BARRIERS TO DECONSTRUCTION AND MATERIALS REUSE

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Summary

Deconstruction may be defined as the disassembly of structures for the purpose of reusing components and building materials. The primary intent is to divert the maximum amount of building materials from the waste stream. Top priority is placed on the direct reuse of materials in new or existing structures. Immediate reuse allows the materials to retain their current economic value. Though definitely on the rise, deconstruction and reuse of building materials is faced with several challenges such as, consumer tastes and perceptions concerning used and recycled building materials, additional time required to dismantle buildings, lack of markets for used components, and the fact that building codes and materials standards often do not address the reuse of building components. In the end, the increased use of reused and recycled building materials is in the hands of the architects, builders, and consumers that use them. Slowly but surely, perceptions have become increasingly positive over the last few years. The natural trend towards increased social and environmental responsibility, along with the maturation of the deconstruction industry, will aid in the effort to improve perception of reused and recycled building materials. This will increase the profitability of the building materials salvage market, making deconstruction a more desirable business alternative. This paper discusses these challenges and suggests ways to make deconstruction and reuse of building materials an alternative to demolition and landfill.

1. Introduction

In the United States every year construction industry contributes to a large amount of waste to municipal solid waste stream. The US Environmental Protection Agency (EPA) has estimated that total waste generated from construction, renovation and demolition of buildings, roads, bridges, and dams was 295 million metric tones (MMT) in 2003 (RCRA, 2004). Building related C&D waste was estimated to be 143 million metric tons in 2000 (Chini and Bruening, 2005). It is estimated that 70 MMT of this was the product of demolition. Table 1 summarizes estimated waste due to building and infrastructure related construction and demolition as well as municipal solid waste (Chini, 2007). The table also shows estimated weight of recovered materials. As Table 1 shows only concrete and steel have a recovery rate of 50 per cent or above. The recovery rate for other materials is not significant, but it is increasing due to rising cost of landfilling waste, stringent new government regulations, and a steady growing concern for the environment.

Figure 1 shows that over 27% of the waste that is generated from construction and demolition of buildings is wood waste. If a portion of this can be reused back in the construction industry in place of virgin lumber, this would mean a great reduction in harvesting, transporting, processing, and other energy intensive steps that are used to produce virgin lumber (Chini and Acquaye, 2001). The United States is fortunate to have a vast supply of trees that are harvested each year. In fact, about one-third of the US land mass is currently forested; from this over 255 MMT of wood are produced each year (Falk 1997). In the past century over 4 billion metric tons of lumber have been produced, and much of it still exists in buildings around the country. According to Horne-

Brine and Falk, if only 2% of these buildings were deconstructed each year, with only 25% of the lumber being reclaimed, it would supply up to one quarter of the overall lumber market in the United States for over 50 years (Horne-Brine, Falk 1999).

Table 1 C&D waste generation and recovery (MMT)

Material	Building C&D Waste	Infrastructure C& D Waste	Steel Products	Municipal Solid Waste	Re-covered
Concrete	55	127	-	-	91
Wood	36	-	-	27	10
Drywall	13	-	-	-	2
Roofing	10	-	-	-	NA
Steel	9	12	59	13	70
Bricks	4	-	-	-	NA
Plastics	4	-	-	24	1

NA: the recovered weight is Not Available

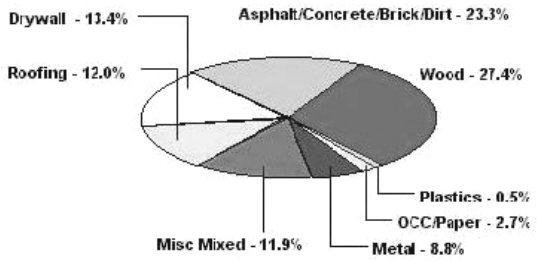

Figure 1 Waste Generated by Construction and Demolition (MSW Factbook 1997)

Deconstruction may be defined as the disassembly of structures for the purpose of reusing components and building materials. The primary intent is to divert the maximum amount of building materials from the waste stream. Top priority is placed on the direct reuse of materials in new or existing structures. Immediate reuse allows the materials to retain their current economic value.

