



# Oman Construction Industry Prospective on Cause of Construction Material Waste

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**Abstract:** Construction industry is second largest industry in gulf countries, that continuously rapidly growing. Similar to other countries around the world, construction industries in gulf region also facing problems due to oil industry uncertainties. Construction industry of gulf countries, construction material waste is getting higher concern. This paper aims to identify various factors in construction management causing construction material waste at Muscat, and Nizwa cities in Oman. Seventy-one (71) factors were collected from literature around the world and organized in structured questionnaire distributed amongst the construction experts focusing clients, consultants and contractors involved in the construction projects. The questionnaire was designed in such a way to collect construction waste causing factors in five major categories in (Design, Handling, Workers, Management, Procurement, and Site conditions). The collected data were analyzed by using Average Index method for each factor. Furthermore, construction material waste causing factors analyzed by individual response of client, consultant and contractor prospective. Analysis identified that 'frequent design changes'; 'wrong material storage'; 'worker's mistakes during construction'; 'poor supervision'; 'mistakes in quantity surveys'; and 'poor site conditions'; are highest significant causes in each category respectively. The result of this study is useful to create or/and improve guideline considering waste generated from construction industry, to avoid problems in looming construction. It is concluded that the government organizations or/and construction industry itself can develop or improve legislation for avoiding construction material waste.

**Keywords:** Construction waste, material waste, physical construction waste, causes, factors, management

## 1. Introduction

Construction industry is known for contributing economic growth particularly in gulf countries. However, it is also contributing to negative impact by generating construction material waste from the construction activities [1]. The generation of construction waste has caused serious problems both in the vicinity and worldwide. The amount of construction material waste engendered is directly proportional to the hefty demands of projects such as residential building or housing projects, hypermarkets or shopping complex and many infrastructure projects need for upgrading life style of peoples [2]. Construction waste can be clustered into two groups namely; physical and non-physical waste. Physical waste is generated in the form of construction material loss such as wood, concrete, metal, brick, drywall, roofing, material packaging, plastics, papers, cardboard and others [3]. Non-physical construction wastes are activities mainly time and cost overrun such as delay times and execution of unnecessary work etc. for construction projects [45]. Countries such as Oman, Saudi Arabia, United Arab Emirates, Qatar, Bahrain, Jordan, are also has fallen into construction

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waste problems, due to rapid development of construction sector. In tandem, with increasing demand of infrastructure projects, residential development projects, large amounts of construction material waste are being produced in Oman. These conditions may contribute a huge impact on project costs and time due to construction material waste for construction industry [2], [3]. This emphasis on the need of a systematic and efficient waste minimization method to control the generation of waste at different level [4], [5]. Therefore, to avoid the construction material waste generation, it is necessary to find out the root cause of the waste in Oman because effective minimization of construction waste contributes to profit maximization.

Research indicates construction waste issues such as cost overrun, illegal dumping, filling up of land fill areas etc., in countries such as Malaysia, Hong Kong, Singapore, Australia, China, Germany, Finland, Sri Lanka, Spain, and US. Despite the serious threat waste poses to the profit objective, no serious attention is paid to identifying factors that cause and contribute to the construction waste in Oman construction industry. The construction of roads, houses, railways, airports, bridges for private or/and for the government, involves many resources. The build-up of the cost of these projects significantly includes the construction material waste. Reducing waste is not limited to small or large construction projects. The situation is again worsening when construction industry contributors (client, consultant, and contractor) do not have any idea about construction material waste management. This is not to say that non operations managers cannot reduce waste but it is believed that the professional can do better than the non-professional. The purpose of this study is to find the construction material waste causes during construction process from planning, designing till completion of project. This information will help client, consultant and contractor to identify the main causes of construction waste which generate waste.

## 2. Literature Review

The gulf cooperation countries (GCC) constantly rank among the top 10% of per capita waste producers in the world [6]. Communally around 120 million tons of waste annually is produced in GCC; among that 55% construction and demolition material waste [6]. In 2017 Ouda et al examine 81 construction companies in the Eastern Province of KSA to determine factors critically affect the sustainable management of construction and demolition waste in the country. Ouda et al found that only 39.5% of the companies studied had a pollution control plan for their projects. It was also found that only 13.6% of construction and demolition waste is recycled and reused every year, whereas the remaining 86.4% construction and demolition waste eventually goes to the landfills [6].

