples professionals to attain reliability. Data were analyzed using SPSS for Windows (version 11.5; SPSS Inc., Chicago, IL. USA). Frequencies, percentage, mean and standard deviation (SD) were determined. Ranking questions of each phase was done according to mean  $\pm$  SD.

### 3. Results

In the present study, the respondents were asked to evaluate causes of materials wastage arising from construction activities. Causes of construction waste generation, frequencies, percentage, means and SDs are all given in table 1. Generation of construction waste is occurred in almost all stages of construction activities.

According to the results, 38.3% of professionals believed that the most common factor in waste generation is related to transportation and storage of building materials (Table 1). Comparatively, The results further show that 55.3% of professionals believed that wrong material storage is the main source of waste in transportation and storage stage. Other causes such as improper transportation, use of second hand appliances, lack of sufficient instructions about handling are known the most influential

factors in this report (Table 2).

Results of this study on procurement stage shows that variations in cost of materials have the highest frequency and the largest impact on wastage in this stage (Table 3).

Study of design phase also shows that five most common causative items in construction waste generation are deliberate choice of low quality materials, lack of designer experience in selection of construction method, lack of knowledge about construction techniques during design activities, variations in the design while construction is in progress and designer's unfamiliarity with alternative products. Among them, choice of low-quality materials has the highest impaction on increasing of the construction wastes (Table 4).

Other causes in this stage that led to waste generation are poor interaction between various specialists, incomplete contract documents at commencement of the project, lack of attention paid to dimensional coordination of products, inefficient use of quality standards, and complexity of detailing in the drawings and lack of information in the drawings.

### 4. Discussion

As it implies in previous studies, Wrong methods of transportation can be occurred due to lack of sufficient knowledge and skills about materials transportation. Also, improper storage can damage and break the materials (13-15). Another research showed that materials storage and handling, documentation factors and procurement factors were considered as the main source of waste on building construction sites (16).

**Table 1.** Level of contribution of waste sources in professionals views

Causes affecting waste generation	Frequency	Percentage	Mean $\pm$ SD	Ranks
Transportation and storage stage	36	38.3	31.70 $\pm$ 8.04	1
Procurement stage	29	30.9	31.30 $\pm$ 9.70	2
Design stage	22	23.4	22.30 $\pm$ 2.07	3

SD: Standard deviation

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**Table 2.** Causes of Waste arising from materials transportation and storage in professionals views

Causes of waste arising from materials transportation and storage	Frequency	Percentage	Mean ± SD	Ranks
Wrong material storage	52	55.3	3.53 ± 1.13	1
Use of wrong methods of transportation	50	53.2	3.51 ± 1.19	2
Damage to materials during handling	44	46.8	3.20 ± 1.40	3
Use of second hand appliance	43	45.8	3.30 ± 1.35	4
Lack of sufficient instructions about handling	43	45.7	3.19 ± 1.30	5

SD: Standard deviation

In Singapore, substitution of new purchases by wasted materials and rebuild to correct mistakes cause heavy financial losses to the contractors (17). The survey results of a study indicated last minute client requirement, errors by operatives, purchased products that do not comply with the specification and lack of onsite materials control as the most causative item on waste production (16).

Studies in Seri Lanka shows a major cause of construction waste are the conversion activities (13). Other researchers in Indonesia identified lacks equipment, lacks of material, rework and supervision delays as the most items in producing of waste (18). Lack of experience was identified as the second factor of waste production in south china (4). According to Nagapan et al. research, frequent design changes were the most significant factor contributing waste, Meanwhile wrong material

storage, workers’ mistakes, poor planning, leftover material on the site, and ordering errors also causing for generating waste (19).

Faniran and Caban reported the five most significant sources of construction waste were design changes, leftover material scraps, wastes from packaging, design errors and poor weather (20).

Inadequate stacking and insufficient storage site is one of the principal reasons for wastage of building materials on the site. Some strategies for waste reduction in transportation and storage phase and design phase was given below:

- Collaboration between storage manager and building material suppliers to avoid over ordering (8).
- Use of packing that reduce damage to materials can be a good action in waste minimization (12).

**Table 3.** Common causes in generation of construction wastes in the procurement stage of materials according to professionals views

Causes of wastage in the procurement stage	Frequency	Percentage	Mean ± SD	Ranks
Variations in cost of materials	52	44.7	3.51 ± 1.30	1
Substitution of a material by a more expensive one	41	43.6	3.49 ± 1.19	2
Purchased products that do not comply with the specification	37	39.4	3.30 ± 1.35	3
Error or mistakes in ordering	29	30.9	3.20 ± 1.40	4

SD: Standard deviation

**Table 4.** Major causes of waste generation in design stage-engineers view

Causes of wastage in the procurement stage	Frequency	Percentage	Mean ± SD	Ranks
Variations in cost of materials	52	44.7	3.51 ± 1.30	1
Substitution of a material by a more expensive one	41	43.6	3.49 ± 1.19	2
Purchased products that do not comply with the specification	37	39.4	3.30 ± 1.35	3
Error or mistakes in ordering	29	30.9	3.20 ± 1.40	4

SD: Standard deviation

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-To avoid wasting a lot of blocks on construction sites, it is advisable to take into consideration storage and handling operations on site:

1. The blocks should be stacked on pallets or on level grounds.
2. It should be stored in a container or a covered space.
3. It should not be stored in where people always walk.

-To find ways that use fewer materials is another good way to produce less waste (14):

1. Increasing the distance between the timbers and studs or use of more insulation can reduce wall thickness and reduces thermal bridging.
2. Use of standard timber reduces its cutting and sawing which, therefore, reduce the amount of wastage.
3. Use of steel instead of a wooden framework is another solution. These materials are more recyclable, have more strength, are lighter in weight and causes time and cost saving.

- Application of prefabricated technology (3).
- Usage of light materials reduces workers fatigue and their working ability will be increased, and materials damage will be reduced (14).

According to findings of ReCRAFT 90 project in Montana city, in the house's foundation, fly ash increases cement strength; the higher strength allows the use of 6 inch foundation walls rather than the standard 8 inch. Therefore, reduce the amount of material usage and also waste generation (17).

The present study showed that each phase of transportation and storage, procurement and designing had a considerable role in construction wastes generation. Among them, transportation and storage phase had the highest rank in producing of waste that was in agreement with some literature. Procurement and design phases are in later. By comparing of results, wrong method of transportation was

the most causative item on wastage rate. Variations of construction materials had the highest rank in waste generation in the procurement phase. Furthermore, usage of materials with low quality is a major source of waste generation in design phase. Identifying causes of waste production will help us devise more effective plans to control better these sort of wastes.

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