

## GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES QUANTIFICATION OF CONSTRUCTION WASTE GENERATED IN CONSTRUCTION PROJECTS OF IRAQ

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### ABSTRACT

Construction industry has a vital and direct relation in development and prosperity of nations. However, expeditious population growing in addition to the huge expansion in buildings and infrastructure projects for keeping up with the varied nature of living's standards have generated enormous amounts of construction waste. Hence, this research addresses the measurement and the incidence of construction material waste (cement, sand, gravel, lime & gypsum, ceramic wall tiles and floor tiles) in two different of Iraqi project sectors, namely, private and public. Interviews, extensive literature reviews, field observations and documentary analysis of past records were adopted through this study. Results showed that both of lime & gypsum have the highest rates of construction waste among other materials. Furthermore, private projects generate much more quantities of construction waste than in public projects. This proves the commitment of the public construction projects with the standard limits for each construction material in construction site.

**Keywords:** *Construction Waste, Materials Management, Waste Management, Construction Material Losses, Iraq.*

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### I. INTRODUCTION

The construction industry is the key concept beyond the development of the socio-economic of any country. Nowadays, it is facing with several issues related to time, cost overruns in addition to enormous generation of construction waste quantities [1-3]. The construction industry has reported that unacceptable rates of construction material waste were being generated in construction sites [4]. In addition to its adverse impact not only on the financial perspective, but also adds to environmental pollution [5]. These made the construction waste as the main subject of several research works throughout the world.

The construction waste generation has created serious problems, both locally and globally. As a developing country, Iraq is confronting with the construction waste problem which has resulted in illegal dumping that adds to environmental pollution, furthermore increases project cost. This problem can be worse if not addressed properly. In this context, the research is meant to measure the construction waste generated in construction site gathered from private and public projects and establishing a comparison in construction waste between those sectors. Furthermore, indicates the causes of construction waste observed for each material separately.

### II. PROBLEM STATEMENT

Construction waste of materials has been accepted as a major issue threaten the construction industry and has substantial effects both for ecological impacts and the effectiveness of the industry [5]. The intensive rising in the number of construction projects throughout the world have increased the quantities of construction waste significantly and reached unacceptable limits. At the local scale, Iraq is facing many issues in the construction sector mostly related to project cost deviation due to the rapid increase in the construction waste generation rates. Those rates have already exceeded the permissible limits set by the Iraqi Ministry of Construction & Housing (MOCH). Thus, would motivate the researcher to conduct the current research work.

### 1. Concept of Construction Waste

There is no a comprehensive definition for the term of waste. Every researcher has defined it according to his own perspective. Hence, waste in its broadest term, by means of lean production philosophy, is defined as “any inefficiency incurred in materials, labors, equipment, or capital in larger quantities than those considered essential in building production” [6]. In simple words, Freitas defined it as “every resource that is spent in excess, further than the strict necessary to execute a service” [7]. Whereas the European Waste Framework Directive has outlined the waste definition as “any substance or object disposed by the possessor, intend to dispose or required to dispose” [8]. However, in terms of construction waste, Environmental Protection Department (EPD) of Hong Kong has defined it as “waste comprises of unwanted materials generated during construction, including rejected structures and materials, materials which have been over ordered or are surplus to requirements, and materials which have been used and discarded” [9]. In other words, it is defined as “any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client” [10]. Besides a clear comprehension about the construction waste concept, it is necessary to identify the types of construction waste in different perspectives.

### 2. Types of Construction Waste

Construction waste can be classified into two major types: physical waste and non-physical waste.

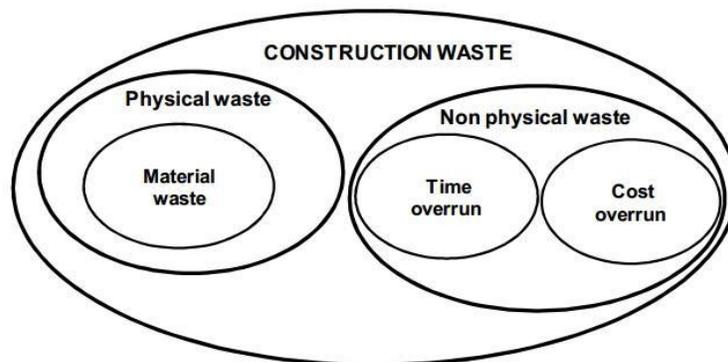


Figure 1: Construction Waste Classifications

#### Physical Waste

Physical waste, represented by materials waste, is recognized as “the debris which can be observed at any stage of construction project and have to be discarded for whatever reason” [11]. Researchers have defined waste of materials as “any material, apart from earth materials, which needs to be transported elsewhere from the construction site or used within the construction site, other than the intended specific purpose of the project due to material damage, excess, non-use, or noncompliance with the specifications or being a by-product of the construction process” [4]. It is worth mentioning that, this paper focuses on materials waste only.