Construction industry in Jordan is not an omission [7]. It generates tons of construction wastes per year, making construction wastes a pressing issue for in depth investigation [7]. In 2016 Jawad and Omar aimed to investigate the main factors and causes contributing to material waste in the construction industry in Jordan. A survey was carried out, employing semi-structured interview, to gather information from construction professionals about causes of waste in construction materials. Jawad and Omar results show that the most significant factors contributing to construction waste can be categorized mainly into two groups: management-related and workforce-related. Examples of these are: 'lack of skilled workers and subcontractors' and 'lack of quality management system' [7].

In Qatar construction material waste is more than 75% of all solid waste. The majority of construction material waste is dumped in landfill areas in the desert away from the capital city Doha [8]. It is contaminating an progressively large area of land. Qatar has National Development Strategy of recycling 38% of solid waste that requires significant improvements in the management, to tackle this issue [8]. Reid, Hassan and Al-kuwari discussed a collaborative approach to address construction material waste, including government departments, research organizations and industry. They highlighted that the codes of practice for construction and demolitions are being developed to improve the quality of waste on site. They suggested different idea to administration and construction industries to recycle and re-use the demolished construction material waste. However, to effectively implement the use of recycled materials, required further measures about quality and durability, together with revising the Qatar Construction Specifications. They also addressed concerns and raising awareness of the economic and environmental benefits of reducing construction waste [8].

The United Arab Emirates (UAE) is facing the challenge of achieving sustainability on construction sites [9]. One of the main barriers lies in the increasing amounts of material waste generated from construction activities and dumped in landfills [9]. In 2011 Al Hajj et al examined previous studies about the sources of construction material waste and the recommended measures to minimize at UAE. Four construction projects were visited before a survey was conducted of the perceptions of contractors on the problem and causes of material waste; waste minimization measures and their benefits. Al Hajj et al research revealed that the main causes of material waste are lack of awareness; excessive off-cuts resulting from poor design; and rework and variations. The most frequent measures practiced to minimize material waste are: staff training; adequate storage; and just- in time delivery of materials. Waste measurement and waste segregation are areas that need more efficient implementation to achieve material waste minimization targets. Moreover, contractors' perceptions towards the benefits of material waste minimization revealed that this waste is primarily considered a financial problem and its minimization a cost cutting activity. In contrast, the environmental dimension was neglected by surveyed companies [9].

## 3. Methodology

In this study, quantitative method via structured questionnaire was implemented to evaluate the construction professional's perceptions about factors in management, those can contribute in production of construction material waste. This survey designed in accordance collection of data from relevant literature about causes of material waste. Pilot questionnaire were distributed to find out what people know and what they perceive as the important issues considering

construction waste. Based on responses of pilot questionnaire and discussions questionnaire was finalized to conduct survey. The collected data were analyzed by using Average Index method to get most significant causes of construction waste. In the end recommendation based on construction industry professionals are suggested to overcome construction waste problems in future construction.

### 3.1 Data Sources

The questionnaire also was used to collect detailed information about respondent’s organization, experience and impressions regarding material waste. Data was collected from two resources. Primary source of data collection was by the elects through the use of questionnaires, and site visits (observation). The secondary sources of data were obtained using the research papers. Seventy-one (71) factors causing construction material waste have been extensively studied and extracted under construction project sources such as designing phase, handling phase, workers, and management, procurement, and site conditions from the literature [11].

### 3.2 Structure of Questionnaire

Questionnaire is divided into three parts: Demographics, factors causing construction waste, suggestions and recommendations. In first part, basic details of respondents [10], in second part, causes of construction material waste based on literature studies mentioned, and in third part, respondent suggestions and recommendations regarding reduction of material waste in construction project.

### 3.3 Data Collection

The questionnaire survey was carried out by distributing a total of 150 questionnaire sets based on convenience method [3], [7], [12], [13], among 150 questionnaires 102 were received as data collection. It was found that 12 of collected questionnaires were having error considered unacceptable, and excluded from data analysis. The collected data of 90 respondents used in analysis.

