Wood-Framed Building Deconstruction

A Source of Lumber for Construction?

By Bob Falk

The sounds are much like those found at any building site. Hammers pounding. Saws whining. Lumber in motion. However, everything here seems to be in reverse… windows and doors are being unhung rather than set in place, nails are being pounded out of boards instead of into them, lumber is being stacked up, banded, and hauled away rather than delivered and unstacked. This is the scene at a wood-framed building deconstruction site.

What is wood-framed building deconstruction?

Deconstruction describes a process of selective dismantling or removing material from buildings before or instead of demolition (NAHB 1996). Unlike many demolition practices that mechanically reduce a building's volume for recycling or landfilling, the goal of wood-framed building deconstruction is to preserve lumber, doors, windows, and other components in their whole form so they can be used again in construction.

Deconstruction is really nothing new. At least as early as the Egyptian Pharaohs, people have been salvaging building materials for reuse. Before World War II, wood-framed building disassembly was quite common in the United States; however, back then labor was relatively inexpensive, materials relatively expensive, and heavy machinery less common. Since then, we have steadily moved from a manual labor workforce to machine-based operations. Over time, a disincentive to salvage material for reuse has been created because of increasing labor costs, the emphasis on immediate turnaround time for building removal, and stringent protection laws for workers. However, as Bob Dylan once said "The times they are a changing..." The realization that too many high quality (and often scarce) building materials are ending up in the landfill has resulted in a resurgence of interest in deconstruction and material reuse, especially among those in the green building and resource conservation fields.

Why use building deconstruction?

Many of the buildings that are candidates for deconstruction were constructed during the decades of old-growth harvest and contain material largely unavailable from any other resource. As Jim Primdahl, former deconstruction coordinator for Deconstruction Services (a firm in Portland, Oregon, with over 150 deconstructions of single-family homes under its belt), said recently, "We joke that we're the only ones in the Pacific Northwest legally harvesting old-growth timber." Many consider this material to be of higher aesthetic quality (higher density, slower grown, fewer defects, etc.) than the lumber produced today (and are willing to pay more for it).

Deconstruction can help offset the disposal costs of building removal, in addition to reducing the volume of waste destined for landfills. Landfill tipping fees vary considerably around the United States, so the economic advantages of deconstruction will also vary. The U.S. Army's Twin Cities Army Arsenal in St. Paul, Minnesota, saved over $70,000 in transportation and tipping fees while salvaging 1.5 million board feet (BF) of lumber from the deconstruction of a large industrial building (Lantz and Falk 1999). More holistically, the reuse of lumber products will help conserve our natural resources and ease harvesting pressure on the existing forest resource.

Because many of the residential buildings slated for demolition are also in areas in need of community development, many private sector organizations and government agencies see deconstruction as an opportunity for local job and entrepreneur training (NAHB 2000, King 1999). If you can train someone basic jobsite safety, tool use, and construction sequencing while deconstructing a building, the skill levels of the local labor pool will improve along with opportunities for employment in the construction industry (Leroux and Seldman 1999).

The Institute for Local Self-Reliance (ILSR) is currently working with the U.S. Department of Housing and Urban Development (HUD) to evaluate how HUD programs such as Hope VI (which provides hundreds of millions of dollars annually to demolish buildings) might use deconstruction on public housing while helping HUD meet its Section 3 (community investment) obligations. ILSR is currently working with the Hartford (Connecticut) Housing Authority and Manafort Brothers, Inc., a local construction and demolition (C&D) enterprise, to deconstruct six units of the Stowe Village Public Housing Complex using local labor.

Deconstruction of a single-family home in Portland, Oregon.

The demolition of wood-framed buildings results in the wood members being broken up, intermixed with other materials, and greatly reduced in value.

Why is deconstruction the preferred method for the salvage of wood materials?

