Building Deconstruction: Reuse and Recycling of Building Materials

Alachua County Solid Wastes Management Innovative Recycling Project Program

Prepared by:
Bradley Guy, Interim Director, Center for Construction and Environment
PO Box 115703, Gainesville, Florida USA 32611-5703, Tel: (352)-392-7502

ABSTRACT

The CCE deconstructed six (6) houses during 1999-2000 to examine the cost-effectiveness of deconstruction and salvage when compared to traditional demolition. This research was funded through the Florida Department of Environmental Protection (FDEP) Innovative Recycling Projects grant program. The one and two-story houses that were deconstructed represent typical Southeastern US wood-framed residential construction from 1900 to 1950. Regulatory issues include the costs and implementation of environmental, demolition, and historic permitting practices in the Gainesville / Alachua County, Florida region, and handling of lead-based paint (LBP) materials, and asbestos containing materials (ACM). Worker safety issues and technical issues include protection from environmental and site hazards. The salvage issues include a case-by-case materials management process for each building. Reuse and materials redistribution scenarios include on-site and off-site redistribution and associated costs and benefits. Over 500 pieces of salvaged lumber were visually graded by the Southern Pine Inspection Bureau, to understand the effects of use and the deconstruction process might have on salvaged lumber for use in structural applications.

KEYWORDS: deconstruction, selective dismantling, C&D wastes management, building salvage, building materials reuse.

Project Background

From August, 1999 to May, 2000 the Center for Construction and Environment, University of Florida, with funding from Alachua County Public Works Division and the Florida Department of Environmental Protection (FDEP) deconstructed six (6) wood-framed residential structures in Gainesville, Florida. University students provided a labor force on the first three buildings and Americorps*NCCC members worked on the second three. Of note is how much more efficient a trained team of workers is than workers who are being trained. No particular worker, other than CCE staff, worked on more than two buildings. Houses were acquired mainly through word of mouth. Four houses were in disuse and did not have time constraints for the removal, and two were being removed as part of a redevelopment. Permitting processes included issues of historic preservation, demolition delay requirements, licensed contractor requirements and environmental, safety and health certifications for hazardous materials management, utility disconnections, and septic tank removals. Each house was tested for lead-based paint (LBP) and asbestos containing material (ACM). All structures were completely removed from the site, comparable to a total demolition. Time and activity data was collected for each worker and all associated costs and estimated revenues from salvaged materials were calculated. Each building was also estimated for demolition in order to make a comparison with deconstruction and salvage. There was considerable variety in the buildings' conditions, the location of the buildings, and the efficiency of each deconstruction.

Buildings Summary

The structures ranged from approximately 1000 to 2000 SF and were both single and two-story. The oldest structure was built approximately 1900 and the youngest built in 1950. All of the structures had at least one addition and most had two or three major alterations or additions. The typical construction was a raised wood floor structure on brick and/or concrete piers, light wood wall framing, roof rafters, and interior and exterior wood cladding and sheathing. Two structures had plaster and lathe interior wall finishes. In one case gypsum wall board was applied directly over the wood beadboard interior wall finish. One structure also had two roof finishes, metal over asphalt shingles, and two floor finishes, an oak floor laid directly on top of a pine floor. Three (3) of the structures required the removal of asbestos floor tile, and one required the removal of asbestos gypsum wall board, roofing materials and duct insulation material. Lead-based paint was found in all structures. All of the structures had rot from water damage principally in kitchen or bath floor areas, but also including wall areas at leaks from the roof.

