# Waste Materials Recycled in Construction Projects

**Ali Ebraik[1], Zedan Hatush[2], Ali Al Barkous[3]**

*1 Project Manager, ODAC*

*2 Professor of project management, Civil engineering department, Tripoli University*

*3 General Department of Transmission Projects, General Electricity Company*

## ABSTRACT

More Construction equals more waste, more waste creates environmental concerns of toxic threat. An economically viable solution to this problem should include utilization of construction waste materials for new products which in turn minimize the heavy burden on the nation's landfills.

Recycling of waste construction materials saves natural resources, saves energy, reduces solid waste, reduces air and water pollution, and reduces greenhouse gases. The construction industry can start being aware of and take advantage of the benefits of using waste and recycled materials. Studies have investigated the use of acceptable waste, recycled and reusable materials and methods.

The use of recycling physical material such as: Metal materials (steel), cement kiln dust, Electro copper wires and cables, glass, plastic, asphalt pavement and concrete aggregate in construction is becoming increasingly popular due to the shortage and increasing cost of raw materials.

In this study a questionnaire survey targeting experts from Organization for Development of Administrative Centers (ODAC) construction Projects was conducted to investigate the current waste materials occurrence, their impact on project's constraint and the current practices of the uses of waste and recycling them in the ODAC construction Projects.

This study will present assessment of current wastes materials in ODAC projects and understanding of the current strengths and weaknesses of the practice methods or techniques for reused or recycled materials as construction materials in ODAC Projects as Case Study.

**Keywords:** Waste Material, Recycled waste Materials, Construction Materials, (ODAC).

## INTRODUCTION

In the last decades, due to the modern lifestyle, the progresses in industry and technology had led to an increase in the amount and type of wastes. The problem of waste accumulation every year is all over the world. The wastes represent a major problem for the environment because the air pollution (the dust and very fine particles which spread in the atmosphere) and leaching toxic chemicals (arsenic, beryllium, boron, cadmium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, hydrocarbon compounds, etc.) when are dumped in landfills, quarries, rivers, or oceans. The capitalization of waste is difficult because of their variety, as well as their unknown properties over time [1].

The building material industry is a domain of interest for using the wastes and researchers have tried to produce new construction materials incorporating wastes. The new generation of building materials is developing on other theories in concordance with the sustainability of environment [1].

The construction industry uses many different types of materials in large quantities. This means there are many opportunities for construction businesses to increase the amount of waste they reuse or recycle. There are many benefits associated with recycling waste from construction projects. Recycling waste reduces disposal costs and carbon emissions. It also helps comply with environmental legislation and restrictions on what can be sent to landfill. Often the materials used on construction sites are a mixture of virgin materials and those that already contain a level of recycled materials. However, there are simple, yet effective changes can make to your operations to allow more waste to be recycled [2].

While the increasing rate of urbanization is a critical concern for environmental and social reasons, this also causes a rapid increase in construction activities around the world [3] .This trend presents challenges in terms of more extraction of natural raw materials and the generation of a substantial quantity of construction and demolition (C&D) waste [4]. Construction activities consume more raw materials by weight than any other industrial sector, nearly 32% of the world's resources, including 12% of water and up to 40% of energy. Approximately 40% of all raw materials extracted from the Earth and 25% of virgin wood are used for construction [5]. Furthermore, due to the continuous rate of waste generation and the nature of the industry, it is a challenging task to achieve a zero-waste [6]. As resources are increasingly scarce, opportunities to create circular resource flows- otherwise known as the circular economy- cannot be overlooked [7]. This means more efforts should be directed towards keeping the resources in the loop for a longer period through reusing repairing and recycling [8].

## CONSTRUCTION WASTE

Construction waste can be clustered into two groups namely the physical and non-physical waste, as shown in Fig. (1) basically physical wastes related to the materials generated during the process of execution the projects such as ( steel reinforcement, Bricks, Concrete, Aggregate, Sand, Polystyrene foam, Rockwool, Plastic, Wood, Metal, water….),whereas non-physical wastes related to: defects (errors), delays, over- processing, over-production, excess inventory, unnecessary transport and conveyance of materials and equipment, and unnecessary motions and movement of people [9] during the processes of execution of the projects.