As anyone who has taken out the garbage in the last 25 years knows, we have seen a major emphasis on the recycling of materials of all kinds. However, recycling is but one of the three tenets of efficient material use. We all know the three "R's" mantra..... REDUCE, REUSE, RECYCLE. This hierarchy of environmentally wise material usage suggests that we first reduce the use of materials (conservation of resources), then reuse materials (in existing form, where possible, to reduce embodied energy), and finally recycle whatever is left.

In the context of building removal, some materials are better suited to recycling, some to reuse. Metals, for example, are well suited to recycling. Steel can be roughly treated (bent, torn apart, and otherwise manhandled) and still retain a relatively high value. Even if it is intermixed with other materials, it can be separated (magnetically) for recycling.

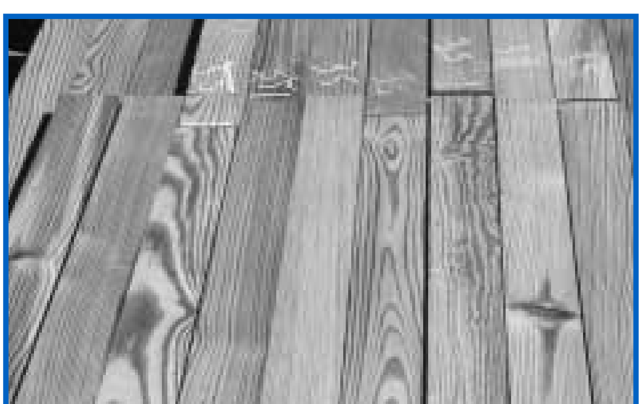
Not true with lumber. If solid lumber is mistreated and broken up, it is impractical to separate it from other building materials and any value is vastly reduced. Even if it is separated, in this broken-up state, options are limited. Chipping for mulch, fuel, or possibly furnish for particleboard or fiberboard are all possible end uses, but these are low-value outcomes for what prior to demolition was a relatively high-value solid material. To maximize the value of whole lumber and timber members, deconstruction is the clear choice over demolition.

There are millions of board feet of lumber in military buildings slated for disposal.

How big is the salvaged lumber resource?

Little information exists regarding the amount of solid wood available for reuse, so at best we can only make educated guesses. A review of historical data on lumber production levels indicates that since the turn of the century, over 3,000,000,000,000 (3 trillion!) BF of lumber has been produced in the United States (Ulrich 1990, Steer 1948). We do know that most of our 100 million or so housing units are wood-framed, so it's safe to assume that a significant portion of this lumber still resides in our residential building infrastructure. As these structures age, a portion will need to be remodeled or replaced. National Association of Home Builders economists have estimated that the number of residential housing units destroyed through intentional demolitions or disaster (such as fires or weather-related incidents) between 1980 and 1993 averaged 245,000 per year (EPA 1998, Carliner 1996). Today's housing (average size house is about 2200 $ft.^2$) uses about 13,000 BF of framing lumber (WPC 1999, USDOC 2000). Even if we assume that the average demolished home is half the size of today's homes, these 245,000 homes could potentially produce about 1.2 billion BF of framing lumber per year (25% loss assumed). Although this would represent only about 2 percent of the 54.5 billion BF of softwood framing lumber used in the United States in 1999 (Howard 2001), it is nonetheless a large volume of potentially recoverable material.

Even less information is available for estimating the lumber available from commercial, industrial, and governmental buildings; although, in 1995, the U.S. Army estimated that over 250,000,000 BF of lumber was available for reuse from its World War II wood buildings then slated for demolition (Dolan 1995). Certainly, if other branches of the military, other government agencies, and the private sector have similar buildings, millions more BF of lumber could be available for reuse.



Longleaf pine (heart pine) flooring remanufactured from salvaged timbers commands a high price in the specialty building products market.

Speaking of value, what's this stuff worth?

Bill Bowman, Habitat for Humanity deconstruction coordinator, says that salvaged dimensional lumber sells rapidly at their ReStore in Austin Texas (part of their chain of used building materials stores) at prices typically set at 50 percent of retail lumber prices (Bowman 2002). As everyone in the lumber business knows, lumber prices vary. Currently (January 2002), softwood lumber wholesales for slightly less than $300 per thousand board feet (MBF) (Random Lengths 2002).

