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Estimating the sustainability returns of recycling construction waste from building projects

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ABSTRACT

The focus of this study is incorporating construction sectors within the concept of sustainable building, which essentially concerns resource management as well as waste management. It is evident that building construction is one of the largest consuming activities of non-renewable resources and natural materials worldwide. Simultaneously, enormous amounts of construction and demolition waste are generated as construction works expand to meet the increasing demand. This is not only considered an economic loss, but also an accelerating environmental threat. Therefore, it has become crucial for construction waste management to evolve away from the long practiced traditional methodology, which has been proven economically and ecologically inefficient, toward sustainable alternatives that prioritize waste recovery over disposal. Within this context, this study addresses the management of construction waste by selecting case studies of actual construction projects and scrutinizing their waste management data. The study took place at the University of Massachusetts—Amherst, where all selected projects conform to the U.S. Green Building Council standards. Thus, the study works on estimating the financial and environmental returns attained by recycling construction waste from such projects. By utilizing the results from the data analysis, the study eventually sets a statistical paradigm with field-based values for typical construction projects to be followed as a guide, indicating how much cost can be saved, and how much landfill volume can be relieved when material waste is recycled. Thereby, the study serves to enhance the sustainable management of construction waste by maximizing the returns of construction waste recovery.

1. Introduction

Construction sectors are considered the greatest worldwide consumers of resources, whether raw materials or energy, besides being among the major producers of carbon-polluting emissions (UNEP Division of Technology, Industry, and Economics, 2003). In addition, construction and demolition waste accounts for a large share in the total municipal waste of developed countries, while it grows to constitute the largest share in most of developing ones. Such waste is conventionally disposed of in landfills, which represents a major loss of resources. Furthermore, those conventional methods of disposal ultimately result in the saturation of landfill capacities, which increases the load on the environment and arouses worries about further ecological threats and health hazards. This leads to the concept of recycling as a crucial element for establishing sustainable development in construction sectors. Managing construction and demolition waste by recovery do not only conserve landfill space and reduce the environmental impacts of manufacturing new materials, but it also reduces the overall expenses of building projects through avoiding high purchase and disposal costs (EPA, 2000).

In the United States, several institutions supported by local governments have acquired the experience and the methodology to develop policies, sustainability guides and demonstration projects for more sustainable management of construction and demolition waste. Massachusetts has specifically presented several leading green building initiatives with particular regard to construction waste management. The University of Massachusetts—Amherst, where this study was performed for post-doctoral research, is a prominent state institution with a campus classified as “Green”. Thus, the study addresses the sustainable management of construction waste by selecting actual construction projects on UMass campus as case studies, and scrutinizing their waste management data. All selected projects conform to the U.S. Green Building Council standards and were also granted LEED (Leadership in Energy

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and Environmental Design) awards for new buildings. Thereby, the research utilizes these cases to set up a guiding model for similar building projects in order to enhance the sustainable management of construction waste by maximizing the returns of waste recovery.

1.1. Objectives

This study works on estimating the prospective financial and environmental returns attained by recycling construction waste from building projects. It aims to set a statistical paradigm with field-based values for typical construction projects to be followed as a guide. Such a guide is meant to indicate how much cost can be saved, and how much landfill volume can be relieved when material waste of construction projects is recycled. Furthermore, the utilization of these research findings is expected to serve the following broader goals:

- Decreasing the loss of materials, thereby reducing the costs of building construction, operation and maintenance due to the economic return of resource optimal use.
- Reducing the negative effects of building activities on the environment by limiting the accumulation of waste, and maintaining the base of resources.
- Promoting the practice of sustainable development and activating its applications within construction sectors by emphasizing its economic and ecological benefits.

1.2. Methodology

The research plan is generally based on an inductive analytical approach, while it applies quantitative research methods to process the data from the studied cases through the following stages:

- Literature review on sustainable management of construction waste.
- Rationale of the case study.
- Statistical analysis of data.
- Setting up a model for the estimation of recycling savings.

2. Background—sustainable management of construction waste

Construction and Demolition (C&D) Debris is waste material that is produced in the process of construction, renovation, or demolition of structures. Components of construction and demolition waste typically include concrete, asphalt, wood, metals, gypsum wallboard, and roofing (EPA, 1998). This is in addition to other structural materials as well as a variety of secondary materials such as those used for insulation or other types of installations. However, material sorts and ratios vary considerably in the waste streams of construction and demolition projects due to factors like project type, location, structural system, and most of all, regional material availability (The Center for Sustainable Systems, 2005a).

2.1. Construction waste management alternatives

Construction and demolition waste is managed in a variety of ways, ranging from disposal in landfills or combustion facilities to waste recovery options. The traditional and still most common management method is land-filling, whether at permitted landfills or unpermitted inert debris sites (EPA, 1998). This conventional approach of disposal results in the depletion of material resources, as well as the energy and cost spent in material manufacturing. Moreover, the option of land-filling associates with additional disposal costs and is liable to the expiration of landfill capacities, which imposes multiple economic and ecological threats. Thus, the concept of construction and demolition waste management has been progressing toward sustainable alternatives that concern: Waste Reduction, Waste Reuse, and Waste Recycling, leaving disposal as the last option.

2.2. Recovery options for resource efficiency

Among the elements of resource efficiency (alongside material manufacturing considerations) is the proactive process of preventing waste materials from entering air, land, or water. Within this approach, waste can be reduced or eliminated at the source, thereby avoiding the prospect of waste handling while reducing the demand on natural resources (The Center for Sustainable Systems, 2005b). Having been already generated, waste can be processed for the purpose of recovery to preserve its value, which makes waste recovery the best management method for construction and demolition waste. However, the efficiency of construction waste recycling is most directly affected by elements like existing impediments, recycling feasibility, and expected benefits which are explained subsequently.

2.2.1. Recycling impediments

In some cases, recycling is not the chosen method of management by waste generators for various reasons, including economics, convenience of mechanisms, and markets, as well as prevalent mindsets and behavioral tendencies. Government agencies interested in promoting recycling of waste for the greater environmental benefit often introduce legislations (in the form of specific regulations or policies) which are meant to overcome those barriers. Such legislations usually come together with a set of other strategies like providing market incentives for recycling activities, increasing disposal restrictions, and enforcing a recycling percentage on projects as part of Green Building requirements, as well as providing education and spreading awareness in this regard (Cochran, Henry, Dubey, & Townsend, 2007).

2.2.2. Recycling feasibility

Some factors are primarily considered by waste and project managers before implementing any recycling plan to ensure that the recycling program for their project is both financially and methodologically feasible. Those factors include (Dolan, Lampo, & Dearborn, 1999):

- Waste quantity and composition.
- Specific materials targeted for recycling and the design of programs intended to recover them.
- Expected effectiveness of participation in the program.
- Types of additional operations required to prepare the recovered materials for marketing.
- Overall costs of waste handling, collection, and processing.
- Financial and logistical risks and uncertainties associated with the proposed recycling program.
- Availability of markets for recovered materials, prevailing prices, price volatility, and the potential effect of market development programs.

2.2.3. Recycling benefits

Numerous benefits can be acquired by promoting the recycling of construction and demolition waste. While recycling building materials conserve resources by diverting them from landfills, this diversion of bulky and difficult-to-handle waste from the municipal solid waste stream increases the operating life for local landfills, and results in fewer associated environmental impacts such as groundwater contamination. Furthermore, construction and demolition waste generators (contractors, dealers, and owners) can expect