Construction Demolition Waste Management in Lebanon

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ABSTRACT

The significant amount of waste generated from construction demolition has become a chronic problem in Lebanon. In the city of Beirut alone, approximately one million ton of construction demolition waste (CDW) has been generated over the past two years. The country is suffering from a constant problem in the management of its solid waste; and therefore, devising methods to manage the amount of CDW is a must and is the primary goal of an ongoing research at the American University of Beirut. This paper presents the first major step in this research effort. The paper studies the quantification, composition, and managing of CDW in Lebanon by examining three case studies consisting of 50 to 60-year old buildings being demolished for reconstruction. Based on the case study analysis and a set of interviews conducted with demolition contractors, the paper proposes a set of rules and regulations necessary for proper handling of CDW in the context of the Lebanese construction industry.

Keywords: construction demolition waste, demolition methodology, waste management, sustainability.

INTRODUCTION

Even though construction demolition waste (CDW) constitutes a main portion of the solid waste produced in Lebanon, neither a management plan nor laws to regulate its processing are in place. Also, the country is lacking data on the amount of demolition waste generated, its composition, and documentation of the methods used to handle and dispose the resulting material. Part of the generated CDW is being reused in applications such as backfilling, port expansion, and sea reclamation. Other individual constituents, such as steel, are being salvaged for reuse or recycling in Lebanon and neighboring countries. However, the majority of the CDW is being illegally dumped in empty quarries or valleys.

This paper examines the current practices adopted in Lebanon for handling of CDW. First, the paper estimates the quantity of waste generated in the city of Beirut and two other municipalities (Zalka and Jdeide) within the Greater Beirut metropolitan area. The paper also describes the demolition procedures adopted, the resulting material composition, and their corresponding destinations. The paper concludes with a set of recommendations for implementing a CDW management plan in Lebanon and other developing countries.

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BACKGROUND

Construction and Demolition Waste: A Working Definition

Construction and demolition waste is a term widely used when referring to waste resulting from the construction industry. As the term implies, the waste is derived from both construction and demolition activities. According to Poon et al. (2001) and Fatta et al. (2003), construction and demolition waste refers to a wide variety of materials resulting from different activities and sources:

- Soil, rocks, and vegetation resulting from excavation, land leveling, civil works, and site clearance,
- Roadwork and associated materials (such as asphalt, sand, gravel, and metals) resulting from road maintenance works,
- Worksite waste materials (such as wood, plastic, paper, glass, metal, and wires) resulting from construction, repairing, and renovation works, and
- Demolition waste or debris (e.g., bricks, concrete, soil, gravel, gypsum, and porcelain) resulting from total or partial demolition of buildings.

Broad Overview of CDW

The recent boost in construction activities worldwide, coupled with limited space for new development, has led to an increase in the number of facilities to be demolished. This, in turn, is causing a major strain on the few existing landfills and is resulting in the depletion of raw materials. Countries are looking for ways to reduce the effect of CDW by implementing management strategies that aim at minimizing the waste and diverting it from landfills (Warren et al. 2007). An effective waste management plan is the cornerstone for successful CDW recycling and should begin as early as possible in any construction project (Lennon 2005).

The first step in setting up a waste management plan consists of estimating the generated quantities of CDW (Del Rio Merino et al. 2010, and Lage et al. 2010). This leads to the next step of estimating the various types and composition of waste produced and comparison with the available capacity of waste treatment facilities and engineered landfills. The data gathered help in estimating the cost of sorting, treating, disposing, and/or recycling the generated waste materials.

The materials resulting from demolition activities highly vary from one country to another depending on the characteristics of the construction industry, and from one project to another depending on its type and size. As such, the composition of waste materials for a particular site should be estimated prior to demolition. This is typically done through a survey executed by the manager of the demolition project (Symonds Group 1999). Knowing the composition of CDW is important as it indicates the types and quantities of materials that can be recycled or reused.