Deconstruction of buildings has several advantages over conventional demolition and is also faced with several challenges. The advantages are an increased diversion rate of demolition debris from landfills, “sustainable” economic development through reuse and recycling, potential reuse of building components, increased ease of materials recycling, and enhanced environmental protection. Deconstruction preserves the invested embodied energy of materials, thus substituting recovered existing materials for the input of embodied energy in the harvesting and manufacturing of new materials.

The challenges include: consumer tastes and perceptions concerning used and recycled building materials, existing buildings have not been designed for dismantling, dismantling of buildings requires additional time, lack of markets for used components, building codes and materials standards often do not address the reuse of building components, and the fact that buildings built before the mid-1970’s contain lead-based paint and asbestos containing materials.

Though definitely on the rise, perceptions of reused and recycled building materials must be improved in order for the long term profitability of deconstruction to increase. This paper discusses ways to rectify the many doubts consumers have concerning recycled and reused building materials.

2. Consumers Tastes

The successful implementation of deconstruction relies on successful resale of recovered building components. If materials cannot consistently be marketed and sold in a timely manner, it is virtually impossible for deconstruction to be profitable. For this reason, consumer tastes and perceptions concerning used and recycled building materials is often a barrier to the successful implementation of deconstruction. The most influential persons regarding the purchase of used and recycled building materials are the architects, the builders, and the consumers.

2.1 Planners

Architects and landscape architects have the potential for impacting the use of used building materials in new construction. Although architects tend to be more open to the use of used and recycled materials than builders, their perception overall appears to remain negative. Brand or manufacturer loyalty poses one barrier to expanding the use of used and recycled building materials. Currently, architects are more likely to specify a particular product from a product line or manufacturer they trust than to establish a non-brand specification which allows used materials to fill that specification.

2.2 Builders

Builders and their subcontractors play an important role in the selection of construction materials. In an industry that is conservative the movement towards new products is slow. This attitude reflects real worries in construction, where products that are not up to high standards of quality and safety can cause disastrous accidents. For this reason, builders are the market segment that is slowest to accept used and recycled building materials. Contractors view the use of reused and recycled building materials negatively because they perceive them to have the following characteristics (Grothe and Neun, 2002):

- Dimensional Problems: Contractor's view finding used materials that fit into a pre-dimensioned space as more difficult than purchasing a new product.
- Inconsistency in Supply: Contractor's perceive the inconsistent availability of the right quantity and size of used materials as inconvenient.
- High Risk: Due to the high personal risk involved when something goes awry in the construction process, builders are reluctant to trust used and recycled products.
- Poor Quality: It all boils down to the overall perception that used and recycled materials are of lesser quality than virgin materials.

2.3 Consumers

Those people purchasing commercial and residential construction, as well as those renovating buildings, are extremely important in driving the environmentally sound construction movement, including the use of recycled and reused building materials. The prevailing attitude remains that reused and recycled building materials are "substandard but environmentally friendly." Many architects and builders have admitted that they would use more used and recycled products if their clients directed them to do so.

3. Lack of Design for Deconstruction Strategies

The aim of design for deconstruction is for the next generation of buildings to be more efficiently disassembled at the end of their useful lives. More efficient disassembly implies a process that is quicker, causes less damage to recovered building components, and is safer for the workers involved. The problem facing the industry today is that the benefits of design for deconstruction will not be realized until many years from now. Currently, the lack of design for deconstruction in the buildings that are coming to the end of their useful lives is a major barrier to efficient and profitable deconstruction (Chini and Balachandran, 2002).

Buildings that are approaching the end of their useful lives today were not built with deconstruction in mind. Deconstruction is a fledgling industry, much younger than the houses being deconstructed. There are several aspects of design for deconstruction that are currently hindering the materials recovery process. These are lack of kept construction records, abundance of hazardous materials, use of adhesives to hold fasten building components, and lack of labeling of building components.

3.1 Construction Records

Today, buildings to be deconstructed do not contain of the original construction information. This lack of information drastically decreases the speed and efficiency of the deconstruction process. The presence of blueprints, materials lists, location of wiring systems, and photographs of connections used in the construction of the building would aid in the planning and implementation of its dismantling (Guy, 2001).