Salvaged timber prices differ somewhat. Because of their large size, niche market appeal, and remanufacturing option, larger timbers can command higher prices. A recent check of websites of salvaged timber brokers indicates a price range of salvaged timbers from $1.20/BF to about $4.20/BF depending on quality, quantity, and species (larger, longer, clearer timbers cost more).

Remanufacturing can greatly increase the value of this salvaged timber. This is especially true for flooring. Prices in excess of \$16/$ft.^2$ are not unheard of for specialty longleaf pine (heart pine) flooring, although prices typically range from \$6/$ft.^2$ to \$10/$ft.^2$. Other pines and Douglas-fir species are less costly, in the range of \$4/$ft.^2$ to \$7/$ft.^2$.

Interestingly, the characteristics (nail holes, discoloration, etc.) that might lower the grade of virgin lumber often serve as quality attributes for salvaged flooring, invoking such imaginative market descriptors as *cottage rustic, character select, heritage, antique, legacy* etc.

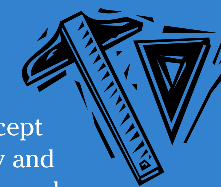
What's limiting the use of wood-framed building deconstruction?

As I have discussed, there are many positive attributes of deconstruction. However, is there too much downside to squelch a future for this practice? Several factors, not insurmountable, work against deconstruction.

The methods and materials used in construction significantly influence the practicality of deconstruction. Experience indicates that older wood buildings are easier to deconstruct than newer wood buildings. Prior to the 1960s, we didn't use construction adhesives in a big way, and their use makes disassembling a building more difficult. Also, the solid board sheathing found in older wood structures is easier to remove without damage than the plywood or oriented strandboard found in newer buildings. As wood engineers, we expend a lot of effort designing wood products and buildings that are structurally efficient, while assuring occupant safety. The use of high-performance composite wood products, adhesives, composite action, and load sharing all work to give us safer structures, but will these factors make eventual building disposal more difficult? Very little thought has been given to how we will take our wood buildings apart in the future (see sidebar).

Time, it seems, is always in short supply. This is especially true when a building is to be removed. The time constraints of the new property developer (and their financial backers) often make deconstruction an obstacle. However, it is ironic that a building can sit for years unused and decaying and as soon as a decision is made to "revitalize" the site, there is rarely enough time to deconstruct and salvage materials. Last year, Deconstruction Services, in an effort to show that deconstruction can be a speedy

Looking Into Our Building Future: Designing for Deconstruction



Design for deconstruction (DfD) is an emerging concept that borrows from the fields of design for disassembly and recycling, and reverse manufacturing in the consumer products industries. Its overall goal is to reduce pollution impacts and increase resource and economic efficiency in the adaptation and eventual removal of buildings, and recovery of individual components and materials for reuse, re-manufacturing, and recycling.

DfD considers the whole life cycle of the building, not just construction and operation, or even maintenance and repair, but major adaptations, and eventual whole-building removal from the site. If overall "sustainable development" necessitates an increase in the reuse and recycling of urban land and even first-generation suburbs, the trends towards renovation and rebuilding to use existing infrastructure will only increase. Addressing the decisions made in the design and construction of buildings now might well mitigate the "waste" that will be generated from building removals in the 21st century and beyond.

The economics of building-related debris disposal or recovery are driven by the relative and highly externalized costs of local debris landfill tipping fees. Two other very important factors are labor costs and speed of the disassembly process itself. These factors illustrate the opportunities and challenges related to DfD. Debris disposal costs are out of the hands of the individual building designer, but the designer does have control of the types and specific uses of materials and how they are connected.