One of the main parameters affecting the management of CDW is the demolition method adopted (Kourmpanis et al. 2008). The method by which a building is demolished affects the composition and characteristics of the resulting materials (Poon et al. 2001 and Fatta et al. 2003). As illustrated by Kourmpanis al. (2008), demolition methods can be broadly classified into the following three groups:

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- **Conventional demolition:** where buildings are demolished using explosives, wrecking balls, hydraulic crushers, or top-down methods.
- **Complete selective demolition:** also known as deconstruction. This method takes place by reversing the steps of construction. It is when workers manually use light mechanical tools to dismantle the structural elements and as a result recover a higher amount of materials when compared to conventional demolition methods.
- **Partially selective demolition:** which is a combination of both previously mentioned demolition methods. It is when workers remove materials of high value with light mechanical tools and then proceed with the demolition conventionally.

While selecting the appropriate demolition method, project managers have to plan for managing the resulting materials. The alternatives for dealing with CDW, by decreasing order of preference, are: reduction, reusing, recycling, composting, incineration (energy recovery), and landfilling or safe disposal (Peng et al. 1997, Symonds Group 1999, Kartam et al. 2004, Warren et al. 2007, and EPA 2009).

Snapshot of CDW in Lebanon

Handling of CDW is a major challenge for developing countries, where the waste typically ends up at uncontrolled landfills (Kartam et al. 2004). Lebanon is a good example. Since the post-war era in the early 1990's, the Lebanese construction industry has witnessed a continuously active period accompanied by significant amounts of generated waste from the construction and demolition processes. The country has also been suffering from a chronic problem in the management of the solid waste due to highly populated areas, high production of refuse, and low availability of land adequate for disposal (Massoud 2003). In addition to the scarcity of space that can be used for landfilling in Lebanon, the boost in construction is causing a threat to the country's natural resources. The country has 1,200 quarries of which only 75 have permits to operate (Yager 2004). The annual production of Lebanese quarries is 3.0 million cubic meters, which is not enough to meet the annual demand for construction of 3.77 million m^3 (Srour et al. 2010).

In addition to the active construction industry, the country is prone to "emergency demolition waste". In summer of 2006, Lebanon went through a 34-day war which resulted in approximately 3 million m^3 of rubble (Nasr et al. 2009). The majority of the resulting waste was dumped at temporary existing and reclaimed sites, both on and off-shore. Another example of "emergency demolition waste" in Lebanon is the 0.6 million m^3 of rubble that resulted from the armed conflict in the Nahr-El-Bared refugee camp in 2007 (UNRWA 2008). Based on an agreement with UNRWA (United Nations Relief and Works Agency), the UNDP (United Nations Development Programme) implemented a rubble removal project where CDW from 5,000 housing units have been removed and transported to a nearby site, where sorting, crushing and screening will take place prior to final disposal.

Unfortunately, up to date there is no documented plan on how to manage both the non-emergency and the emergency waste in Lebanon. Additionally, there is a lack of understanding of proper landfilling, as well as the economical and environmental benefits of recycling of CDW among the various stakeholders involved in the demolition process, particularly among demolition contractors.

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RESEARCH SCOPE, OBJECTIVE AND METHODOLOGY

The goal of this study is two-fold. First, the paper investigates the state of construction demolition in Lebanon. This entails studying the quantities and composition of typical CDW generated from buildings as well as the procedures followed by demolition contractors. The second goal of this paper is to propose rules and regulations for managing CDW in the context of the Lebanese construction industry. The methodology includes analysis of case-studies consisting of buildings that are in the process of being demolished as well as interviews with demolition contractors and officials from the Ministry of Environment the municipalities of Beirut City and two of its suburbs. Overall, three case studies consisting of buildings undergoing demolition processes were examined as shown in Table 1 below. The first two case studies are of buildings completely demolished; whereas, the third is a building where only the slabs were demolished as part of a rehabilitation effort.