Summary of Buildings

Building address #	**2930**	**711**	**14**	**2812**	**901**	**3650**
Built	1915	1945	1900	1900	1920's	1950
Stories	1	2	2	1	1	1
Light framed wood construct.	Y / CMU	Y	Y	Y	Y	Y
Size (SF)	2,014	1,436	2,059	1,238	992	1,118
Urban or rural-sized parcel	Rural	Urban	Urban	Rural	Rural	Rural
Additions	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
# of additions	3	1	1	2	3	1
Internal renovations	Y	N	Y	N	Y	N
Inhabitable	**Y**	**N**	**Y**	**N**	**Y**	**Y**
Require major repair	N	Y	N	Y	N	N
Asbestos						
Exterior wall finish	Y	N	N	N	N	N
Roofing	N	N	Y	N	N	N
Insulation	N	N	Y	N	N	N
Floor tile	**Y**	**N**	**Y**	**N**	**N**	**Y**
Drywall	N	N	Y	N	N	N
Abatement	Y	N	Y	N	N	Y
Lead-based paint						
Interior trim	N	N	Y	Y	N	N
Exterior trim	**Y**	**Y**	**N**	**Y**	**N**	**Y**
Interior surfaces	N	Y	N	N	Y	N
Exterior surfaces	**N**	**Y**	**Y**	**N**	**Y**	**Y**
Reason for removal						
Redevelopment site	**Y**		**Y**	**Y**	**Y**	
Taxes / expense						Y
Safety / disuse		Y				
Homeless / fire hazard				Y		

Table One – Building Summary

All of the structures had additions, and these were typically for; 1) adding enclosed living space, 2) adding kitchen and bathroom facilities on older structures, 3) enclosing an existing open porch area. Four (4) out of six (6) could be made inhabitable, three (3) of six (6) had been recently occupied prior to the building's removal. One (1) house had been occupied by homeless persons without heat, kitchen, or bathroom facilities. Three (3) of the six (6) structures were found to have asbestos containing materials (ACM) requiring abatement. Two (2) of the structures contained only non-friable asbestos which could have been "wet demolished" by mechanical means but would have required the entire demolition wastes load to be disposed off in an asbestos certified landfill. One building had LBP only on the inside, typically LBP was found on exterior window and door trim, where it was used in gloss and semi-gloss paint for durability.

There were a variety of reasons for the owners' desire to remove the structure, but two (2) of the (6) six were on property slated for immediate commercial or multi-family redevelopment, two (2) were on property slated for long-term redevelopment, and two (2) buildings were on land not slated for redevelopment. The latter two (2) structures may have been left vacant for an indeterminate length of time if they had not been used for this project. During the course of the project, one building verbally committed to the deconstruction project, on a site slated for commercial redevelopment, was demolished. In addition, two candidate buildings, on sites slated for redevelopment, were moved. One structure that was considered for the project was considered too dilapidated for a reasonable deconstruction and another was passed over due to scheduling conflicts and was subsequently partially renovated by the owner. The average size for the principal structures was 1,476 SF.

Based upon literature review and anecdotal information, this sample of structures would appear to be representative of residential demolitions in the United States. Approximately 94% of all residential buildings built each year in the US are light wood-framed construction (NAHB, 1994).

Data Collection

On-site labor was documented by recording each worker's activities on a 15-minute time increment. There have been several well-documented deconstruction pilot projects in the US with this detail of data collection, most notably the Fort Ord Pilot Deconstruction project conducted by the Fort Ord Reuse Authority (Cook, 1997) and the Riverdale Pilot Deconstruction Project conducted by the National Association of Home Builders Research Center (NAHBRC, 1997). These projects provided models for creating the data collection process. Based upon these studies and personal experience, the CCE has refined its data collection techniques over time. Data is divided into two categories; the deconstruction of the structure and the processing of the salvaged. The deconstruction labor data is sub-categorized according to the location in the building, and the specific material. The cost of a traditional demolition was calculated for each structure, including disposal costs. Salvage revenues were estimated using a percentage (%) of retail price from local building materials suppliers and the experience of a former used building materials store owner/operator in Gainesville, Florida. Disposal costs were estimated by weight and costs data provided by the wastes haulers for the project.

Worker activities were divided into categories of activities, the location or component of the building and the materials that were handle. This was done for the purposes of connecting the costs of deconstruction and processing to the deconstruction itself, the costs of deconstructing a particular component of the building, and the costs to salvage by unit of material. The latter information was used to assign a unit cost of extraction and processing that could be compared to the pricing units for materials, i.e. number, linear feet, or board foot of material. Labor productivity data was collected in the following task categories:

(S) upervision

Directing and planning the flow of work on the job site.

(Decon) struction

Labor involved in the initial removal of materials from the structure. Any manual or mechanical procedure required to remove materials for salvage either the direct handling of a material or removing other materials to gain access to the salvage material.

(Demo) lition

The hand or mechanical removal of building materials for direct disposal.

