Making the Case for Construction Waste Management

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Construction and demolition activities generate a large portion of the total solid waste stream in the United States and have a significant impact on the environment. To reduce this environmental impact, some contractors have implemented construction waste management plans on their projects in order to divert construction and demolition debris from landfill disposal. Yet there are still many contractors who do not use construction waste management plans on all their projects. The paper makes the case for construction waste management plans and discusses the growing need for such plans due to stricter governmental regulations, growing demand for sustainable buildings and increasing cost of landfill tipping fees. To generate greater acceptance of construction waste management practices within the contracting industry, the second part of the paper identifies best practices for construction waste management. These practices include implementing a flexible waste diversion system, developing a specific waste management plan for each project, defining waste management responsibilities in subcontracts, enforcement of the waste management plan and capturing waste management lessons learned in a company wide knowledge base.

Keywords: sustainable construction, green buildings, LEED, construction waste management, recycling.

Introduction

Construction and demolition activities generate a large portion of the total solid waste stream in the United States. In 1998 the total annual construction and demolition waste generation in the United States was 136 million tons (U.S. Environmental Protection Agency, 1998). Construction and demolition (C&D) waste is estimated to equal 40% of the total solid waste stream in the United States (LEED 2003). It is also estimated that average new construction yields 3.9 pounds of waste per square foot of building area and that average building demolition yields 155 pounds per square foot (Dion and Tessicini. 2006). In other words a 50,000 sf newly constructed building will yield 100 tons of C&D waste while demolishing a 50,000 sf building will yield 3875 tons of C&D waste. In addition, building construction accounts for 40% of all raw materials used and 75% of that ends up as waste (Dion and Tessicini 2006)

If not disposed off properly, C&D waste will end up in landfills and will increase the quantity of virgin materials used in construction. For these reasons, construction waste management plans are becoming more and more important. The goal of construction waste management plans is to recycle and reuse construction debris and divert it from landfills. However, there are still many contractors who do not have a plan to divert C&D waste on all their projects. For example, although Turner Construction Company has achieved a 96% C&D waste diversion rate on its projects in Seattle, Washington, none of its projects has diverted C&D waste from landfills in Kansas city and only 6 out of 26 projects have diverted C&D waste in Dallas, Texas (Lennon 2006).

The objective of the research described in this paper is to make the case for construction waste diversion. To meet this objective, the author has conducted an extensive literature search, reviewed published case studies related to construction waste management and conducted interviews with several project managers.

Growing Need for Construction Waste Management

In addition to the environmental impact of C&D waste discussed above, the research has concluded that there are several other trends that will likely increase the importance of C&D waste diversion in the near future. These trends are discussed in the following subsections and they are:

- Increasing cost of landfill tipping fees
- Increasing number of LEED projects
- Government regulations

Increasing Cost of Landfill Tipping fees

The increasing cost of landfill tipping fees is making recycling and/or reuse of construction waste economically feasible. As a rule of thumb, when landfill-tipping fees exceed $50 per ton, recycling becomes cost-effective (LEED 2003). In some areas of the country, such as in the Northeast, landfill tipping fees have reached $105 and made recycling not only feasible on LEED projects but on all projects (Lennon 2006). Table 1 (adapted from Lennon 2006) shows the average total costs of recycling in the Northeast (including transportation of waste) for several construction and demolition materials. As indicated in Table 1, the average cost of disposing C&D in landfills ($136/ton) is much higher than recycling for nearly all construction and demolition materials. Even the cost of recycling mixed debris ($114/ton) by sending it to a Material Recycling Facility (MRF) where it is recycled offsite is cheaper than merely transporting the C&D waste and disposing it in landfills. In some areas, recycling and reuse of materials is not only economically feasible but also produces first cost savings. Dion and Tessicini report a total first cost savings of $32,000 on a high school project where 75% of the construction waste was diverted (Dion and Tessicini 2006).