### 3.4 Average Index Method for Analysis

The questions were constructed using the Likert scale. The respondents were asked to rank on a scale of 1-5 factors that cause delay and cost overrun where 1 = “Not Important”, 2 = “Least Important”, 3 = “Important”, 4 = “Very Important” and 5 = “Most Important” [2]-[5], [10]. The significant of the factors are determined by Rating & Ranking Average Calculations. Rating Scale questions calculate a weighted average based on the weight assigned to each answer choice. The rating average is calculated as follows:

$$AverageIndex(AI) = \frac{W^1X^1 + W^2X^2 + W^3X^3 + W^4X^4 + W^5X^5}{N} \tag{1}$$

where N= Total number of respondents, W<sub>1</sub> = 1 for ‘Not Important’, W<sub>2</sub> = 2 for ‘Least important’, W<sub>3</sub> = 3 for ‘Important’, W<sub>4</sub> = 4 for ‘Very Important’, W<sub>5</sub> = 5 for ‘Most Important’, X<sub>1</sub> = No. of respondents of W<sub>1</sub>, X<sub>2</sub> = No. of respondents for W<sub>2</sub>, X<sub>3</sub> = No. of respondents for W<sub>3</sub>, X<sub>4</sub> = No. of respondents for W<sub>4</sub>, X<sub>5</sub> = No. of respondents for W<sub>5</sub>.

## 4. Demography of Survey

The demography of this survey is the respondents of contractors, consultants and clients. Fig. 1(a) shows the organizational contribution of the respondents. It was found that the majority of the respondents represent client with 36.12%, followed by consultant 37.22%, and contractor's representatives are 29.16%. In term of experience in the construction industry, 38.9% of respondents had working experience of 0 to 5 years, followed by 38.9% respondents who possessed working experience of between 6 to 10, 66.66% of respondents had working experience of 10 to 15 years, and 55.53% having experience of 16 to 20 years, as shown in Fig. 1(b).

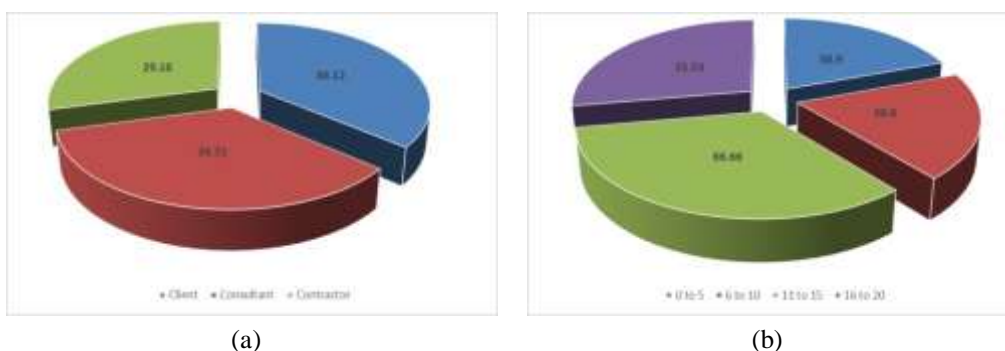


Fig. 1 - (a) The organization of Respondents; (b) The experience of Respondents

## 5. Significant Causes of Material Waste

### 5.1 Design Phase Factors

Fig. 2 shows the frequency of respondents for flaws in construction management causing construction material waste during design phase. Fig. 3 shows the average index analysis of material waste significant causes in designing phase considering all responses of client, contractor and consultant. ‘frequent design changes’ is ranked on top with average index value of 3.9, ‘last minute client requirements’ is considered as second significant cause with index value 3.63, and ‘Poor design quality’ is considered as third most significant cause of material waste in construction projects with average index score of 3.5.

