Material recycling & minimization of construction waste

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Abstract— According to the rapid natural growth in Gaza strip, construction wastes increased up to 25% of total quantity of solid wastes. In addition, construction wastes are costly. For example, in the United States, wages of disposed construction wastes sector costs 50,000 $ per 100 housing units.

This paper aims to define the types of construction wastes, find ways to decrease the quantity of construction wastes, handle the related regulations, give awareness for the interested in the construction management.

This paper will utilize the descriptive analytical approach, using previous studies and studying experiments of other countries. The paper results will define techniques to minimize the quantities of construction wastes and the costs of disposing them, and will study how to reuse or recycle these wastes.

Index Terms— Material recycling & minimization, construction waste.

I. INTRODUCTION

Gaza population reached up to 1.7 million because of the rapid natural growth, which is estimated by 3.4% at the end of 2013. People in Gaza strip are moving towards small families rather than big and branched ones. These changes lead to the need of more housing units, which estimated by 11,000 units yearly till 2017.

Automatically, construction wastes increased up to 25% of total quantity of solid wastes, and the daily total quantity of Gaza’s city solid waste is 600 ton approximately. In addition, construction wastes are costly. For example, in the United States, wages of disposed construction wastes sector costs 50,000 $ per 100 housing units.

This paper aims to:

1) Define the types of construction wastes and its management basics.
2) Find ways to decrease the quantity of construction wastes.
3) Handle regulations related to construction management (if exists).
4) Give awareness for the interested in the construction management to achieve sustainable development.

This paper will utilize the descriptive analytical approach, using previous studies and studying experiments of other countries. The paper results will define techniques to minimize the quantities of construction wastes and the costs of disposing them, and will study how to reuse or recycle these wastes.

II. THEORETICAL PART

Wastes generated on the construction site can be classified in the following three classes according to their origin:

1. Building waste, generated during the construction process due to defects, damages, breakage or due to excess.
2. Packaging waste, generated from packaging of materials and products delivered to construction site.
3. Wastes produced by workers, similar to municipal waste such as paper, glass, cans …

The main types of waste from construction activities are follows:

- Wood
- Metals
- Mineral debris (such as stone, bricks, mortar and concrete)
- Plastics
- Papers and cardboards
- Glass
- Hazardous wastes (such as paints and glues)

There are also other specific wastes, depending on the type of construction and materials used, such as plaster, gypsum board or carpets.

The 5R approach to minimize waste:
The Figure below shows the 5R waste hierarchy to
prioritize waste Minimization option:

- **Reduce**
- **Re- Use**
- **Recycle**
- **Recover**
- **Residual disposal**

**Figure1: The 5R Approach to Minimize Waste**

**Reduce:**

In order to reduce construction wastes many steps should be taken:

- a. Draw a waste management plan.
- b. Assign a senior staff member with an interest in waste minimization.
- c. Set realistic waste reduction targets.
- d. Reward your team if waste reduction targets are met.
- e. Inform the team.
- f. Design considerations: Encourage designers to use stand and product diversions.
- g. Material estimates: Provide detailed plans to define accurate material quantities needed.
- h. Incentivize subcontractors: making them responsible for the supply of materials and responsible management of any waste.
- i. Prevent unauthorized public dumping.

**Re- Use:**

- a. Builders’ re-use: Several waste materials can be readily re-used.
- b. Re-use by homeowners and others. Useful excess materials such as (Leftover paint, fixtures and fittings) can be neatly stored for the homeowner’s future use.

**Recycle:**

Most construction waste is recyclable and to achieve a perfect recycling process:

- a. Preferred waste operators: Contract with the better skip company as a part of your waste management plan.
- b. Onsite sorting and Re- use of materials:
- c. Lunch waste: The senior should provide a dedicated rubbish bin or bag for workers Lunch wrappers, food scraps,.... A recycling bin for bottles, cans, newspapers.

**Cost analysis of construction & Demolition Waste Management:**

Cost of management of C & D waste $C_m = C_{col} + C_{sort} + C_{store}$

Where:
- $C_{col}$ = cost of collection and onsite transport of waste material.
- $C_{sort}$ = cost of sorting waste materials on - site.
- $C_{store}$ = cost of storing waste materials on - site.