Table 1: Case studies

Case Studies	Age (years)	Function	No. of floors	Floor Area (m^2)
Case 1	60	office/ residential	4	200
Case 2	50	residential	7	260
Case 3	50	residential	8	250

In addition to the case studies, five interviews were conducted with demolition contractors familiar and active in the Lebanese construction industry. The interviews addressed demolition methodologies, dismantling processes, materials' recovery, and landfilling procedures. The interviews lasted about 45 to 60 minutes. Observations and analysis of the case-studies and interviews, gave the authors an in-depth and comprehensive understanding of CDW management practices in Lebanon (e.g. disposal options and demolition techniques). Additionally, the information and data gathered were useful for estimating the quantities of CDW generated and its composition.

Two other interviews were also conducted: one with a senior employee in the engineering group at the Beirut Municipality, and one with the head of the Pollution Control Department for the Built Environment at the Ministry of Environment. Those interviews addressed the rules and regulations for demolition and landfilling in Lebanon in addition to opportunities and obstacles for development and implementation of a CDW management plan.

ESTIMATION OF CDW GENERATED IN LEBANON

Estimating the generated quantities, which is the first step in any CDW management plan, is not a straight forward task (Kourmpanis et al. 2008). It requires accurate quantification and classification of materials according to same parameters (e.g. percentage composition of concrete, aggregate, wood, plastic, glass, and ceramic). Unfortunately, the majority of the composition data are not readily available for Lebanon. This is a typical problem for a large portion of developing countries where national statistics authorities often overlook waste generated from construction/demolition activities.

The US Environmental Protection Agency proposed a method for quantifying the amount of CDW (EPA 2009). This amount is the result of the multiplication of the number of buildings demolished in the studied year by the average demolished area and the typical amount of waste generated per surface area. NTUA, (2002) and Fatta et al., (2003) proposed a similar but more elaborate formula:

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$$DW = ND \times ANF \times AS \times V \times D \quad (1)$$

Where *DW* is the amount of generated CDW, *ND* is the number of buildings being demolished, *ANF* is the average number of floors, *AS* is the average surface area (m^2), *V* is the volume in m^3 of the generated waste per 100 m^2, and *D* is the density of the generated waste (t/m^3).

Along the lines of Eq. 1, we developed a similar formula, Eq. 2, to estimate the CDW generated in Beirut City in 2009 and 2010 and in two other municipalities, Zalka and Jdeideh, in the Greater Beirut Metropolitan Area in 2010 (Table 2).

$$DW = ND \times ABA \times V \times D \quad (2)$$

where, *ABA*: average built-up area of a sample of the buildings that were demolished (see below for details), *V*: volume of waste generated per m^2, this amount is estimated to be 0.73 m^3/m^2 (see below for details), and *D*: the specific gravity of the conglomerate cementitious material (includes concrete and masonry blocks) from the CDW, ranging from 2.10 to 2.40 ton/m^3 (Average = 2.25; tested at the Materials Lab at the American University of Beirut).

Table 2: The estimated amount of CDW in the Greater Beirut Metropolitan area

City	**ND** (2009)	**ND** (2010)	**ABA**	**V**	**D**	**DW**
Beirut	111	118	2,300	0.73	2.25	865,105
Jdeide	Not available	9	1,200	0.73	2.25	17,739
Zalka	Not available	6	675	0.73	2.25	6,652

This formula provides a rough estimation of the amount of CDW generated in Lebanon. The calculations made in this study rely on the following assumptions:

- The estimated volume of 0.73 $m^3$of waste generated per m^2 is an average value derived from case studies 1 and 2 mentioned above. This value varies from one project to the other depending on the type and age of the structure. This is illustrated by determining the estimated volume per m^2 for two other newly constructed structures that were surveyed for quantities of materials: the first is a residential building (4 floors including 2 basements), and the second is a single unit structure (villa). The residential building yielded an estimated volume of 0.6 m^3/m^2 and the villa yielded a higher ratio of 1.13 m^3/m^2 (as shown in Figure 1). Since case studies 1 and 2 are more representative of the typical CDW generated from demolished buildings in Lebanon, their average was used in this study.
- The estimated volume takes into consideration the main structure only (concrete, masonry, steel and tiling). No additional allowance is made for doors, kitchen and toilet fixtures, and electromechanical items as these had been removed when the quantification process was carried out. Hence, the density used reflects concrete materials and masonry which compose the majority of the CDW, but not all of it.
- To estimate the average built-up area (ABA), a sample of 11 land parcels from the Municipality of Beirut City was chosen. The maximum allowable built-up area in the zones of these areas was used to estimate the built-up area of each building. As for Zalka and Jdeide, the areas of all the buildings demolished were attained from the corresponding municipalities and the average was calculated accordingly.