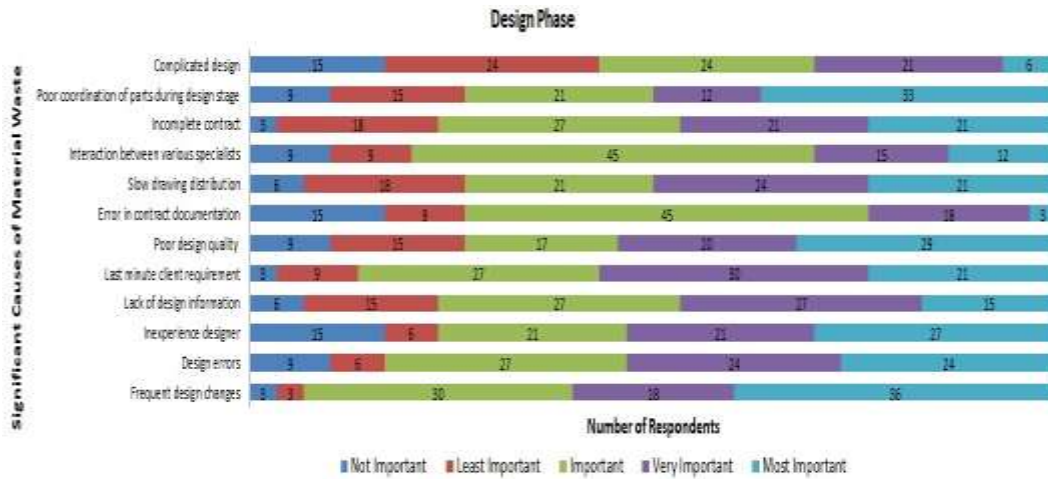


Fig. 2 - Distribution of response in design phase

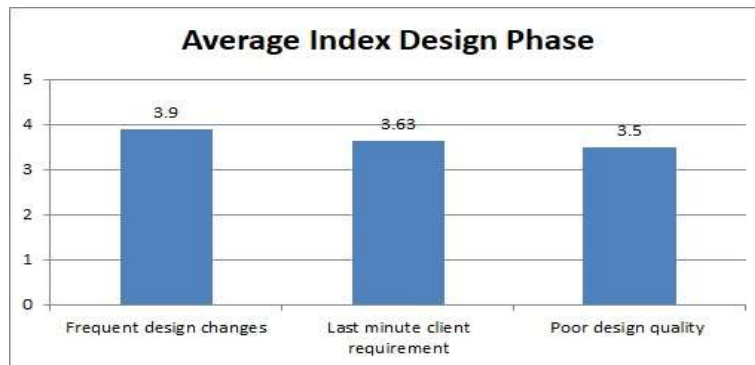


Fig. 3 - Ranking of factors causing material waste in designing phase

Table 1 shows most significant causes of construction material waste in construction projects considering client, consultant, and contractor perspective. In designing phase results from client, consultant and contractors gives idea that all those factors are inter-related with each other. Based on client perspective it is revealed that ‘In-experience designer’, ‘poor design quality’ and ‘frequent design changes’ are main causes of material waste in construction industry. However, based on consultant, ‘last minute client requirement’ and ‘poor co-ordination during design stage’. According to contractor ‘In-complete contract’, ‘frequent design changes’ are considered as main causes of material waste in construction projects.

Table 1 - Client, consultant and contractor’s prospective in designing phase

Category	Respondents	Most significant factors
Design	Client	In-experience designer
		Poor design quality
		Frequent design changes
	Consultant	Last minute client requirement
		Poor coordination during design stage
	Contractor	Incomplete contract
	Frequent design changes	

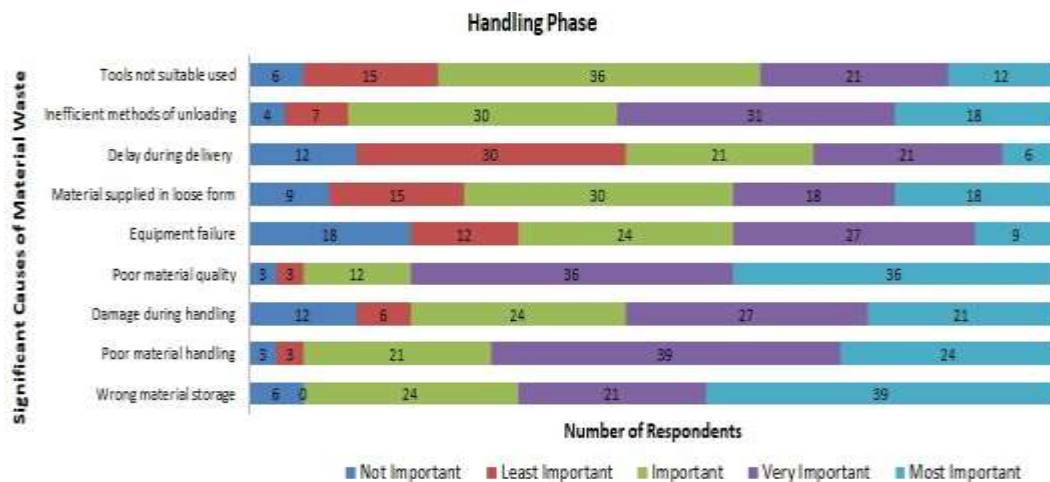
### 5.2 Handling Factors

Table 2 shows the result of factors causing construction waste for material handling management considering owner, consultant, and contractor prospective. Based on client 'Poor material handling', 'wrong material storage' and 'damage during handling' are considered as main causes of construction waste in projects. Consultant shows understanding with responses of client on 'Poor material handling', 'wrong material storage' and furthermore with consultant prospective 'poor material quality also contributes in construction waste. According to contractor 'wrong material storage' and 'tools not suitable used' are considered as main causes of waste generation in construction projects.