However, there are still some areas of the country were landfill tipping fees are below $50. For example, in Kansas, average tipping fee is $44/ton (Nies 2006). But even in these areas, by carefully evaluating local conditions, some contractors can find that recycling/reuse of construction materials can still be economically feasible. For example, some local governments sometimes inflate tipping fees artificially to encourage greater recycling efforts. Also contractors can obtain some small financial benefit in projects where recycling offers shorter hauling distances than transferring waste to landfills or in cases where reprocessing and reusing some materials on site is possible; for example, grinding demolished concrete for use as structural fill - can be cheaper than hauling debris away and purchasing gravel (LEED 2003).

Table 1. Total cost of recycling construc tion materials in the Northeast ($/ton). (adapted from Lennon 2006).

Material	Total cost for recycling and transportation ($/Ton)
Metals	-$18
Concrete, Brick, Block	$22
Glass	$51
Bathroom Fixtures	$51
Asphalt Shingles	$57
Doors, Windows	$70
Gypsum Wallboard	$72
Clean Wood	$84
Commercial Roofing	$86
Mixed Debris	$114
C&D Waste Disposed in Landfill	$136

Increasing Number of LEED projects

LEED is a national standard for rating sustainable construction projects that offers certification for the completed building. The demand for LEED projects in the construction industry is growing (Pulaski et al. 2006, Nobe and Dunbar, Kibert 2005). In the next five years, it is estimated that the LEED building market will grow up to 30% annually (Dion and Tessicini 2006). The growing demand for LEED projects will likely increase the need to implement construction waste management plans. LEED offers up to 2 credits for implementing construction waste management plans. LEED Materials and Resources (MR) credits 2.1 and 2.2 deals with construction waste management. The intent of these credits is to divert construction, demolition, and land clearing debris from landfill disposal, redirect recyclable materials back to the manufacturing process and redirect reusable materials to appropriate sites. The following are requirements for receiving LEED MR credit 2.1:

> *Develop and implement a waste management plan, quantifying material diversion goals. Recycle and/or salvage at least 50% of construction, demolition and land clearing waste. Calculations can be done by weight or volume, but must be consistent throughout.*

To receive credit 2.2 in addition to 2.1 for construction waste management, there must be an additional 25% of the construction, demolition, and land-clearing debris recycled and/ or salvaged (LEED 2003). The contractor's involvement in achieving these 2 credits is paramount. The contractor is responsible for developing the waste diversion plan and documenting the percentage of recycled/salvaged waste. In the past many LEED certified projects have received one or both construction waste management credit and this trend is expected to continue. Of the first 58 LEED certified projects, 80% received credit MR 2.1 – 50% waste diversion and 55% of the projects received credit MR 2.2 – 75% waste diversion (Nies 2006).

One of the most effective strategies for minimizing the environmental impacts of C&D waste is to reduce the generated amount of this waste. This can be accomplished for example by reusing existing buildings, using structural elements as finishes, choosing materials that have long life cycles and/or using construction methods that results in less waste. Although many of the techniques for reducing the generated amount of C&D waste are primarily design issues, the general contractor/construction manager can still have an impact on these issues if he/she participates early in the design process and recommends reducing construction materials/waste during constructability/value management reviews.

LEED particularly recognizes the reuse of existing buildings as an effective way to reduce the generation of C&D waste. Rehabilitation of existing building shells and non-shell components reduces solid waste volumes and diverts these waste volumes from landfills (LEED 2003). LEED Materials and Resources (MR) credits 1.1, 1.2 and 1.3 deals with building reuse. The intent of these credits is extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport (LEED 2003). The following are requirements for receiving LEED MR credit 1.1:

> *Maintain at least 75% of existing building structure and shell (exterior skin and framing, excluding window assemblies and non-structural roofing material).*

To receive credit 1.2 in addition to 1.1 for building reuse, there must be an additional 25% (100% total) of existing building structure (exterior skin and framing) maintained excluding window assemblies and non-structural roofing material (LEED 2003). To receive credit 1.3 in addition to credits 1.1 and 1.2 for building reuse, the project must maintain 100% of existing building structure and shell (exterior skin and framing, excluding window assemblies and non-structural roofing material) AND at least 50% of non-shell areas (interior walls, doors, floor coverings and ceiling systems).