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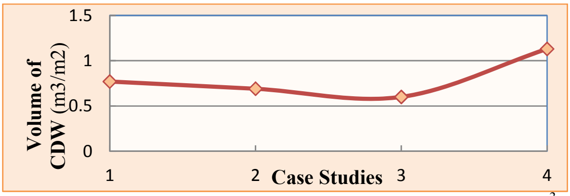

Figure 1: Estimated volume of rubble generated per building (m^3/m^2)

CDW MANAGEMENT IN LEBANON

Construction Demolition Waste Handling in Lebanon

The interview with the representative of Beirut City municipality revealed that there are minimal regulatory and procedural requirements for handling CDW in Beirut City. The process for obtaining a demolition permit is relatively simple and entirely administrative. Approval is granted upon submittal of supporting documentation, such as drawings showing location and size of the building, photos, clearance from the electrical and water companies, approval of the Ministry of Culture, and an insurance policy. The municipality does not impose any safety or environmental regulations. The only regulatory clause set by the municipality relates to collection and transport of the generated waste to a “specialized landfill”. However, as learned from the interviews with the demolition contractors, this regulation is hardly enforced. According to the head of the Department of Pollution Control at the Ministry of Environment there is only one landfill that can officially accept CDW. This landfill is located in Bsalim, Mount Lebanon which is approximately 18 km East of Beirut. It receives around 130-150 tons of inert waste per day. Most of the remaining CDW, and as corroborated by the interviewed contractors, is dumped either at private dumpsites for an average price of US$20 per 20$m^3$ truck, or is subject to “fly tipping”; that is, illegally dumping waste beside a road, in open land or in valleys. Common examples of fly tipping include illegal dumpsites such as the one in Chouaifat, valleys of Beit-Meri and Fanar, Mediterranean shoreline, and backfilling for construction projects such as those for the Monastery of St. Georges in Naameh, the Monastery of Saint Roukoz in Dekouane, and Solidere Marina.

Demolition Methods Adopted in Lebanon

As observed in the three case studies and corroborated by the interviews, the typical methodology adopted in Lebanon is the *partially selective demolition*. It starts by dismantling the potentially sellable items such as doors, windows, tiles, electrical fixtures, copper wires, and steel. All interviewed contractors highlighted the importance of separating steel during this process for future resale. The conventional demolition method is sometimes used, unlike the selective demolition method which is hardly ever used. Of the conventional methods mentioned above, explosives are not widely used in Lebanon, although not banned; whereas, wrecking balls are sometimes used in less congested areas where the buildings are considerably far from each other.

The execution of the demolition method is typically top-down; i.e., demolition starts from the roof and proceeds floor by floor until reaching the ground. This approach is usually used in highly populated areas (Poon et al. 2001), and entails the use of tools such as hydraulic and manual hammers. Additionally, as shown by case study 3, contractors can use mechanical saws to cut the slabs while maintaining/bracing the beams and columns. This method is usually used in reconstruction (where preservation of columns is required) or where minimal

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disturbance and nuisance to neighboring buildings is necessary. However, its associated cost exceeds the cost of the other methods.

The resulting waste from the conventional demolition methodology is co-mingled, which makes separation of reusable materials laborious. However, if the items that could be dismantled are not profitable or require high labor cost, then the building is demolished conventionally and only steel (reinforcement, balustrades, pipes, etc.) and copper (from electrical wires) are separated on the ground.