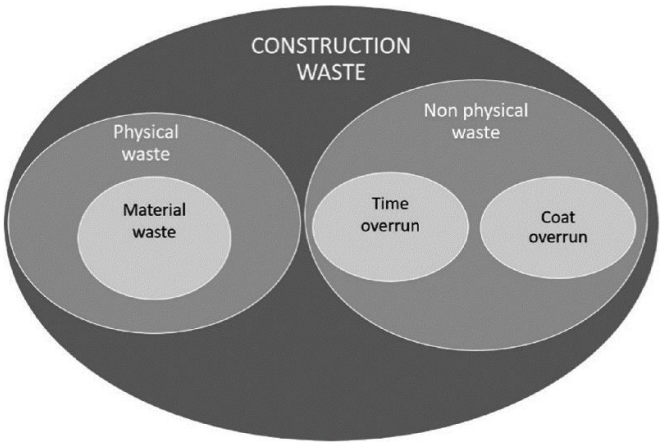


Fig. 1: Classification of Construction waste [10].

## Physical Waste

Physical construction waste is defined as waste which arises from construction, renovation and demolition activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation [11]. However, some defined directly to solid waste: the inert waste which comprises mainly sand, bricks, blocks, steel, concrete debris, tiles, bamboo, plastics, glass, wood, paper, vegetation, and other organic materials [12], [13]. Another way to understand the physical waste or construction debris can be seen in construction site. This type of waste consists of a complete loss of materials, due to the fact that they are irreparably damaged or simply lost. The wastage usually removed from the site to landfills, as shown in Figures (2,3,4).

Fig. 2: shows cement waste.

Fig. 3: shows Bricks, Concrete waste.

Fig. 4: shows wood waste.

## Non-Physical Waste

On the other hands, waste can be defined as non-value adding works. The term non-value-adding activity is used to differentiate between physical construction waste found on-site and other waste which occurs during the construction process. This type of waste also mentioned by other researcher as intangible waste, in-direct waste or non-physical waste. Womack and Jones [14] describe waste as any human activity that absorbs resources but creates no value, such as mistakes that require rectification, production of items no one wants, process steps that are not needed, unnecessary movement of employees, and people waiting for the conclusion of upstream activities. Furthermore, Koskela [15] also describe waste as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities. In other words, waste in construction is not only focused on the quantity of waste of materials on-site, but also related to several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers [16] Similarly, researcher from Indonesia defined waste as not only associated with waste of materials in the construction process, but also other activities that do not add value such as repair, waiting time and delays [17]. In the context of both construction and production, waste is primarily defined in seven categories: defects (errors), delays, over- processing, over-production, excess inventory, unnecessary transport and conveyance of materials and equipment, and unnecessary motions and movement of people [9] , as shown in Fig. (5).

Womack and Jones describe waste (Muda) as any human activity which absorbs resources but creates no value. Thus, by eliminating waste, activities can become ‘lean’; which provides more with less resources [14].

Muda. It’s a Japanese word, it means “waste,” specifically any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren’t actually needed, movement of employees and transport of goods from one place to another without any purpose, groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don’t meet the needs of the customer [14].


Fig. 5: shows Non-Physical Wastes.

## CONSTRUCTION WASTE IN (ODAC).

Libya has seen an increase in construction during the past two decades. However, many projects have experienced generation of huge amounts of waste. Also, the construction sector in Libya is an important sector that affects the country's economy. This paper will discuss and study mainly physical wastes (Materials) in one of the important organizations in Libya which is the Organization for Development of Administrative Centers (ODAC) that provides management services technical supervision and execution of all engineering construction projects for all sectors (education, health, housing, and public utilities sector …...) in different Libyan cities through the contracted companies (local & foreign) with budgets estimated in billions.