(P) rocessing

Preparing materials for redistribution in reusable form. Denailing is the most typical processing activity.

(N) on-production

Non-production occurs when no work is being performed. This includes breaks and lunch, and the unloading and clean-up of daily tools. Any work stoppage greater than five minutes and not coordinated by the supervisor is considered non-production.

(C) lean-up / (Dis) posal

Sweeping and/or removing debris or demolition materials from a work area and/or disposal into a roll-off container. Clean-up does not involve denailing, loading, stacking or transporting processed materials.

(L) oading/unloading

Loading or unloading materials from the site onto a truck for transport and at the final storage area. Any efforts to move, stack or place the lumber is a loading activity.

Labor Time by Work Categories

Category Hours									
House #		Super	**Decon**	**Process**	Demo	**Dis/Clean**	Non-Pro	Load	**Total**
2930	hr	60.50	**179.50**	**204.80**	0.00	**100.00**	52.75	80.00	**677.55**
Percentage	**%**	8.93	**26.49**	**30.23**	0.00	**14.76**	7.79	11.81	**100**
Hours / SF		0.030	**0.089**	**0.102**	0.000	**0.050**	0.026	0.040	**0.336**
711	hr	20.50	**24.33**	**8.67**	42.95	**80.50**	14.33	12.25	**203.53**
Percentage	**%**	10.07	**11.95**	**4.26**	21.10	**39.55**	7.04	6.02	**100**
Hours / SF		0.014	**0.017**	**0.006**	0.030	**0.056**	0.010	0.009	**0.142**
14	hr	62.13	**113.56**	**124.56**	26.67	**81.00**	27.00	42.87	**477.79**
Percentage	**%**	13.00	**23.77**	**26.07**	5.58	**16.95**	5.65	8.97	**100**
Hours / SF		0.030	**0.055**	**0.060**	0.013	**0.039**	0.013	0.021	**0.232**
2812	hr	16	**84**	**91.85**	64.5	**35**	50.5	17.25	**359.10**
Percentage	**%**	4.46	**23.39**	**25.58**	17.96	**9.75**	14.06	4.80	**100**
Hours / SF		0.013	**0.068**	**0.074**	0.052	**0.028**	0.041	0.014	**0.290**
901	hr	11.75	**124.8**	**47**	27	**25.75**	23	1.75	**261.00**
Percentage	**%**	4.50	**47.80**	**18.01**	10.34	**9.87**	8.81	0.67	**100**
Hours / SF		0.012	**0.126**	**0.047**	0.027	**0.026**	0.023	0.002	**0.263**
3650	hr	16	**84**	**91.85**	64.5	**35**	50.5	17.25	**359.10**
Percentage	**%**	4.46	**23.39**	**25.58**	17.96	**9.75**	14.06	4.80	**100**
Hours / SF		0.014	**0.075**	**0.082**	0.058	**0.031**	0.045	0.015	**0.321**
Avg %		7.57	**26.13**	**21.62**	12.16	**16.77**	9.57	6.18	100.00
Avg Hr / SF		0.019	**0.072**	**0.062**	0.030	**0.038**	0.026	0.017	**0.264**

Table Two – Labor Category Summary

The largest percentage of time was the deconstruction activity, an average of 26% of total time. The house with the largest percentage of time in deconstruction was the house at 901 SR 301 (47.8%). This house was being removed for redevelopment and had a very short time frame for the deconstruction. Because of its location on a major highway in the corner of shopping center site, materials were able to be redistributed by placing them neatly in separate piles at the site and “Free Materials” signs posted to encourage passersby to remove the materials themselves. Most of the 2x4 was not de-nailed in order to maximize the labor spent on deconstruction. All of the materials were removed within one day after the completion of the deconstruction. The house with the lowest percentage of time in deconstruction was the house at 711 NW 7th Avenue (12%). This structure was in the poorest condition of any of the structures and also had the lowest amount of salvage. It was not considered an economically viable deconstruction and was used in the study because of availability and to remove a hazard to the nearby owner and the neighborhood. Commensurately, this building had the highest percentage of time spent in disposal and cleaning (39.6%). The next greatest percentage of time was spent in processing materials at an average of 21%. Excluding the house at 711 NW 7th Avenue which had a very low salvage rate and very little processing (4.3%), processing was a relatively consistent percentage of time between 18 – 30% of total time. Disposal and cleaning required an average of 17% of total time. Demolition required an average of

~12% of total time. The house at 711 NW 7th Avenue had the highest percentage of time spent in demolition, consistent with low deconstruction and high disposal and cleaning efforts.