As noted above, reusing a building also reduces the amount of solid waste leaving the project site. Thus, building elements qualifying for MR credit 1 can also be applied to MR Credit 2 (Construction Waste Management). If a portion of a building's structure is reused, but this portion does not meet the minimum levels stated in MR credit 1 (building reuse), the reuse activities can be applied to MR Credit 2 (construction waste management). If an item that cannot be reused for its original function is reprocessed (on or off the site) and installed for a different use, it can be counted toward MR Credit 3 (Resource Reuse). Wood beams that are re-milled for a similar use, for instance, can be applied MR Credit 3. Demolished concrete that is crushed on site for use as structural fill would also be applicable to MR Credit 3 (LEED 2003). However, materials included in MR credit 3 (Resource Reuse) can't be applied to MR Credit 2 (Construction waste management).

Government Regulations

Several cities, states and federal agencies have announced that all their future buildings will meet minimum sustainability requirements as established by the US Green Building Council's Leadership in Energy and Environmental Design (LEED) program (Nobe and Dunbar 2004). As discussed in the previous section, many of these future buildings will likely implement waste diversion plans in their attempt to obtain LEED certification. In addition to their LEED certification requirements for their new governmental buildings, some states are enacting C&D regulations that will affect not only the state's future governmental building projects but also all construction projects in the state. Massachusetts for example, has enacted regulations to ban the disposal of asphalt pavement, brick and concrete, metal, and wood that are generated from construction, demolition, and renovation projects. The regulations became effective on July 1, 2006, and prohibit any transfer station or disposal facility in the state from accepting these materials for disposal (Waste Ban Regulations 2005).

C&D Waste Management Best Practices

The objective of this research is to make the case for construction waste recycling and reuse. The first part of the research explained the trends that will likely increase the importance of C&D waste management in the future. The author hopes that contractors will realize the significance of these trends and start implementing C&D waste management efforts on their projects. To generate further acceptance of C&D waste management practices within the contracting industry, the second part of the research sought to identify best practices for construction waste management. These practices are discussed in the following subsections and can be categorized as follows:

- Implementing a flexible waste diversion system
- Developing a specific waste management plan for each project
- Defining waste management responsibilities in subcontracts
- Enforcement of the waste management plan
- Capturing waste management lessons learned in a company wide knowledge base

Implementing a Flexible Waste Diversion System

The best means of diverting C&D waste depends on the type, size and location of the project. The C&D waste diversion system should be flexible enough to accommodate the needs of the various projects. The system should allow for the following options:

- Direct materials reuse: on old construction projects, there are many opportunities for reusing existing building components. All materials that are disassembled from the old project and used on the new project may also be used in the calculations for achieving the LEED credits for building reuse MR 1.1, 1.2 and 1.3 (LEED 2003).
- Source separate materials: as discussed above, in many parts of the country, separating C&D waste on site is cheaper than disposing the waste in a landfill. To adequately separate the C&D waste, the contractor should provide separate receptacles for the various materials and educate construction workers and subcontractors on how to separate the waste.
- Send mixed debris to a Material Recycling Facility (MRF) to be separated offsite. When the project's site is restricted and does not allow for have separate receptacles (e.g. a downtown project), the contractor can take the C&D waste to an off-site MRF facility. Since the MRF facility will separate the waste and recycle it, the waste can still be counted as diverted waste. However, the contractor doesn't get the cost savings he/she would get if the C&D waste is separated on site and for this reason, this option should not be used all the time.

- Dispose the C&D waste in a landfill. In cases where it is extremely difficult or costly to recycle the C&D waste, the contractor can dispose the waste in a landfill.