**Table 2 - Client, consultant and contractor’s prospective in handling phase**

Category	Respondents	Most significant factors
Handling	Client	Poor material handling
		Wrong material storage
		Damage during handling
	Consultant	Wrong material storage
		Poor material quality
		Poor material handling
	Contractor	Tools not suitable used
		Wrong material storage

Fig. 4 shows frequency of responses in material handling phase of construction management. Fig. 5 comprises three significant factors considered based average index method where 'Poor material quality' ranked as third with AI 4.1 ranked as 1<sup>st</sup>. 'Wrong material storage' with AI score of 3.97 is considered as 2nd most significant cause with AI of 3.87, and 'Poor material handling' is ranked and 3<sup>rd</sup> most significant cause of construction waste.



**Fig. 4 - Distribution of response in handling phase**

### 5.3 Workers Related Factors

Table 3 shows causes of construction waste related to workers based on client, consultant, and contractor. According to client 'workers mistake during construction' 'in-competent workers' and 'in-sufficient training for workers' are considered as main causes of construction waste generation in projects. However, consultant response is 'poor attitude of workers' and 'poor workmanship' are causing waste generation in construction projects. According to contractor 'Poor workmanship', 'poor attitude of workers' and 'shortage of skilled workers' are considered as main causes of material waste in construction projects.

A workers category contributes the 2<sup>nd</sup> largest number of significant factors causing material waste in construction project. Fig. 6 shows frequency of responses in construction phase for causes of material waste in construction projects. Fig. 7 shows the highest ranked causes related to workers are 'Worker mistakes during construction', 'lack of awareness', 'in-competent workers' with AI score of 3.8, followed by 'Poor workmanship' with AI of 3.77, followed by 'Poor attitude of workers' with AI of 3.7.

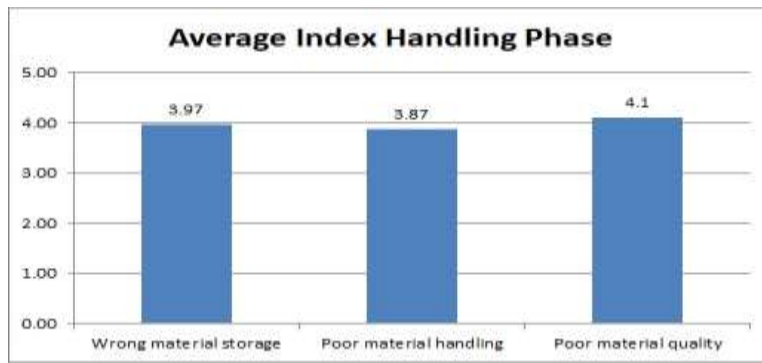


Fig. 5 - Ranking of factors causing material waste in handling phase

Table 3 - Client, consultant and contractor’s prospective about workers

Category	Respondents	Most significant factors
Client		Workers mistakes during construction
		Incompetent workers
		Insufficient training workers
Consultant		Worker's no enthusiasm
		Poor attitudes of workers
Contractor		Lack of awareness
		Poor workmanship
		Shortage of skilled workers