#### Non-Physical Waste

Non-physical waste represented by time and cost overruns which is commonly developed during construction process. Cost overrun involves of unanticipated costs incurred in excess of the budgeted amounts. However, the duration of construction activities consists of inspection, process / reprocess, wait and move time [6]. It is worth mentioning that only process time is recognized as a value adding activity whereas the others recognized as non-value adding activities. Koskela described the value adding activity as “the activity that converts material and/or information towards that which is required by the customer” [6]. On the other hand, non-value adding activity described as “the activity that takes time, resources or space but does not add value”. The last is well-known as waste and needs an appropriate management for the purpose of reduction.

### 3. Sources of Construction Waste

Construction waste has the following sources: overproduction, transportation, movement, substitution, inventories, waiting time, processing, production of defective products and others [10,5]. Table (1) illustrates those sources attached with their descriptions.

*Table 1 Sources of Construction Waste*

Source	Description
Overproduction	Represented by excessive quantities of materials to be produced than the intended / required quantity which results in man-hours, materials and equipment wastage.
Transportation	Referred to the movements of construction materials in site. This type caused by lack of materials control when transported due to use of inadequate equipment or bad conditions of pathways adopted in site resulted from lack of planning.
Movement	Related to unnecessary movements displaced by labors in construction site. This type resulted from poor arrangement of works, ineffective work methods or inadequate equipment used.
Substitution	Referred to substitution of intended materials by expensive ones, employ qualified labors or sophisticated equipment for simple works.
Inventories	Concerned with unnecessary / exaggerated inventories of construction materials that would be transformed to waste due to inadequate storage conditions, deterioration, theft & vandalism.
Waiting time	Represented by the idle time spent by the labors gang / equipment due to lack of materials flow and synchronism
Processing	Referred to the nature of activity that consumes the intended materials which could be reduced to its lowest rates by changing the technology adopted.
Production of defective products	Related to waste caused by the non-compliance of the final product / activity with the intended specification / quality. This might result from lack of planning and control, lack of integration between design and production, poor qualification of the team work, etc.
Others	Waste of any nature different from the previous ones, such as burglary, vandalism, inclement weather, accidents, etc.

### 4. Measuring of Construction Waste

Construction waste is something tangible thus triggered considerable researches to measure it using quantitative approaches. Some of researchers attempted to establish a construction waste comparison generated in different countries whereas the others have suggested to use Waste Generation Rate (WGR) as an accurate index when dealing with such comparisons. WGR “is a brilliant indicator that assists the project manager to predict the construction waste behavior for future works, furthermore creates waste management awareness” [12]. Economical and population growth, maintenance works, seasonal variations and natural disasters are several factors that could affect adversely on WGR. In addition to the type, size and the purpose of the constructed buildings could affect on WGR.

## IV. METHODOLOGY

### 1. Data Sampling

#### *Selection of Construction Materials*

For the purpose of achieving the intended purpose of this research, six different construction materials were involved. The selection of those materials was informed by several reasons. Since their importance which plays a vital role in most construction activities, the high probability that exposed to damage in construction site and indication of several research works of excess waste at which they generate [13]. Therefore; cement, sand, gravel, lime & gypsum, ceramic wall tiles and floor tiles were involved in measuring the construction waste.

**Selection of Construction Sectors**

The varied nature of the construction sectors at which the construction waste had to be gathered made the mixed method approaches appropriate. However, two types of construction sector were involved during this study. The major aim of this point is to determine the construction waste rates variation produced in those sectors. The first type is the private project presented by AL-Ayadi Group Co. For Real Estate specialized in building of residential complexes while the second type is the public projects operated by AL-Mansour State Company for Constructional Contracts that adopts the direct implementation manner during their execution. It is worth mentioning that the first type involves only one huge construction project while the latter involves of four different construction projects.

**2. Approaches Adopted**

Many approaches have been utilized in order to reach on the required objective. Combining different approaches of data collection provides the opportunity to retrieve in-depth information from the different categories of activities. Without this mixed methodological approach, dependence on any single approach to data collection might lead to damage of valuable information. Hence, Interviews, field observations and documentary analysis of paste records have been adopted in data gathering.

**3. Data Gathering**

Pheng and Tan have stated, by means of quantitative measurements, that the construction waste is “the difference between the value of materials delivered and accepted on site, and materials used properly as specified and accurately measured in the work” [14]. According to above expression, a quantitative model is required to measure the construction waste produced. However, if it is considered that the delivered construction materials on site to be consumed on a specified activity as "Actual" and the required quantity to finish the same activity measured from design plans considered as "Estimated", simply the waste as a percentage from the Estimated quantity can be determined using the following equation:

$$\text{Wastage (\%)} = (\text{Actual} - \text{Estimated}) / \text{Estimated} \times 100 \dots\dots\dots (1)$$

**IV. RESULTS AND DISCUSSION**

As mentioned earlier, construction waste has been measured in two different construction sectors. Accordingly, the results of construction waste have been divided into two different categories, namely, private and public projects. Table (2) represents the construction waste acquired from those projects in addition to the permissible limits set by the Iraqi MOCH.