Developing a Specific Waste Management Plan for Each Project

The number one key to a successful C&D diversion program is to outline all the requirements from the project's inception so that all parties involved understand what is expected (Burt et al. 2006). The construction waste management plan should clearly define waste management goals such as "reuse or recycle 60% of project wastes". The plan should also identify potential markets for recycled materials and develop a list of haulers for the various construction materials to be recycled. The plan should specify procedures for waste separation and removal of salvaged material and locations of waste receptacles on the jobsite. Waste separation and adequate monitoring of recyclables is important for the success of the construction waste management program. The personnel responsible for recycling should be properly trained on the effective procedures of recycling. Several alternatives could be used to remove salvaged material off-site; Salvage or recycling companies can remove recycle/reuse materials or the contractor can drop the materials at their location. Also, some charities such as Habitat for Humanity could be contacted to pickup the materials. The contractor has to contact the salvage/recycling companies to determine their requirements on whether the materials have to be source separated or can be co-mingled.

The construction waste management plan should also include procedures for handling hazardous waste generated from demolition activities. Hazardous products include lead paint, asbestos, fluorescent lamps and PCB ballast. Special attention must be taken when handling hazardous wastes, which must be disposed of at a hazardous waste facility. Qualified professionals may be needed for proper handling and disposal.

The construction waste management plan should be communicated to all project team members to ensure that all participants in the construction process are aware of the procedures. Communication of plans can take place during subcontractors' orientation meeting prior to their mobilization on site. The project superintendent in particular should be familiar with the plan and should ensure the completion of all activities necessary to comply with the plans.

Defining Waste Management Responsibilities in Subcontracts

Burt et al. 2006 recommends that the GC/CM clearly define subcontractor responsibilities, as well as waste recycling goals for the project, in subcontracts in order to decrease the likelihood of future misunderstandings concerning subcontractor involvement in the construction waste management plan. Dion and Tessicini 2006 further recommends that during the purchasing stage, the GC/CM should ensure that subcontractors understand what they are signing out to do so that the waste management requirements are not hidden in the contract.

Enforcement of the Waste Management Plan

During the construction phase, the GC/CM should ensure that the plan is being enforced. They should make sure that all dumpsters are placed in their planned location and that proper signs are visible on waste receptacles. They should also check the content of the dumpsters to make sure that materials are discarded according to the construction waste management plan. They should warn subcontractors who are not adhering to the plan in writing and require them to remove the material and dispose it correctly. If these subcontractors still do not comply with the waste management plan, the GC/CM should properly separate the C&D waste and backcharge the non-complying subcontractors (Burt et al. 2006).

Capturing Waste Management Lessons Learned in a Company Wide Knowledge Base

The contractor should develop a historical lessons learned knowledge base from previous projects. This will provide an effective means for transferring lessons learned throughout the company and assist in minimizing waste and optimizing the use of natural resources. The interviews conducted as part of the research have identified several lessons learned that advise the contractor to:

- Use an effective materials management system to minimize the amount of time that materials are on site and reduce the chance of damage.
- Adequately inspect the amount and quality of materials upon delivery and require suppliers to take back substandard or excess items.
- Use construction methods that minimize waste such as using reusable metal forms for concrete instead of wooden forms.
- Use products with less packaging and encourage manufacturers to recycle their packaging materials.
- Ensure that construction materials is adequately stored and handled to prevent damaged material from going to the waste stream
- Minimize ordering errors to reduce amount of waste on the construction site.
- Purchase materials to minimize waste. For example, purchase 9' sheets of drywall if the ceiling height in a building is nine feet.

Conclusions

The need for implementing construction management plans will likely increase in the future due to the increasing number of LEED buildings, stricter government regulations and rising costs of landfill tipping fees. To stay competitive and responsive to owners' needs and government regulations, contractors have to learn and understand how to implement construction waste management plans on their projects. The paper made the case for construction waste management plans and presented some best practices for optimizing the cost of such plans. These best practices include implementing a flexible waste diversion system, developing a specific waste management plan for each project, defining waste management responsibilities in subcontracts, enforcement of the waste management plan and capturing waste management lessons learned in a company wide knowledge base.

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