Cost of Landfill Disposal $C_{LF} = C_M - C_{sort} + C_{TLF} + C_{Disposal}$

Where;
- $C_M$ = Total cost of processing dry wall waste Module.
- $C_{sort}$ = cost of sorting materials.
- $C_{TLF}$ = Transport cost of materials to nearest Land Fill.
- $C_{Disposal}$ = cost of material weighing, admission & disposal at Land Fill.

Cost of Recycling $C_{Rec} = C_{M} + C_{Rec} + C_{ADM}$

Where;
- $C_{Rec}$ = Transport cost of material to nearest recycling facility.
\[ C_{ADM} = \text{cost (benefit) of material admission to recycling facility.} \]
Cost of Reuse \( C_{RU} = C_M + C_{TRu} + C_{process} - B_{Ru} \)

Where:
- \( C_{TRu} \) = Transport cost of materials to off-site or on-site processing center.
- \( C_{process} \) = Cost of processing material.
- \( B_{Ru} \) = Benefit of reuse.

**III. Cost analysis of construction & Demolition Waste Management in Gaza Strip**:

The cost of management of C & D waste \( C_m = C_{cde} + C_{sort} + C_{store} \)
\( C_m = 10S + 4S + 1S = 15S/\text{Ton/Day} \)
Cost of Landfill Disposal \( C_{LF} = C_M - C_{sort} + C_{TLF} + C_{Disposal} \)
\( C_{LF} = 15S - 4S + 3.5S + 1S = 15.5S/\text{Ton/Day} \)
Cost of Recycling \( C_{Rec} = C_M + C_{TR} + C_{ADM} \)
\( C_{Rec} = 15S + 3.5S + 10S = 28.5S/\text{Ton/Day} \)
Cost of Reuse \( C_{RU} = C_M + C_{TRu} + C_{process} - B_{Ru} \)
\( C_{RU} = 15S + 3.5S + 10S - 10S = 18.5S/\text{Ton/Day} \)

According to the above cost analysis for the different ways to get rid of construction and demolition waste, it appears that dumping wastes has the least cost, but if we consider the high cost for limited land in Gaza strip, we will find that the dumping cost will rises by 55 daily, so reusing construction and demolition wastes is the best and most economic solution in Gaza Strip.

**IV. Assessment of legal situation related to solid wastes in general and construction wastes in particular**:

Legislation related to solid waste management is usually fragmented, where there are several laws (e.g. public health law, MOLG law, Environmental law etc….), which include some clauses on rules/regulations regarding SWM.

The rules and regulations are enforced by different agencies which often leads to:

- Duplication of responsibilities of the institutions involved.
- Gaps/missing elements in the regulatory provisions for the Development of effective SWM system.
- The existing laws don’t give enough attention to construction waste management and minimization.

To achieve the effectiveness of legislation, more clauses must be added relevant to construction waste management in details, in addition to the necessity to avoid the duplication of responsibilities, and the enforceability should be handled in order to reach sustainable development SWM system.

**V. Case Study 1**:
The case study is a construction pilot project in Malaysia with an area of 49,662m², which is located in “University kebangsaan Malaysia”, Bangi, Selangor.
The construction wastes categorized by its components, such as soil, sand, bricks, concrete, wood, metal, roofing materials and plastic & packaging materials, which gave the following percentages according to weight.

<table>
<thead>
<tr>
<th>material</th>
<th>percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete &amp; aggregate</td>
<td>65.8%</td>
</tr>
<tr>
<td>Soil &amp; sand</td>
<td>27%</td>
</tr>
<tr>
<td>Wood materials</td>
<td>5%</td>
</tr>
<tr>
<td>Bricks &amp; blocks</td>
<td>1-16%</td>
</tr>
<tr>
<td>Metal products</td>
<td>1%</td>
</tr>
<tr>
<td>roofing materials</td>
<td>0.2%</td>
</tr>
<tr>
<td>plastic &amp; packaging materials</td>
<td>0.05%</td>
</tr>
</tbody>
</table>

The advisor on the site practiced waste minimization & recycling, where 73% of the waste materials is reused & recycled. The highest amount of reused materials was concrete comprising 67.6%, followed by soil & sand (27.33%), wood (4%).
brick & blocks (0.64%), metal (0.27%)……etc.
Economic feasibility is carried out and gave the following results:
Table 2: Net benefit for reusing and recycling of construction waste materials on the project site:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value (ringgit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Benefits</td>
<td>1055796</td>
</tr>
<tr>
<td>Total costs</td>
<td>198754</td>
</tr>
<tr>
<td>Net benefits</td>
<td>857042</td>
</tr>
</tbody>
</table>

The net benefit of reusing & recycling on site is estimated by 2.5% of the total budget of the project. Thus Reusing & Recycling of waste materials significantly affect contractor’s profit

VI. CASE STUDY 2

Christchurch City Council as of the “Target Zero” Waste minimization funded a 6-month project conducted by “Merz” company. Thus, four construction projects by “Hawkins” and “Fletchers” were studied.