	Super	Decon	Process	Demo	Dis/Clean	Non-Pro	Load	Total
Average %	5.89	24.14	20.91	8.64	10.18	8.40	5.18	100
Average per SF	0.017	0.069	0.061	0.025	0.029	0.025	0.015	**0.240**

Table Three - Labor Categories Excluding 711 NW 7th Avenue.

The deconstruction process roughly follows the reverse of the construction process. The premise is that materials which have been put on last will come off first. Variations occur for whole building sections, for example, an addition will be removed in its entirety separately from the rest of the building. The practice of focusing on each material type in a reverse order of the construction process is more efficient for separating materials for reuse, recycling, and disposal at the time of removal. Additions are an impediment to removing one type of material or whole sections of the original structure, but can provide a working surface for other parts of the building, and be structurally dependent on other parts of the building. For these reasons, additions were typically removed in their entirety, regardless of breaking up the material-by-material consistency of the deconstruction process.

Economics

The net cost of the deconstruction is modeled by the expression*: (Deconstruction + Disposal + Processing) – (Contract Price + Salvage Value) = Net Deconstruction Costs*. The net cost for demolition is*: (Demolition + Disposal) – (Contract Price) = Net Demolition Costs.* If materials are not resold or redistributed on-site or reused by the deconstruction contractor in new construction, transportation and storage costs may be additional costs for deconstruction. In order for deconstruction to be cost-effective and competitive with traditional demolition and disposal, the total costs must be reduced by the sum of savings from disposal and revenues from resale of materials.

There are multiple options for contracts and costs/revenues between a building owner and the deconstruction contractor, such as:

- Deconstruction as a service to the building Owner and the Owner retains ownership of the salvaged materials. This can also be a guaranteed "buy back" of the materials and treated according, with some consideration for the Contractor's costs for processing and handling. The Owner will pay more than demolition but could be "buying" very high value materials.

- Deconstruction with shared ownership of the materials, with a reduction in the deconstruction contract based upon the Contractor receiving materials as in-kind payment.

- Deconstruction with the Contractor retaining all materials, and charging an internally calculated price based upon revenues to be received from resale of salvaged materials.

- A non-profit can perform a deconstruction and charge the building owner no more than direct labor costs, with the Owner donating the materials as a tax write-off. The Owner pays minimal costs for the deconstruction and recoups some of the expense of deconstruction by using the value of the materials.

An economic factor for deconstruction on a redevelopment site is the time costs of money in financing and construction loan interest. A large site may have enough development activity that an unwanted structure can be isolated from the other construction activity and be deconstructed without delaying the site development. In the case of a site where the new construction will take place on the footprint of the existing structure, the time for removal of the existing structure by deconstruction is a significant economic impediment.

On top of the higher initial costs to deconstruct and the necessary added infrastructure and costs to store, transport, supervise the redistribution of the materials to accrue a significant portion of the economic return, it is no surprise that deconstruction has significant economic barriers as a building materials recycling strategy on near-term redevelopment sites.

Permitting

The City of Gainesville has a unique demolition permitting process which allows the City to place a 90-day demolition delay on any structure that may have historic value. During this 90-day delay, the residential structure is posted as free to anyone willing to pay the costs of moving. This delay can be waived by demonstrating a financial hardship. Within designated historic districts a demolition permit is reviewed by the Local Historic Preservation Board (LHPB) and can either be approved outright or be denied. In Alachua County, there are no historic districts or delays. A demolition permit can be applied for and immediately executed.

There is no differentiation in Alachua County and the City of Gainesville between a deconstruction and a demolition for permitting purposes. The total costs of permits range from $60 to $100 for single or two-story residential structures. The City of Gainesville charges by the total number of stories of a structure, and Alachua County charges by the estimated value of the demolition work. These factors are not conducive to encouraging deconstruction.