Efforts are ongoing to explore the obstacles and opportunities for DfD in the residential arena and at the whole-building scale. Some obstacles include: 1) prevalence of materials that have become regulated environmental hazards; 2) electrical and plumbing systems located within walls, floors, and ceilings; 3) use of connectors that are inaccessible and cause damage in the process of separating materials; 4) the risks involved when buildings are weakened and de-stabilized during deconstruction; 5) the difficulty of matching the scale of a human laborer to the scale of building components; 6) construction processes that make it difficult to reuse or recycle materials, e.g., drilling, nailing, and use of binders, adhesives, and coatings.

Some of the concepts of DfD fly in the face of our current design of engineered wood products and systems. DfD means making it easy to dis-entangle materials and systems, reducing the use of chemically disparate binders, adhesives, or coatings. Finding thermal/chemical/mechanical means to better separate constituent materials will also be important.

Both a *construction* blueprint and a *deconstruction* blueprint might be developed before the building is constructed. Barcodes could be developed for materials such that a deconstruction contractor will have "handling" instructions for the material or component upon removal. Also, the use of more modular construction might help reduce waste in renovation, before a building gets to the end of its life cycle.

Two notable examples of recently constructed commercial buildings that relied heavily on recovered materials and were also designed to facilitate future materials recovery are the Phillips Eco-Enterprise Center, Minneapolis, MN, and the C.K. Choi Building at the University of British Columbia, Vancouver, BC.

For further information, contact Brad Guy, Center for Construction and Environment, University of Florida, Gainesville, FL; minou@grove.ufl.edu; www.cce.ufl.edu.

process, deconstructed a 1,000 ft.^{2} 2-story structure in 12-1/2 hours (cover photo). Although it took 26 workers and tremendous coordination, this 1920s home (with lathe and plaster walls, hardwood flooring, and wood siding) was reduced to several denailed and NEATLY stacked piles of reusable flooring, siding, and lumber. Windows, doors, and other architectural items were salvaged. Two 30-yard dumpsters contained the unusable debris (mainly roofing and plaster) and a single 30-yard dumpster contained clean wood scrap that was recycled and sold as mulch. The total contract price was $7,800 for building removal, with labor costs totaling $5,800. The salvaged materials sold for $12,000 (Primdahl 2002).

Deconstruction is a labor-intensive business. As mentioned earlier, a more tender touch is needed for lumber salvage than many demolition machines can provide, therefore more people are needed for the job, which means higher labor costs. Also, nail removal requires a lot of labor, although methods and tools are being developed to speed up this process.

Not unlike construction, safety is a big concern for deconstruction and it involves working in dirty conditions, working at heights, working with materials with potential health hazards, e.g., asbestos and lead-based paint (LBP). Asbestos is an important issue for building deconstruction and

Deconstruction and Lead-Based Paint

The presence of lead-based paint (LBP) in buildings can affect the salvage and reuse options for wood materials. In the United States, LBP was used until 1978 and would indicate that as much as two-thirds of our housing stock contains this material (Howard 2001). While structural members aren't usually painted, many salvageable wood members are (e.g., solid wood siding, fascia, etc.). If the wood is painted (with LBP or other paint), the paint can obscure the characteristics needed for visual grading. But a bigger hurdle is the issue of toxicity and the resulting health effects of LBP exposure. The impact of paints on the stress grading of lumber probably isn't that significant because there are not large volumes of painted lumber. However, the presence of LBP can affect the reuse, remanufacture, and disposal of other wood members, like windows and doors.

Current regulations are somewhat daunting (at least to the uninitiated) and involve a bewildering series of state and federal requirements involving definitions of both hazardous and/or solid wastes. EPA's Resource Conservation and Recovery Act (RCRA) defines what materials qualify as solid waste. If a material is being sent for disposal, recycling, processing, or treatment, it's solid waste. Further, it may qualify as hazardous waste. RCRA has various definitions of hazardous wastes, some very specific. Others are defined by their toxicity characteristic, as determined by the Toxicity Characteristic Leaching Procedure (TCLP). This test involves crunching up a waste product, mixing it with water, and determining if certain contaminants are present at levels of concern. For lead, the regulatory level is 5 mg/L (as defined by Consumer Product Safety Commission [CPSC] regulations).