These projects were successful, with reductions in waste disposal volumes of 20 – 40% and costs of 10 – 80%.

The four projects were led by 16 foremen who have the responsibility for waste minimization.

The efforts to minimize construction wastes resulted in the following:

Table 3: Summary of solid waste and cost savings

<table>
<thead>
<tr>
<th>Case site</th>
<th>Waste to landfill (m³)</th>
<th>Diverted materials (m³) [% of total]</th>
<th>Net cost of waste removal</th>
<th>Cost without diversion [% saving]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hagly college</td>
<td>92</td>
<td>41 [30]</td>
<td>310$</td>
<td>1920$ [84%]</td>
</tr>
<tr>
<td>St. Martins</td>
<td>240</td>
<td>68 [22]</td>
<td>3340$</td>
<td>3720$ [10%]</td>
</tr>
<tr>
<td>College of education</td>
<td>48</td>
<td>33 [41]</td>
<td>1370$</td>
<td>2290$ [40%]</td>
</tr>
</tbody>
</table>

The pilot study also highlighted several key factors that affect the achievement of construction wastes minimization aim:

1) Clear economic incentives are needed to encourage waste minimization.
2) Local authorities play a key role in overcoming initial barriers.

VII. APILOT PROJECT

A pilot project is conducted in Rafah, Where a CDW recycling plant was established by the Italian Development cooperation Program (IDCP) in 2005. It is equipped with a small jaw-crusher having a maximum capacity of 60tons/hr. Two Laboratories (the one at the Islamic university, and the other at the Engineers syndicate) were engaged to test the recycled debris, which concluded that the recycled aggregates were acceptable for use in concrete (particularly for non-structural applications and concrete hollow blocks and very good for use as a road sub-base).

A test road was constructed with recycled CDW aggregate; the test results were very encouraging.

Consequently, IDCP planned to denote several big crushers to clear the Gaza Strip of CDW within 2 years.

A diploma thesis prepared in 2005 by Samuel Schmidt, a student of the Fachhochschule Beider Basel, in Muttenz, Northwest Switzerland, on “Recycling and Reuse of construction and demolition waste in Palestine”. The thesis shows that the aggregate produced would last for 6 years of new construction, so that the bulk of it would have to be stored somewhere and would encourage illegal dumping of surplus CDW.

The thesis concludes that “the recycling of CDW in Palestine is possible, it would solve many problems, it is profitable, and it would make Palestine a little bit more independent.”

VIII. CONCLUSION:

dumping wastes has the least cost, but if we consider the high cost for limited land in Gaza strip, we will find that the dumping cost will rises by 5S daily, so reusing construction and demolition wastes is the best and most economic solution in Gaza Strip.
IX. Recommendations:
For the interested in the construction management:

1) To reduce on-site waste generation, coordination among all those involved in the design and construction processes is essential.

2) Government should enact laws and establish policies that engender positive attitudes towards waste minimization at all levels in a construction industry.

3) In collaboration between government agencies and construction industry, guidelines for preparing waste management plans should be developed.

4) The construction industry should also adopt Low waste and environmentally friendly technologies onsite.

5) Government should give incentives to the construction industry to encourage the reduction, recycling and re-use of construction waste.

6) Construction organizations should also provide waste reduction training to site staff to raise their environmental awareness.

7) It is important to develop information systems which gather & analyse data about the quantity and quality of wastes.

8) Proper market for recycling and reusing of waste will require an aggressive marketing effort to locate markets to sell waste material to be recycled.

9) Industry professionals and building homeowners will educate and be educated concerning problems like useful utilize, effective methods for identification and separation of wastes, and economically viable means that promoting reducing total waste disposed.

10) Effective management of building – related waste needs coordinated action of governmental, business, and skilled teams and their activities.
REFERENCES