A possible incentive for deconstruction under the 90-day delay ordinance is to shorten the delay to 14 days, for example, for a “deconstruction permit”. By shortening the delay for deconstruction, it would be less viable to claim economic hardship posed by the delay, some time is allowed to arrange a building removal, and sufficient time is allowed for deconstruction and still result in a net reduction over the 90-day delay.

The City of Gainesville and Alachua County both allow residential building owners to pull permits for demolition. In the City of Gainesville, work must then be supervised by the Owner or by a licensed contractor, whereas Alachua County allows work to be performed on small structures ~1,000 SF, by an agent for the Owner.

Environmental Issues
For the purposes of maintaining worker health and safety, deconstruction is a distinct activity in EPA and OSHA regulations. Relevant environmental and worker health and safety regulations governing the deconstruction of buildings include: US EPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61, Subpart M), Occupational Health and Safety (OSHA) Asbestos Regulations (29 CFR 1910.1001), OSHA Lead Regulations (29 FCR 1926.26) and Classifications of Landfills Florida Statue Rule 62-701.200 (19).

Hazardous Materials in Deconstruction
The NESHAPS regulation requires any commercial properties or residential properties greater than 4 units to have a reasonable effort to identify hazardous materials prior to demolition or deconstruction. The NESHAPS regulation also controls the techniques for removal, containment, and transport of asbestos containing materials (ACM). The NESHAPS regulations exempt residential structures of 4 dwelling units or less. Residential units demolished as part of larger public or commercial projects such as highway construction and shopping centers are not exempt from NESHAPS even if less than 4 dwellings units. A group of individual residential buildings under the same ownership on a site is considered an installation and is also not exempt from the NESHAPS regulations. Hazardous materials are required to be disposed of in a lined landfill or other disposal facility that is permitted for those materials.

Worker environmental safety is regulated under OSHA and EPA guidelines regardless of the construction activity. The CCE utilized a certified LBP and ACM surveyor to perform a lead-based paint (LBP) survey and an asbestos survey if asbestos containing materials (ACM) are visually identified during the building assessment. The building assessment survey also includes noting the presence of fluorescent lights, thermostats, or high-density discharge lamps that may contain mercury or PCBs, and containers of suspect chemicals, paint, oil, etc. A Phase II ESA investigation is conducted with spot testing for LBP for all structures was conducted for all of the structures.

LBP is assumed in any structure built prior to and during the period between 1970 - 1980 and OSHA began ACM regulation in 1970. Samples were taken from all suspect, homogeneous ACM and LBP surfaces on all of the structures in this study. Polarized Light Microscopy with dispersion staining was used to analyze the ACM samples using US EPA Interim Method for the Determination of Asbestos Minerals in Bulk Materials. LBP samples are tested using the NIOSH Method #7082. Samples were analyzed by EMSL Analytical, Inc., Program, Greensboro, NC. The HUD minimum threshold for the presence of lead is 0.5% Pb. A summary of LBP findings for the structures is provided in Table One.

According to the US EPA, regulated ACM (RACM) is: a) friable asbestos material; b) Category I non-friable that has become friable; c) Category I non-friable that will be subject to sanding, grinding, cutting, abrading; d) Category II non-friable that has a high probability of becoming friable in the course of renovation or demolition activity.

Removal and disposal of all friable asbestos must be completed prior to demolition by a licensed professional asbestos abatement firm. Category I non-friable ACM (asphalt roofing shingles, floor tiles) and Category II non-friable ACM (asbestos siding shingles, transite board) need to be removed prior to demolition only if they are RACM. Category I non-friable ACM flooring and shingle materials and Category II non-friable ACM are not RACM and do not have to be abated prior to demolition if they are in good condition and not likely to become friable during demolition. Removal of Category I non-friable ACM is permitted according to the Resilient Floor Covering Institute (RFCI) and the National Roofing Contractors Association (NRCA) acceptable work practices. The NRCA association's recommendations are to remove asbestos shingles by hand and lower them to the ground. Theoretically, demolition should render all ACM regulated since it is comprised of crushing, cutting, and grinding activities. However, Category II non-friable ACM is allowed to be demolished in place using proper wetting and containment techniques during the removal and transport.