Therefore, simple reuse — for example, giving or selling a used door or window with LBP to someone for reuse as a door or window — is NOT allowed under RCRA. In 1998, the EPA Office of Toxic Substances proposed a regulation prohibiting resale of LBP-containing items, possibly by requiring a warning label. To date, the proposal has not been accepted, and therefore has no force of law at this time.

Complicating things further, it's not currently clear how to proceed if you want to salvage and then reprocess painted wood. For example, say you wanted to salvage painted wood siding and replane it to remove the paint and use it again as new wood siding. When you take the piece off the building it might have a TCLP level greater than or less than 5 mg/L (as determined by the TCLP procedure).

If less than this level, it is not regulated by RCRA and apparently you can replane and reuse the produced siding. However, the resulting shaving/paint debris generated may have a lead content greater than 5 mg/L, and is therefore regulated. It would seem that you would now be the waste generator and have to dispose of this debris in the appropriate fashion.

What if the original siding had a lead level greater than 5 mg/L? Now it is regulated by RCRA; however it isn't clear if you must then dispose of the whole piece, or if you can plane the paint off and reuse the underlying wood (disposing of the shaving/paint debris as a hazardous waste). Things get even cloudier if you sell the original siding, because it is not clear if you, the buyer, or both, are hazardous waste generators.

As if things weren't complicated enough, for residential remodeling there is an exemption. Homeowners, including a home contractor (deconstructor?) can send waste, even if it contains LBP, to a municipal solid waste landfill or a construction and demolition landfill. This is called the "household hazardous waste exclusion," which means that Joe Homeowner doesn't have to send his waste to a hazardous waste landfill every time he throws out a piece of painted wood.

Important caveat: States always have the option to be more stringent in their regulations than the EPA, and many are. More information can be found at the following website: www.epa.gov/lead/leaddebr.htm. It will become increasingly important to have consistent and clear regulations on these issues that impact deconstruction. It is hoped that the Building Deconstruction Consortium (see sidebar) will be able to address the hazardous waste issues related to deconstruction and encourage clarification of the regulations.

fortunately regulations regarding the handling and disposal of this material are rather explicit. Regulations and guidance for LBP on wood are less clear (see sidebar).

Technical barriers to reusing dimensional lumber in construction

Currently, salvaged dimensional lumber is not easily traded as a commodity product. Why? As we all know, quality control is a critical element in the acceptance and trade of lumber products used in construction. The grade stamp on virgin lumber allows each piece to be individually sold at retail outlets and verifies its quality and adherence to grading agency rules. This allows its widespread acceptance by engineers, architects, and building officials at a building site.

Although existing grading rules can be used to grade salvaged lumber, neither these rules nor the standards behind them specifically address the use of salvaged lumber. Occasionally, old grade stamps can be found on salvaged lumber. Unfortunately, grading criteria has changed over the decades, making the information on many of these stamps obsolete. Also, because existing grade criteria have been developed for virgin lumber, guidance on evaluating defects commonly found in salvaged lumber is lacking, such as for severe drying checks, nail holes, and damage from deconstruction.

In addition, existing rules typically require that a grading certificate be issued for each batch of graded material. This certificate limits the sale of this batch of lumber to a single order, restricting its marketability and acceptance. Currently, the only other option is to sell salvaged lumber for uses that do not require a grade stamp, which are typically non-structural, low market value applications. To what extent the defects found in salvaged lumber affect lumber strength has not been fully quantified, so the limitations in the existing rules can result in salvaged lumber being downgraded or disallowed for many applications. Amending grading rules to address salvaged lumber as well as the establishment of a grade stamp specific to this material will broaden markets and reuse options by allowing each piece to be individually sold.

Research is ongoing at the USDA Forest Service, Forest Products Lab (FPL), to help address some of these issues, in part funded by the Partnership for Advancing Technologies in Housing (PATH). The main objective is to establish necessary grading criteria, develop engineering property data, and propose appropriate reuse options for salvaged lumber. This project is a cooperative effort between FPL, the U.S. Army, the West Coast Lumber Inspection Bureau (WCLIB), and the Southern Pine Inspection Bureau.