*Table 2 Construction Waste Percentage & their Causes Construction Waste*

Material	Wastage (%)			Wastage Causes Observed
	Private	Public	Permissible Limits	
Cement	10.41	6.93	6-7	<ul style="list-style-type: none"> <li>• Inadequate equipment used in site.</li> <li>• Sever handling &amp; transp.</li> <li>• Exaggerated cement mortar used in brick wall joints.</li> <li>• Inadequate coordination between brick walls and concrete structure.</li> </ul>
Sand	12.77	7.85	6-9	<ul style="list-style-type: none"> <li>• Lack of labor’s experience.</li> <li>• Excessive thickness of cement plaster and mortar bed.</li> <li>• Non-tropical of structural elements during execution.</li> <li>• Deviation in design of the concrete slab level.</li> </ul>

Gravel	9.77	8.22	6-9	<ul style="list-style-type: none"> <li>• Poor handling and transportation.</li> <li>• Non homogenous concrete mix.</li> </ul>
Lime & Gypsum	15.99	11.35	10-15	<ul style="list-style-type: none"> <li>• Poor handling of materials.</li> <li>• Material damaged due to bad storage conditions.</li> <li>• Material quality.</li> <li>• Labors experience.</li> <li>• Working accuracy.</li> </ul>
Ceramic Wall Tiles	8.41	7.87	4-7	<ul style="list-style-type: none"> <li>• Quality, integrity and size homogeneity of tiles.</li> <li>• Manner of execution.</li> <li>• Labor experience.</li> <li>• Cutting tiles and the equipment used in cutting.</li> </ul>
Floor Tiles	14.7	6.03	6-10	<ul style="list-style-type: none"> <li>• Sever storage conditions.</li> <li>• Inadequate handling &amp; transp.</li> </ul>

However, the construction sector divergence will relate significantly to the study, especially the idea of comparing the waste produced between those two different sectors. To show that, figure (2) indicates those variations of construction waste between those two different sectors:

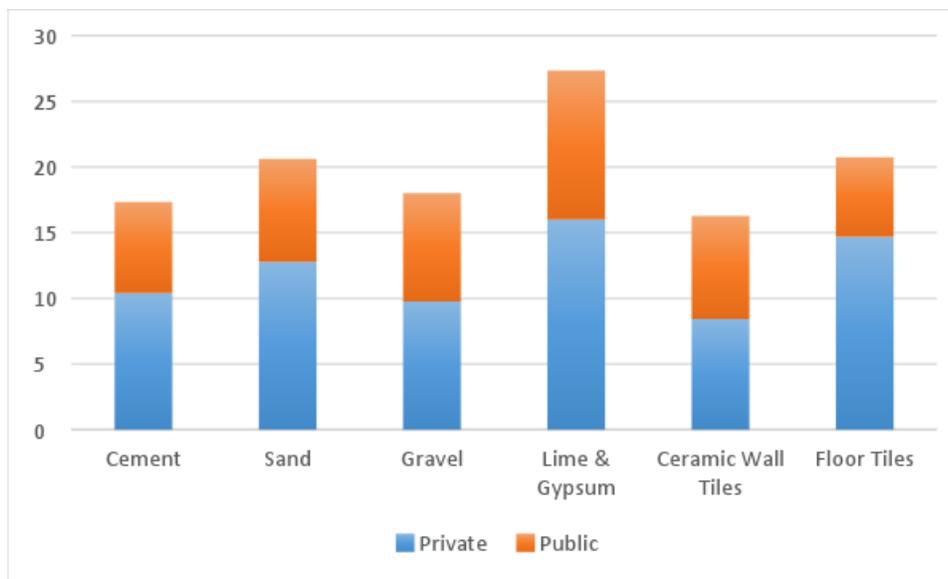


Figure 2 Variations of Construction Waste between Private & Public Projects

## V. CONCLUSION

Materials waste have been recognized as a major problem in the construction industry that have important implications on both of the efficiency of the industry and on the environmental impact of the construction projects. Measuring waste is an effective way to assess the performance of production systems at any construction site. However, this paper measures the construction waste of several construction materials that are highly exposed to damage which gathered from different construction sectors. Inadequate labors experience, resident engineer and technical staff and existence of several mistakes during project execution are considered as major causes beyond the high rates generated in privately construction projects. On the other hand, the low rates of construction waste generated in public projects indicates their commitment of the required material quantities for each activity due to the direct supervision on them.

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