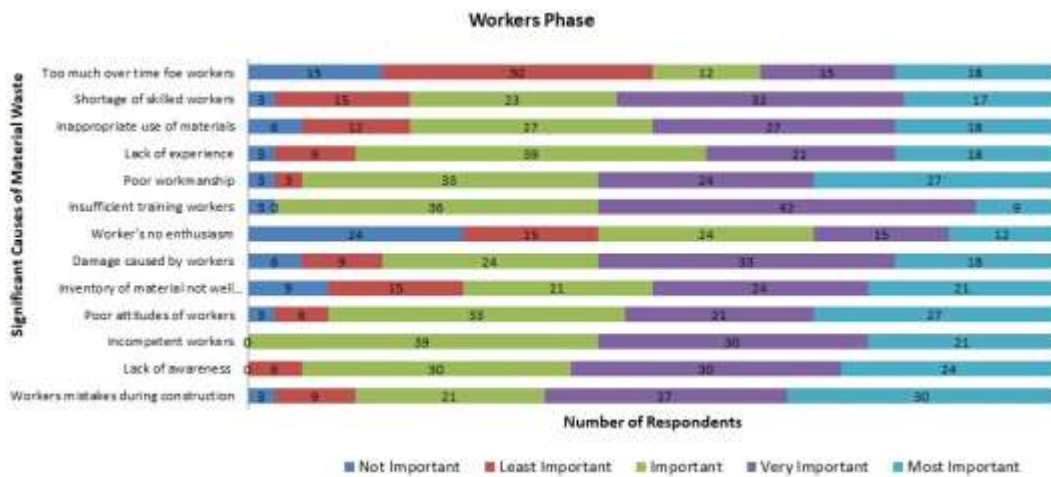


Fig. 6 - Distribution of response for workers

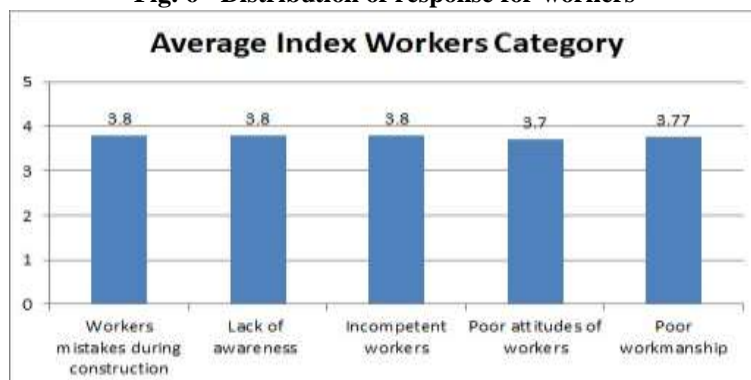


Fig. 7 - Ranking of factors causing material waste for workers



### 5.4 Management Factors

Management factors contributes the largest number of significant factors causing material waste in construction project. The frequency of factor is shown in Fig. 8. In Fig. 9, the analysis of Average Index value shows that the ‘poor supervision’ is highest ranked cause in this category with AI score of 4.17, ‘poor site management’ is second major cause with AI of 4.09, ‘poor planning’ is third major cause with AI of 4.07, followed by ‘resources problems’ and ‘lack of waste management plan’ with AI 3.9, ‘In-appropriate construction’ with AI of 3.83, ‘lack of co-ordination’ and ‘poor controlling’ are major causes with AI of 3.73.



Fig. 8 - Distribution of response in management phase

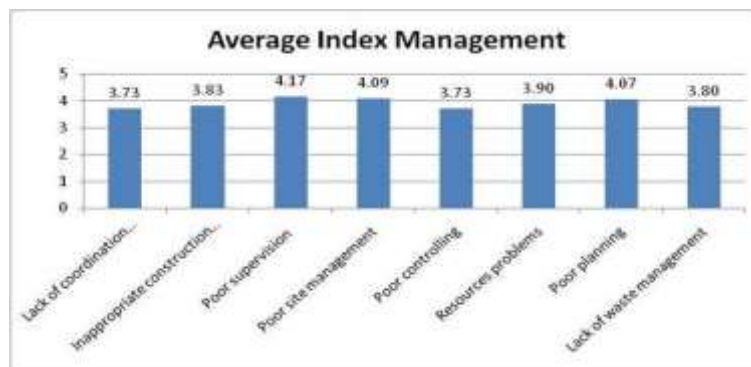


Fig. 9 - Ranking of factors causing material waste in management phase

Table 4 shows the ranking with prospective of client, consultant and contractor. In management related issues based on client 'Poor site management' and 'in-appropriate construction method' are considered as main causes of construction in projects. However, consultant responses are 'poor supervision' and 'rework' are main causes and according to contractor 'resource problems', 'rework' and 'lack of waste management' are considered as main causes of delay in construction projects.