Resawing longleaf pine for flooring. The low moisture content (9% to 12%) of most reclaimed timber makes it ideal for remanufacture into flooring, molding, and other indoor building products.

To date, several thousand pieces of full-size Douglas-fir lumber have been graded by WCLIB grading supervisors at deconstruction sites, several of which are decommissioned military bases, including the Twin Cities Army Arsenal in Minnesota; Ft. Ord in California; and the Oakland Naval Supply Center in California. Grade yield and quality for a subset of this lumber can be found in Falk et al. (1999b). At this time, full-size testing of about 1,200 pieces of this lumber is nearly completed and we've collected engineering property data as well as information on the effect of salvaged lumber defects on failure. Preliminary data suggest that salvaged lumber is somewhat lower in bending strength than expected (Falk et al. 1999a); however, we haven't analyzed all the data, so the jury is still out. We hypothesize that the defects unique to salvaged lumber (nail and bolt holes, damage, etc., produced

Bending test of 2 by 10 reclaimed lumber at the USDA Forest Products Laboratory.

Building Deconstruction Consortium

In 2001, a group of building professionals dedicated to maximizing the reuse of building materials formed the Building Deconstruction Consortium (BDC). This group was brought together to identify and develop technical resources that encourage building material reuses that are fiscally, environmentally, and occupationally sound. The following organizations are currently involved:

* Department of Housing and Urban Development
* U.S. Environmental Protection Agency
* USDA Forest Serv., Forest Products Laboratory
* U.S. Army Environmental Policy Institute
* U.S. Army Corps of Engineers Construction Engineering Laboratories
* Green Building Community
* Used Building Materials Association
* Habitat for Humanity
* University of Florida, Center for Construction and Environment

The main focus of the BDC is to work with key public and private sector representatives in developing and disseminating technical information on building deconstruction and material salvage. In addition, the BDC is committed to addressing the technical barriers to deconstruction, including the lack of materials reuse standards, methods, and policies. This group is committed to identifying obstacles and opportunities; facilitating necessary research, development, and dissemination of credible information; and institutionalizing the practice of deconstruction for all stakeholders in the building and demolition industries. The BDC believes that building deconstruction and materials reuse represents an underutilized strategy for the efficient use of our country's material resources. The BDC's website is currently being developed and it may be accessible by the time this article is in print: www.buildingdeconstruction.org.

both in the construction and deconstruction processes) are the culprits for strength loss, as lumber stiffness seems to be as expected. To provide more insight into this issue, we are testing small, clear specimens (no defects) from each full-size lumber piece (with defects).

Our hope is that the data we are collecting will provide the technical information necessary to formally recognize salvaged lumber as an acceptable construction material (via a specific grade stamp), even if the range of applications is more limited than for virgin lumber.

Is there a bottom line?

There are many reasons why we should deconstruct, as well as many factors that make deconstruction a challenge. The time and labor costs associated with deconstruction are negatives; on the other hand, avoided disposal fees and the added revenues of salvaged material are positives. The relative magnitude of each varies with building type, local labor costs, tipping fees, and salvaged material markets. Because deconstruction is not yet a widespread activity, economic models are only now being developed. However, even with our limited experience, many agree, including myself, that deconstruction deserves further consideration (Turley 2000, Yost 2000, NAHB 2001).

The author is a Research Engineer, Advanced Housing Research Center, USDA Forest Service, Forest Products Laboratory, Madison, Wis. *The assistance of the following people in the development of this article is appreciated: Bill Bowman, Habitat for Humanity ReStore; Chris Cross, Deconstruction Services; Brad Guy, University of Florida; Ken Sandler, EPA; Thomas Napier, U.S. Army Corps of Engineers; and Jim Primdahl, Institute for Local Self-Reliance.*

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