## STUDY METHODOLOGY

The study methodology consists of the following steps:

1. Development of a closed - ended questionnaire to elicit information to investigate the current waste materials occurrence, their impact on Project's Constraint and the current practices of the uses of waste and recycled them in the ODAC construction Projects.
2. Conducting questionnaire survey through postal mail and personal interviews.
3. Assessment of feedback from questionnaire survey to identify the major waste materials occurrence in the ODAC construction Projects.

The literature review was done through books, conference proceedings, internet, and leading construction management and engineering journals. Through literature review, all the waste materials were identified. In total, 22 wastes.

The questionnaire was used to conduct personal interviews with representatives from 44 engineers in ODAC Construction Company in Tripoli to get their feedback on physical waste materials and their impact on Project's Constraint. The respondents were asked to rank and score the listed wastes for their level of criticality towards Project’s Constraint impact. The survey response is analyzed in the following section.

## DATA GATHERING

### Data Collection Methods

Several variables used in this research for data collected about physical waste materials. Three major collection methods were used: The first method is an observation. Data were collected through direct observation on the site and monthly reports. The second method is through interviews, in carrying out this research, some of the project staff and project managers have interviewed to obtain information about the main physical waste materials occurrence in ODAC. The third method involves collecting data from respondents through questionnaires.

### Data Analysis Tool

Statistical Package for Social Sciences (SPSS) is used for statistical analysis of data.

### Reliability Test

A 10 simple size as a Pilot study to measure and ensure reliability of quantitative data. The Cronbach’s Alpha Reliability Coefficient for Likert-Type Scales test was performed. The overall Cronbach’s Alpha reliability coefficient for 22 items is 0.866 which is highly acceptable. (Note that a reliability coefficient of 0.70 or higher is considered "acceptable" in most management research).

## RESULTS AND DISCUSSIONS

This section deals with the analysis of the information gathered from the questionnaire survey and includes the identification of the current waste materials occurrence, their impact on project constraints and the possibility of recycling them in the ODAC construction Projects.

The analysis and discussion about the questionnaire survey is organized in items as following:

### Sample Size Descriptive Statistics

The response sample included 50 responses, where 44 responses were received. The response rate is 88%. From analysis of general information of response, it could conclude some important characteristics of the sample:

The majority of the study sample are from "Tripoli office" represented 70% from the Sample, while the minority 30% of the sample related to "Technical Department" their numbers, most of them have a long experience (more than 15 years), and the highest percentage (the majority response) of the study subjects had their educational level (Bachelor's Degree), where repented (55%).

### Identification of the Waste Materials Occurrence

The survey identified 22 wastes that currently exist in ODAC Construction projects. Respondents were asked (Always, Frequent, None) to check if these wastes exist in their construction projects. Each waste is ranked or organized rated on a scale where 1 having the lowest score and 3 the highest score.

A histogram diagram of 22 wastes is presented as shown in Fig. (6), the assessment of current construction wastes according to the respondents' options. Its note that the " water" is ranked in the first waste in ODAC Construction projects, with the arithmetic mean is (2.68), then the waste "Hollow & Solid Concrete Blocks / Bricks" (2.45), and waste " Tiles: Terrazzo - Ceramic - Porcelain"(2.32).