Waste Composition and Final Destination

The composition of materials generated from demolition is a function of the age and type of the structure. The case studies and interviews with demolition contractors indicate that only part of demolition waste materials in Lebanon are being re-used or recycled. This is done for pure economical reasons and in an ad-hoc manner. In other words, there are no centralized recycling plants where material is sorted, treated, and re-sold. The typical composition of the CDW generated in Lebanon includes:

- **Steel**: from reinforcement, balustrades, doors, pipes, water tanks, water heaters, radiators, etc. All interviewed contractors concurred that steel is the main salvaged material from CDW. It is sold as scrap for 20-40% of the current market price depending on the quality. Steel is typically cut when the slabs are demolished manually; otherwise, it is separated on the ground prior to transporting the rubble to dump sites. The salvaged steel is then transported to warehouses where it is stored and compressed prior to shipment to another country such as Egypt or Turkey, where it is further processed for recycling.
- **Copper**: from electrical cables/wires. In Case Study 2, the cables were pulled out of the tubes in the walls prior to demolition. Similar to the case of steel, copper is typically shipped to another country for recycling.
- **Glass**: mainly from windows. Unless it can be reused as whole panels, glass is dumped along with other materials. In the three case studies, the glass was not uninstalled, but instead, taken to dumpsites.
- **Tiles**: contractors often try to separate tiles generated from old buildings. The contractor in charge of case study 1 salvaged and sold the decorative mosaic tiles for $25/m^2. All other types of tiles such as ceramic and granite are demolished and transported to dumpsites.
- **Wood**: mainly from doors and shutters. Wood is usually dumped. In case study 1 the wood shutters were carefully dismantled and sold. In the two other cases the wooden doors were dumped. Only one of the interviewed contractor mentioned that the wooden doors can be re-used as formworks or used as temporary doors for site offices in construction projects.
- **Sanitary fixtures**: these are rarely re-used. They are usually crushed and dumped with the rest of the rubble. In all three case studies, the sanitary fixtures were dumped with the rubble. However, all the contractors stated that they check if these fixtures can be re-used prior to disposal.
- **Rubble**: concrete, masonry, tiles and other mixed materials. This constitutes the biggest portion of CDW, and as mentioned earlier, it is dumped at illegal dumpsites and sometimes used for construction projects such as backfilling behind retaining walls, land reclamation, and port expansion (e.g. Tripoli Port).
- **Hazardous materials:** such as mercury-contained in fluorescent lamps, and asbestos. As indicated by the interviewees, hazardous materials are not well-handled in Lebanon. The

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interviewed contractors are not aware of any procedure that is used to check and handle hazardous material. This is due to the fact that they are not obliged to do so by any rules and regulations.

CONCLUDING REMARKS AND RECOMMENDATIONS

The issue of managing CDW in Lebanon is complex. The current poor handling of CDW raises serious environmental concerns. The work presented in this paper, which consists of estimating the amount of CDW generated and highlighting the deficiencies in its management, contributes to the enhancement of the environmental awareness in the country. The issue of CDW shall not only attract the Lebanese authorities, but also all the stakeholders in the construction industry (employers, consultants and contractors). Based on the case studies and interviews' results, the authors suggest the following regulatory measures that need to improve the handling of CDW in Lebanon:

- Document demolition activities and the generated quantities of waste in order to estimate the amount of CDW to be disposed of and/or treated for recycling. This will in turn help in controlling the fly tipping incident (Fatta et al. 2003).
- Limit the disposal of CDW to engineered landfills. This will require constructing new landfills dedicated for CDW. Once these landfills are operational, the government should impose heavy penalties on haphazard dumping. Additionally, the regulations for attaining a permit for demolition should be expanded to address the quantity of waste, composition, and its corresponding destination.
- Devise an affordable fee of dumping. Any taxation or increase in the disposal fees could result in diverting waste from managed disposal sites to totally unregulated "fly tipping" (Symonds Group1999 and Fatta et al. 2003).
- Encourage reuse of generated rubble. This includes regulations and incentives to persuade contractors to use recycled products (Kartam et al. 2004). This entails actions such as encouraging reuse of rubble in major backfilling projects and sea reclamation, and providing tax breaks for recyclers.

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