Table 4 - Client, consultant and contractor’s prospective in management phase

Category	Respondents	Most significant factors
Management	Client	Poor site management
		Inappropriate construction methods
		Rework
Consultant		Poor supervision
		Resources problems
Contractor		Rework
		Lack of waste management

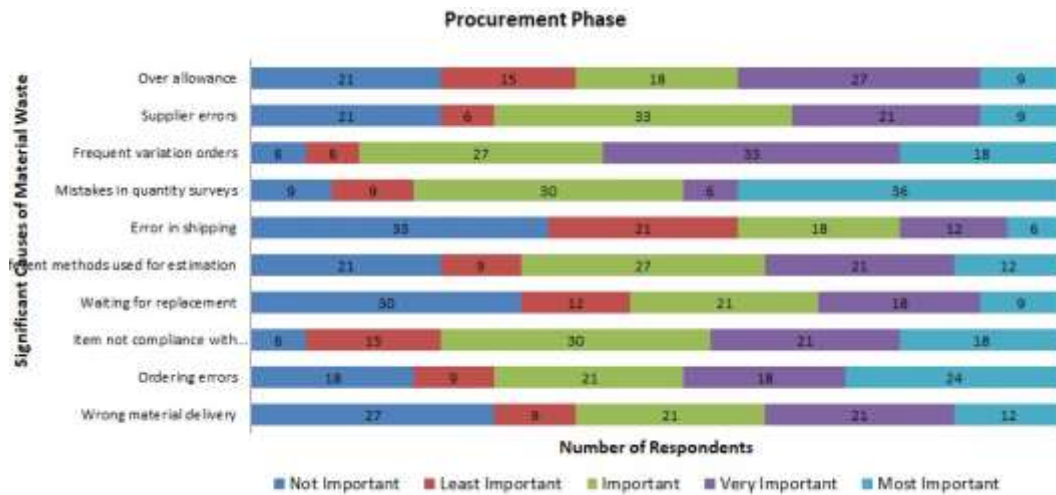
### 5.5 Procurement Factors

Table 5 shows the causes of construction waste during procurement process. According to client 'different method used for estimation' and 'frequent variation orders' are considered as main causes of construction waste in projects. However, consultant responses are 'items not compliance with specification' and 'frequent variation order' is main factor causing material waste in construction projects, and according to contractor 'frequent variation orders' and 'mistakes in quantity surveys' are considered as main causes.

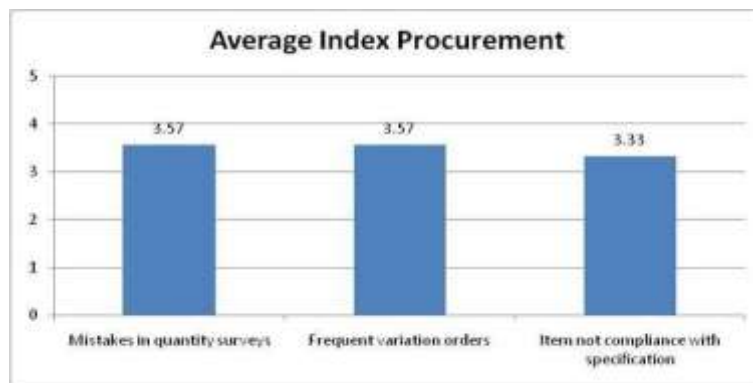
**Table 5 - Client, consultant and contractor’s prospective in procurement factors**

Category	Respondents	Most significant factors
Procurement	Client	Different methods used for estimation
		Frequent variation orders
	Consultant	Item not compliance with specification
		Frequent variation orders
		Mistakes in quantity surveys

In this category three significant factors that contributes to generation of material waste in the construction project, the frequency chart is shown in Fig. 10. The average index chart in Fig. 11 shows that the ‘mistakes in quantity surveys’ and ‘frequent variation orders’ has highest Ai score 3.57. Third cause of construction waste in this category is ‘items not compliance with specifications’ having AI of 3.33.



**Fig. 10 - Distribution of response in procurement factors**



**Fig. 11 - Ranking of factors causing material waste in procurement phase**



### 5.6 Site Condition Factors

The frequency chart is shown in Fig. 12 for factors can produce material waste in construction projects, related to this category. The average index chart in Fig. 13 shows that the ‘poor site conditions, has highest Ai score 3.45. Second cause of waste generation in this category is ‘leftover material on site’ with AI of 3.43, and third ‘waste resulting from packaging’ with AI of 3.4.