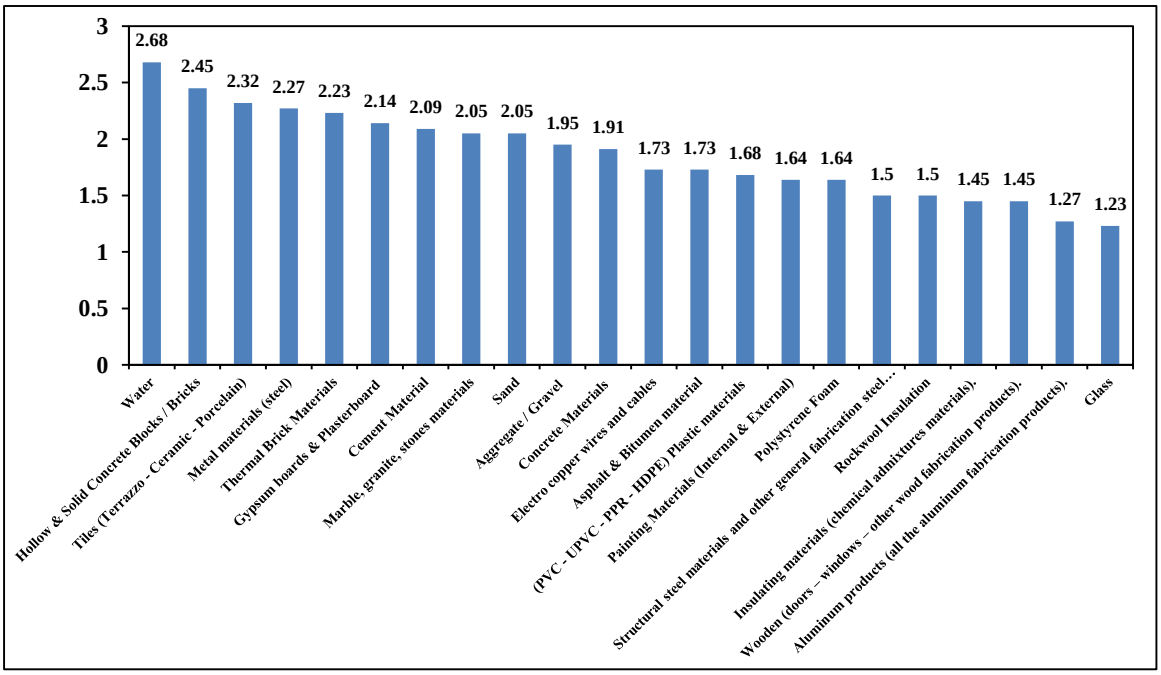


Fig. 6: A histogram diagram of 22 wastes

Based on Fig. (6) the overall extent of the 22 construction wastes in terms of the % (relative frequency) of each occurrence in all answers. As shown in Fig. (7), 68% of construction managers believe that these wastes exist in their project either, frequently, or always.

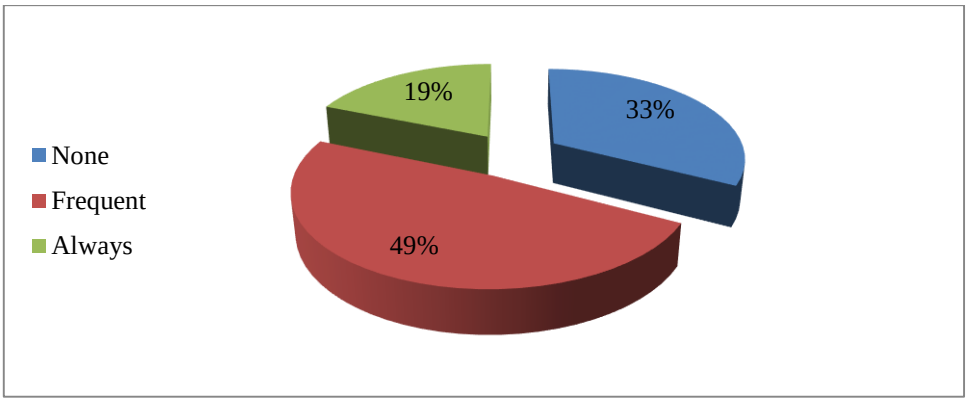


Fig. 7: Relative frequency

## Impact of Wastes on Costs, Quality, and Time in ODAC construction

This section explores statistical analysis about the impact of physical wastes on Cost, Quality, and Time in ODAC construction projects. The survey analyzed the impact of the identified 22 wastes. The respondents were asked to assess the impact of these wastes on the cost (C), quality (Q), and speed (time, T) of the ODAC construction project. Impact is classified as High, Medium, or Low.