3.2 Abundance of Hazardous Materials

Government policies concerning hazardous materials abatement are higher for deconstruction than they are for demolition. This is due to the higher exposure levels for deconstruction workers. These stringent policies increase the cost and time necessary to complete a deconstruction project. Additionally, hazardous materials drastically increase the salvageability of building components. Wastes are defined as hazardous by EPA if they are specifically named on one of four lists of hazardous wastes or if they exhibit one of four characteristics: ignitability, corrosivity, reactivity, or toxicity. Typical examples of C&D wastes that are considered hazardous according to EPA's definition are:

- C&D debris containing mercury: fluorescent lamps, thermostat probes, old paint
- Lead-based paint debris: woodwork, siding, window and doors painted before 1978
- Asbestos debris: Insulation, resilient floor covering, siding shingles, roofing products, and cement products made with asbestos before 1977

3.3 Use of Adhesive

The use of various glues and adhesives in the installation of building materials may increase the stability of those building systems but it serves to decrease the efficiency of the deconstruction process and increase the likelihood of damage during extraction. This is particularly true with glue use on wood products and the grouts used in masonry construction. The glues previously used in wood construction tend to cause splitting and cracking of the wood during extraction. Certain mortars used to bond bricks are not conducive to later separation and cleaning of the bricks. It is only possible to clean bricks that are bonded with soft lime mortar. Those bricks that are bonded with Portland cement based mortar cannot be effectively separated and cleaned.

Currently, it is not standard practice for building components to be labeled before installation. The recovery process is slowed by the necessity to identify the components makeup, how it was fastened, what kind of chemicals may or may not be present, etc…

Design for deconstruction will identify issues involving labeling of building components to speed up the deconstruction process.

4. Additional Time

The successful large scale implementation of deconstruction in the United States is contingent upon increasing the efficiency of the deconstruction process. Currently, time constraints pose a legitimate threat to the growth of the deconstruction industry. In the construction industry, where time is of the essence, the extra time involved to remove a building via deconstruction, as opposed to removal through demolition, may be a deterrent. The level of efficiency on any project is directly proportional to its profitability. Deconstruction must become a more profitable industry if it is to be implemented on any substantial level.

Several factors are limiting the efficiency of the deconstruction process. As discussed earlier, the lack of design for deconstruction has a negative effect on its efficiency. However, the benefits of designing buildings for disassembly will not be felt until the useful lives of the next generation of buildings have expired. There are other factors affecting the efficiency of deconstruction that can be and are being improved right now. One of the major factors affecting the efficiency of the deconstruction process is the current lack of tools available that stimulate the speed of deconstruction while minimizing the damage incurred by recovered materials.

To date, the tools used during the deconstruction process have generally been the same hand tools used in the construction process. These tools were not designed with the efficient, safe disassembly of buildings in mind. For example, crow bars are frequently used tools on deconstruction sites for prying apart building components such as wooden planks. However, a crow bar was not designed to pry apart wooden planks without damaging them. Consequently, the planks are often split during extraction. This damages the wood, reducing its reusability and

thus its resale value. Tools must be developed that facilitate the speed and safety of materials recovery during deconstruction while at the same time minimizing the damage incurred by those materials.

The lack of deconstruction training available is also a barrier to its growth as an industry. Development of programs that promote deconstruction of buildings as an alternative to traditional demolition by training contractors how to effectively dismantle structures with the purpose of reclaiming materials will facilitate the full-scale implementation of the deconstruction industry.

5. Lack of Markets for Used Components

The economic structure of the deconstruction industry requires that the recovered materials be sold in order to achieve any level of profitability. Thus, access to salvaged materials markets is a critical element to the successful implementation of deconstruction. At this juncture, a lack of markets for used building materials is a barrier to deconstruction. The strength of the used building materials market in a given area is directly related to the area's local attitude toward used building materials and the population and location of the area.

As discussed earlier in this chapter, perception of low value of salvaged building materials remains a problem in the construction industry today. This perception of low value has a direct influence on the demand for salvage materials. Thus, the presence of negative perception has an adverse affect on the market for used components. As time passes, the continued effort of the deconstruction industry to educate the public on the benefits of using salvaged building components will serve to alleviate this issue.

Large metropolitan areas tend to support the strongest used building materials markets. There is obviously a positive correlation between the size of a city and its demand for consumer goods. Additionally, the available building stock for deconstruction will tend to be greater in highly developed areas such as large cities. Export Markets in border and port cities create an additional market for used building materials. These markets have the capability to increase the consumer base for deconstructed materials exponentially. Export of used building materials is a strong market in the Miami area, and exporters were identified as a major customer group for recovered materials. Several used building materials markets in the Miami area sell approximately half of their material to exporters from Central American and Caribbean countries.