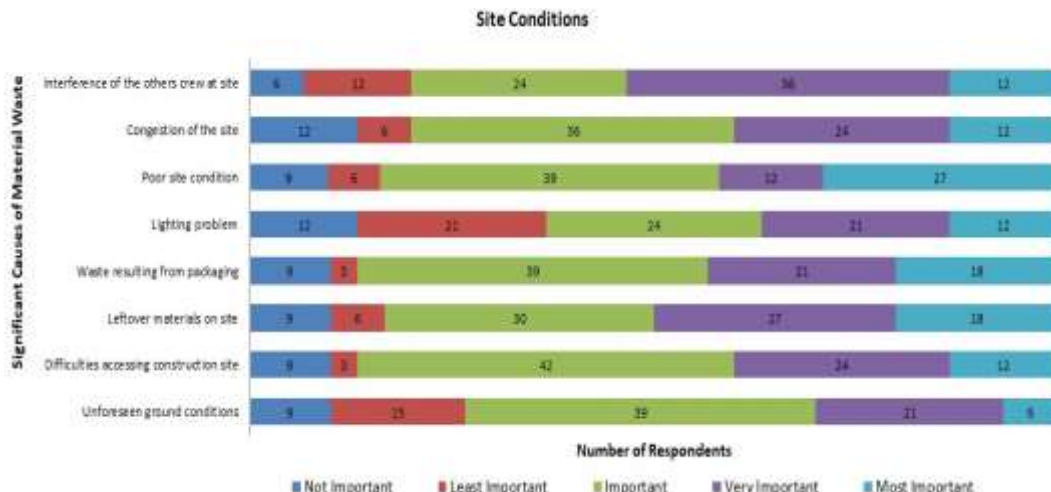


Fig. 12 - Distribution of response in site condition factors

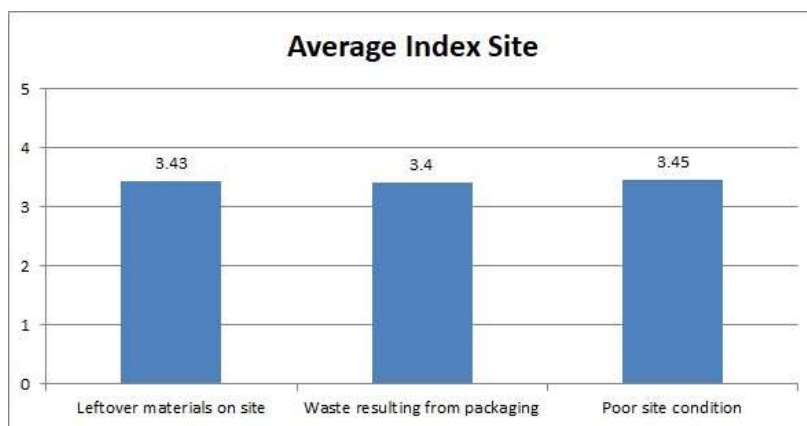


Fig. 13 - Ranking of factors causing material waste in Site conditions

Table 6 shows the causes material waste based on site conditions. According to client ‘waste resulting from packaging’ and ‘unforeseen ground conditions’ are considered as main causes of material waste in projects. However, consultant responses are ‘leftover material on site’ and ‘waste resulting from packaging’ is main factor causing of waste in construction projects, and according to contractor ‘poor site conditions’ and ‘difficulties accessing construction site’ is considered as main causes of material waste in construction projects.

Table 6 - Client, consultant and contractor’s prospective in site condition factors

Category	Respondents	Most significant factors
Site Conditions	Client	Waste resulting from packaging
		Unforeseen ground conditions
	Consultant	Leftover materials on site
		Waste resulting from packaging
	Contractor	Poor site condition
		Difficulties accessing construction site

## 6. Summary

This research has helps to identify factor causes of construction waste in construction at Muscat, and Nizwa cities in OMAN. The most significant factors causing delay in construction process (Design, Handling, Workers, Management, Procurement, and Site conditions) have been analyzed by using average index method with client, consultant, and contractor prospective. It was found workers and management related factors causing construction waste of projects as compared to all other categories. Furthermore for each stage of project most significant factors causing construction waste with respect to construction management are highlighted with client, consultant, and contractors individual and as team prospective. These findings will give a better understanding to the construction industry companies regarding flaws in management and create awareness among them for undertaking future construction projects. It is concluded that the government organizations or individual companies handling solid waste management can develop or improve legislation for construction projects waste based on this study to avoid dumping in landfill area in future.

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