Table (1) and Fig. (8) show the % (relative frequency) of the assessment of the overall impact 22 current construction physical wastes on the Cost, Time, and quality of ODAC projects, also Table (2) shows the assessment of the overall impact 22 current construction wastes on the Cost, Time, and quality of ODAC projects based on assembling score in each category.

Table 1: The % (relative frequency) of the assessment of the overall impact 22 current construction wastes on the Cost, Time, and quality of ODAC projects.

| **Constraints / Impacts** | **High** | **Medium** | **Zero** |
|---|---|---|---|
| Cost | 30% | 55% | 15% |
| Time | 11% | 53% | 36% |
| Quality | 5% | 27% | 68% |

As shown in Fig. (8) and table (1), only 15% believe that construction physical wastes have zero impact on cost and 36% believe that they have zero impact on time. However, 68% of construction managers believe that the identified construction wastes have zero impact on quality.

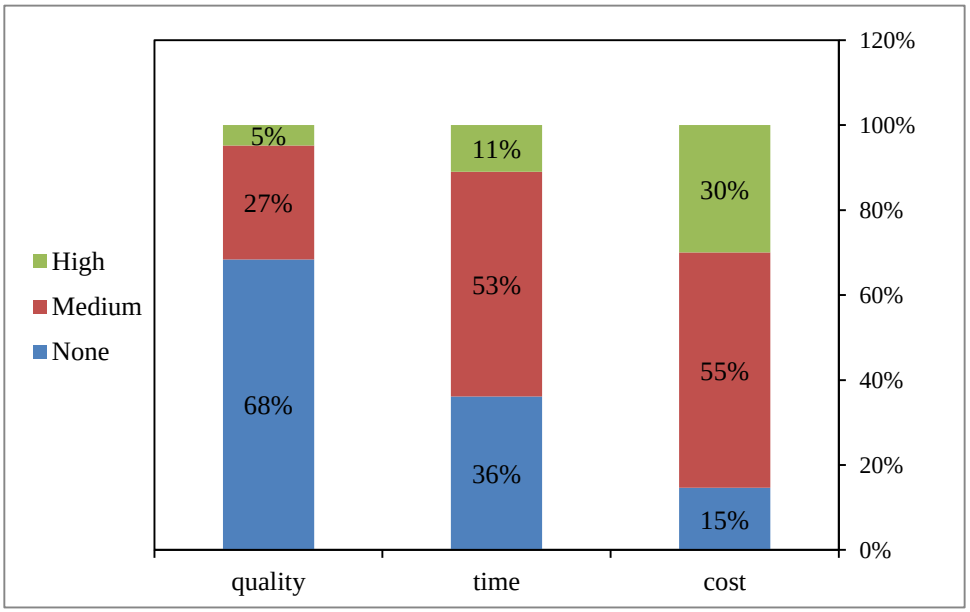


Fig. 8: The % (relative frequency) impacts of construction wastes.

Table 2: The assessment of the overall impact 22 current construction wastes on the Cost, Time, and quality of ODAC projects based on Scores.

| Constraints / Impacts | High | Medium | None | Total |
|---|---|---|---|---|
| **Cost** | 290 | 536 | 142 | 968 |
| **Time** | 106 | 512 | 350 | 968 |
| **Quality** | 46 | 260 | 662 | 968 |
| **Total** | 442 | 1308 | 1154 | 2904 |
| | **15%** | **45%** | **40%** | **100%** |

As shown in Table (2), the majority of construction managers **(**about 60%**)** believe that the identified wastes have some impact on project cost, quality, and time.

## Evaluation of the Recycled Physical Waste Materials

This section explores statistical analysis about the possibility of recycled of physical wastes that mentioned in section (6). The respondents were asked to assess the recycling of 22 physical wastes in the ODAC construction project. Assessment is classified as always, Frequent, or none.