The problem facing the deconstruction industry at this point is that the majority of towns in the United States are not large, port cities with high public perception of used building materials. A major focus of the construction industry must be to network together those areas that may not be able to establish strong reuse markets with those that can. The use of the internet creates an additional medium to obtain and sell used building materials. "Internet sales have the potential to change existing market relationships by allowing end users to purchase materials at reduced prices from sources other than their traditional supplier" *(Grothe and Neun, 2002).* Currently, Internet sales are more conducive to the sell of high-end salvaged building materials because of the intensely high demand for these goods, particularly high-quality structural timbers. Low-end materials do not benefit as well from the internet because added shipping and processing fees tend to negate the money saving benefits of these materials.

6. Lack of Standards for Reuse of C&D Materials

The success of any recycling effort is tied to the marketability of the products that are recycled. The National Demolition Association (NDA) suggests that the U.S. EPA develops a program that analyzes the marketability of the components of the various elements of the demolition waste stream and promotes the reuse of these materials. NDA believes that the EPA could produce a substantial increase in the recycling and reuse of C&D materials by establishing purchasing guidelines and specifications for these materials. The guidelines could contain quality assurance components that would allow specifying agencies to feel comfortable with the use of these materials (NDA Report, 2004).

Total building related and infrastructural concrete waste generated annually in US is estimated to be about 200 million tons (Sandler, 2003). It is estimated that about 100 million tons of concrete is recycled annually into usable aggregates. This is roughly 5 percent of 2 billion tons total aggregates market. The rest is supplied by virgin aggregates from natural sources. If the EPA, working with the Federal Highway Administration and the state transportation agencies, would develop model specifications for the quality of recycled material, this total recycling number would increase dramatically. Standardization of the specifications for the reuse, on a national level, could produce a boom comparable to President Clinton's paper recycling directive.

Similarly, establishing criteria for the reuse of wood products generated on deconstruction sites could significantly increase their reuse. Lumber re-grading for structural use, has become a hot topic in the deconstruction industry. The grade stamp on lumber verifies the quality of each piece of lumber. Currently, existing grading rules can be used to grade salvaged lumber. However, these rules do not specifically address salvaged lumber. Current grading procedures are time consuming and expensive. Grading of salvaged lumber, other than in very large quantities, is not cost-effective. Because the extent to which salvaged lumber defects and their affect on its strength are somewhat uncertain, grading agencies are hesitant to give it their stamp of approval. When they do, they minimize risk by downgrading the lumber or restricting it from particular applications. These issues create a barrier to the implementation of deconstruction by raising costs and reducing the possible applications of salvaged wood. In addition, structural salvaged lumber would draw a much higher price on the market than non-structural wood. Currently, steps are being taken to develop a nationally recognized salvaged lumber re-grading system.

Other materials produced through deconstruction including roof shingles, carpet, drywall, glass, ceiling tiles, plastics, and other construction products are being studied to see if they too can be recycled or reused in an economically viable manner.

7. Setting Goals

Although the federal government has largely avoided any effort to set C&D recycling rate targets, many states and smaller jurisdictions have active programs that encourage C&D waste recycling.

California adopted a legislation in 1989 that requires counties to recycle 50 percent of their waste streams. With C&D material making up such a large percentage of those streams, it did not take long for county and city officials to begin devising C&D recycling initiatives. City of Oakland requires contractors to submit a job-site recycling and waste reduction plan along with their initial bids to the city. The contractor that wins the bid must also submit required reports prior to receiving the final payment. In San Jose, contractors have the option of bringing material to one of more than 20 city-certified facilities (www.sjrecycles.org) that are expected to meet pre-determined recycling rates. The City Council in Irvine requires builders of large projects (more than one residential unit; nonresidential structures measuring 5,000 square feet or more and nonresidential properties that are 10,000 square feet or more) to submit recycling plans. Companies will have to pay a material diversion deposit to the city that will be refunded after the project is complete. At least 75 percent of concrete and asphalt and 50 percent of other C&D debris must be taken to material recovery facilities for a company to get its deposit back. In Sonoma County, California C&D waste loads that have not been sorted for recyclables must pay a 25 percent surcharge for the county to handle resorting (Taylor, 2007).