A histogram diagram of these 22 wastes is presented as shown in Fig. (9), the assessment of recycling wastes according to the Respondents options. Its note that the waste "Metal materials (steel) “could be recycled / Reusing, and it’s ranked in the first waste in ODAC Construction projects, with the arithmetic mean is (2.73), then the waste "structural steel materials and other general fabrication steel works like partitions, stairs doors, windows …" (2.50), and waste " Electro copper wires and cables"(2.45).

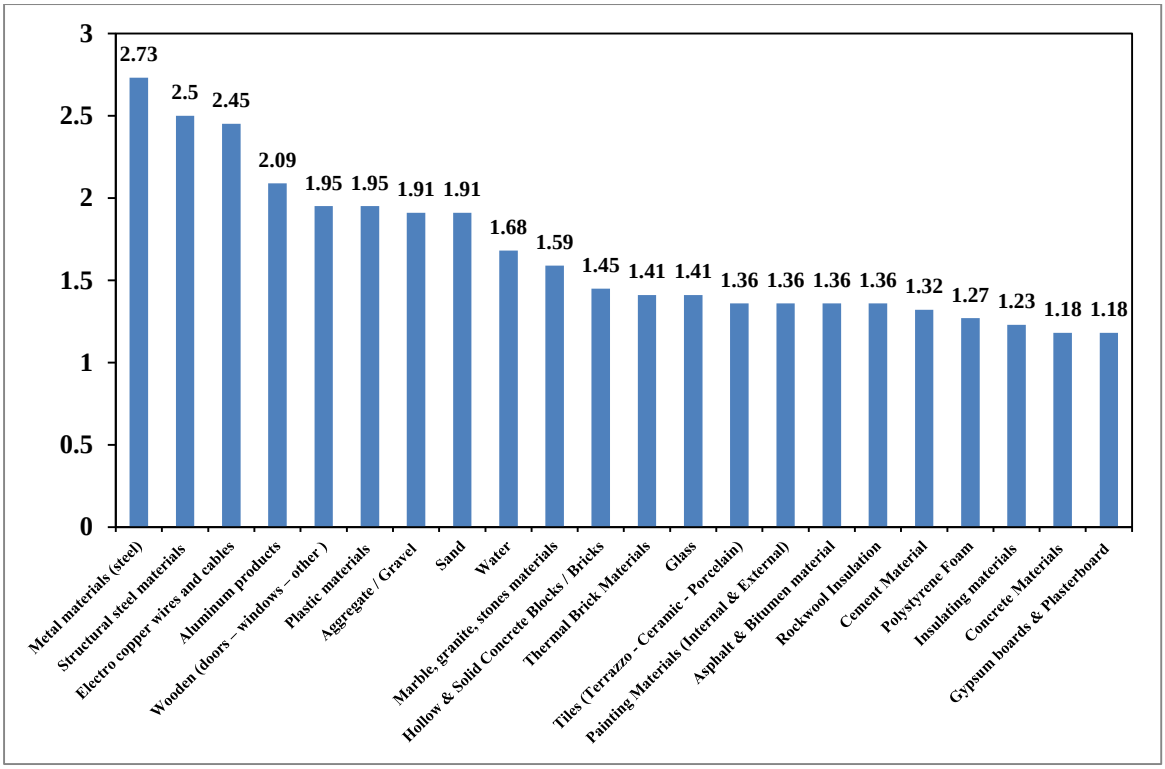


Fig. 9: Evaluation of the recycled physical waste materials

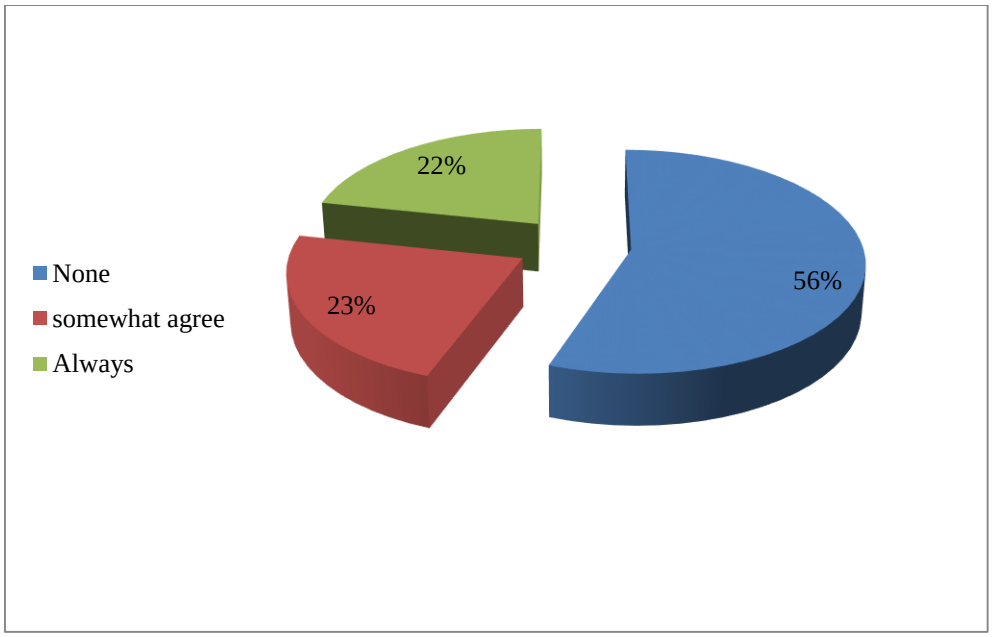


Fig. 10: relative frequency

Figure 10 shows the overall extent of the 22 recycled construction wastes in terms of the % (relative frequency) of each occurrence in all answers. Forty five percent of construction managers believe that these wastes could be recycled in their project either, somewhat agree, or always.

## Obstacles / Challenges of Recycling the Physical Waste Materials.

This section explores statistical analysis about the obstacle for recycling of physical wastes in ODAC Projects. The respondents were asked to assess the 9 obstacles for recycling of physical wastes in the ODAC construction project. Assessment is classified as agree, somewhat agree, or disagree.

A histogram diagram of these 9 obstacles is presented as shown in Fig. (11), the assessment of obstacles according to the respondents' options. It is noted that the "Lack of education "ranked in the first obstacle in ODAC Construction projects, with the arithmetic mean is (2.68), then the obstacle "equipment" (2.66), and "cost"(2.64).