The commonwealth of Massachusetts bans certain materials from its landfills to obtain an 88 percent statewide recycling rate by 2010. In mid 2006 a ban on the disposal, or transfer for disposal, of asphalt pavement, brick, concrete, wood, metals and old corrugated containers became the rule in Massachusetts. The state's Department of Environmental Protection singled out those materials based on a belief that healthy recycling markets existed for all of them. The goal is to add additional C&D materials such as gypsum wallboard, asphalt shingles, carpet and ceiling tiles in the future (Taylor, 2007).

The regional government for the Portland, Oregon has approved construction and demolition recycling legislation that will go into effect in 2009. The policy requires mixed loads of C&D debris to be sorted for recyclables prior to dumping, leaving no more than 15 percent recyclables in the remaining material. The regulation is part of the agency's overall plan to increase recycling rates in the Portland area by 64 percent by the end of 2009. It is anticipated that this policy will keep an approximate 33,000 tons of C&D material out of landfills, enough to boost the overall recycling rate by 1.25 percent (Taylor, 2007).

Chicago recently adopted an ordinance requiring a certain percentage of construction and demolition waste to be recycled — 25 percent for projects that had a permit issued in 2007, and 50 percent if the permit is issued in 2008 (Martin, 2007).

8. Deconstruction is Cost Effective

In almost all cases, the cost of deconstruction is higher than that of demolition. This is due to the labor intensive nature of deconstruction. However, the salvage value regained in deconstruction often makes it more cost effective than demolition. Because the labor intensive factor of

deconstruction is somewhat unavoidable, it is important to focus on minimizing other factors in the cost to make it more competitive. Minimizing costs and maximizing salvage value of building materials is essential to maximizing the potential of deconstruction. Having well trained workers can have a major impact on overall cost. A high level of safety reduces overall costs of deconstruction projects.

According to a survey conducted by the New Jersey Department of Environmental Protection, recycling C&D materials is usually the most cost-effective and environmentally friendly method of disposal. Builders and contractors can save money recycling their construction and demolition materials. The average cost to recycle concrete rubble is $4.85 per ton vs. an average of $75 per ton to haul and dispose of the material in a New Jersey landfill. Similar cost savings came from recycling asphalt ($5.70 per ton) and bricks and blocks ($5.49). Even recycling wood at $45.63 per ton and trees and stumps at $37.69 per ton is economical compared to the $75 average transportation and disposal cost, according to the survey. (www.state.nj.us/ep/dshw/recycle/builderinfo.htm).

9. Recommendations

In the end, the increased use of reused and recycled building materials is in the hands of the architects, builders, and consumers that use them. Slowly but surely, perceptions have become increasingly positive over the last few years. The natural trend towards increased social and environmental responsibility, along with the maturation of the deconstruction industry, will aid in the effort to improve perception of reused and recycled building materials. This will increase the profitability of the building materials salvage market, making deconstruction a more desirable business alternative.

The following aspects of the industry and consumer perceptions must be addressed in order to rectify the many doubts consumers have concerning recycled and reused building materials.

9.1 Information Availability

Aided by the numerous industry associations and increased publicity, information accurately explaining the benefits of recycled and reused building materials has become much more accessible over the last few years. However, as a whole, public knowledge concerning these products is too low. The natural increase in available information and networking that will occur naturally as the industry grows should help to rectify this problem.

9.2 Overcoming the Perception of Risk

Because of the perception of risk, products must show they perform as well or better than virgin products. Component recertification processes must be refined and standardized before this can occur. Additionally, recycled products should be tested and certified in order to offset the high-risk aversion of the industry.

9.3 Economic Incentives

In a market economy, decisions involving which resources are used are primarily driven by economic forces. Therefore, the most effective ways to promote deconstruction industry are to use economic incentives to promote efficient recourse use and minimize waste generation. These include waste generation fees and credits to reward purchase of products that rely on recycled materials. Developing more efficient recycling technologies and developing markets for recycled materials or products are essential for recycling industry to flourish. Government should also play a role through government purchasing programs that increase demand for products with recycled contents.

9.4 Guidelines and Specifications

As the National Demolition Association suggests the federal government should establish specifications and purchasing guidelines for each recovered material; take a leading role in promoting the development of new technologies and processes that will produce durable, economical, high quality recycled products; and develop national inspection standards for recycling facilities.

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