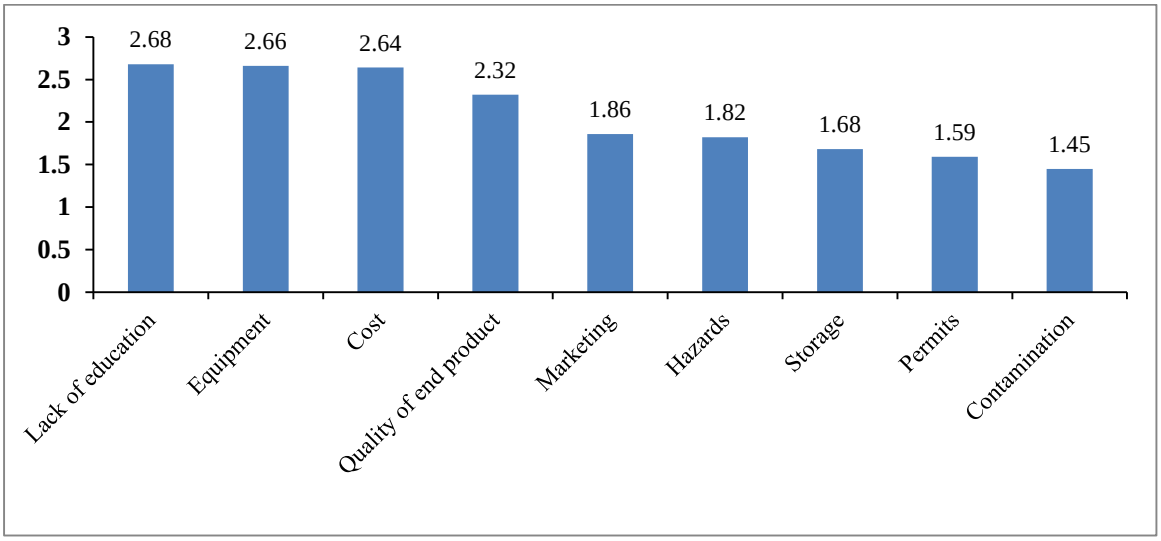


Fig. 11: A histogram diagram of nine Challenges of recycling the physical waste materials

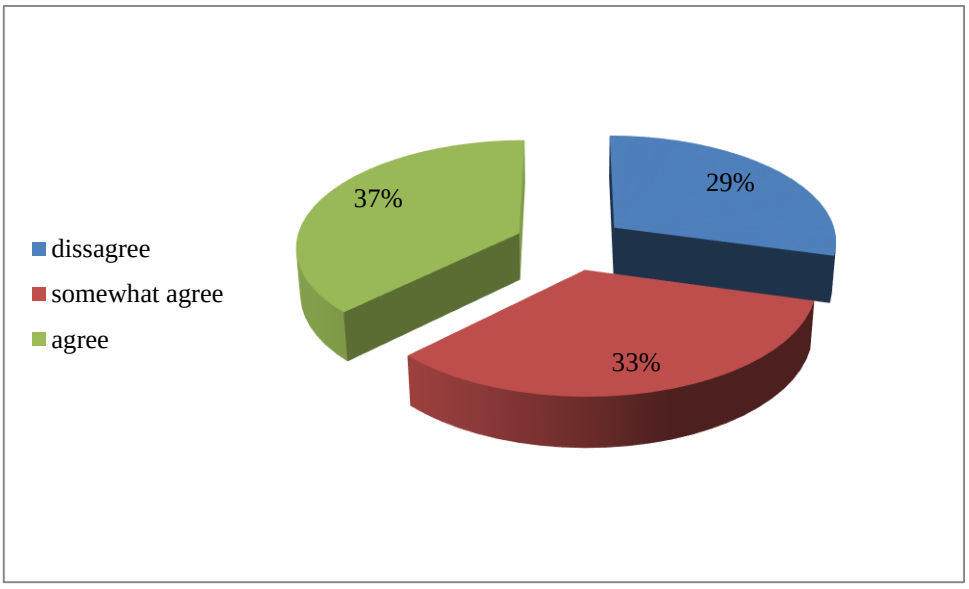


Fig. 12: Relative frequency

Figure 12 shows the overall obstacles that could be faced construction physical wastes for recycling in terms of the % (relative frequency) of each occurrence in all answers. Also 70%

of construction managers agree these obstacles could be the main causes for the don't use the recycling of physical wastes in their project.

## CONCLUSIONS AND RECOMMENDATIONS

Review of several studies suggested that the use of recycled materials has a positive impact through different aspects. This includes the benefits in enhancing sustainability of the construction industry while reducing cost, providing solutions to environmental pollution, and reducing the need for natural resources.

In this study, a questionnaire survey was conducted to find out the current practices in using waste and recycled materials in the construction industry.

From this sample, the most common physical material that could be recycled was Metal materials (steel); followed by Structural steel materials and other general fabrication steel works. The most obstacles for the construction Companies for recycling material was Lack of education; followed by Equipment and Cost. Results indicated that some sample sizes were not aware of the availability, quality of the materials' performance, cost savings, or any other benefits including environmental benefits.

It is, thus recommended; more data and better documentation are needed to encourage the use of waste and recycled materials in the construction industry. The government should invest in the development of Sustainable construction and demolition waste management infrastructure as well as a master plan for developing infrastructure to adapt the new strategies required to guide future developments in waste management.

Construction companies should be persuaded of the significance of establishing internal departments for managing Construction waste.

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