Because deconstruction poses a greater worker exposure than mechanical demolition it is prudent to remove all ACM, both RACM, and ACM that is in good condition. Any materials with asbestos would also not be viable for reuse. In effect, all ACM must be abated prior to deconstruction whether it is considered regulated or not, which could add significant costs to a deconstruction project over traditional demolition.

Any components that are either intended for reuse with LBP remaining on the material or materials that have been repainted to encapsulate the LBP require notification that the material contains LBP. Salvaged materials are not allowed to sit on exposed soils where there is potential for the LBP to leach into the soil. Salvage materials are either moved off –site to an appropriate storage facility, or stored on 6 mil polyethylene sheeting and a waterproof covering. Wastes materials are placed directly into standard 20, 10 and 8 cubic yard roll-offs.

Asbestos Abatement and Lead-Based Paint Protocol

A certified asbestos abatement contractor, Merit Abatement, Macclenny, Florida, was used for any asbestos abatement required during the project. At no time was any sanding, grinding, abrading, cutting, burning or heating of the LBP wood materials permitted. Sine all ACM was abated prior to deconstruction, the primary worker health concern was for lead-based paint (LBP) materials. The primary threat of worker exposure to LBP was through ingestion - inhaling, eating, drinking and smoking while in proximity to the LBP. A hand washing station was established on the job-site and personal protective equipment (gloves) was required of all workers.

In the event of known LBP in an interior environment, according to OSHA Lead Regulations (29 FCR 1926.26), workers are assumed to be exposed to LBP above acceptable levels until proven otherwise through personal air sampling. Methods to insure the removal of LBP and worker protection in this project were primarily building engineering and mitigation techniques. OSHA and EPA both recognize that deconstruction is a less destructive process than mechanical demolition, but conversely has the potential for greater worker exposure. There were two houses in this project that had LBP on interior trim and two different houses that had LBP on interior surfaces. Four houses had LBP on exterior trim or surfaces. Because of the high turnover of workers, and the fact that the presence of LBP was minimal in interior environments or on the exterior or the structures, the following protocol was established for this Innovative Recycling Project to insure worker health safety:

1. All workers receive an ACM and LBP awareness approved training course through the University of Florida TREEO Center.
2. All exterior windows and doors are the first elements removed from the buildings to immediately allow ventilation and prevent accumulation and concentrations of LBP dust.
3. All workers in the LBP environment are provided personal fit-tested and approved respirators if requested, and protective clothing.
4. A HEPA vacuum was utilized throughout the building interior to remove all dust and particulate matter to the maximum extent feasible.
5. Workers are rotated out of LBP environments on a short-cycle and regular basis.
6. Job-site hand washing station was provided.
7. Smoking was prohibited inside the structure and near any salvaged materials.
8. Workers were required to wash hands before breaks and lunch breaks.
9. Sanding, cutting, grinding, abraded, burning and heat-gun stripping of LBP surfaces was not permitted.
10. Workers were provided with uniform T-shirts and required to change them at the completion of the work shift and before leaving the job-site.
11. The job-site supervisor who was the only person consistently on site for every structure was tested for blood lead levels at the beginning and end of the project.

All workers received asbestos and lead awareness training before being allowed on the job-site. The training was provided by the University of Florida's Center for Training, Research and Education for Environmental Occupations (TREEO Center) and was in compliance with OSHA's asbestos section 29 CFR 1926.1101 and lead section 29 CFR 1926.62. The purpose of the training was to expand worker awareness of lead and asbestos issues**.** respirators was taught to the workers and computer-certified fit tests were performed with those that requested it.

Job Safety
A short classroom orientation was developed to introduce beginner workers to basic tips such as the appropriate angle of repose for ladders, communication with other works, and positioning of tools and ladders. The supervisor was also responsible for daily job-safety

supervision. In the field, additional instruction was an ongoing process. Issues of worker safety training included:

- Stabilizing weakened sections of buildings, and working in such as way as to keep the structures as stable as possible via the order of the deconstruction.
- Routes for materials after they have been removed including placing out a window or dropping from the roof for others to remove to the processing area.
- Handling windows (glass), long items, heavy items, and objects with the nails still in them.
- Understanding how components are connected and the best method and tool to use in removing it to minimize force which in turn can result in sudden movements, creating projectiles, slipping, etc.
- Importance of cleaning debris and removing materials from areas where they can be hazards either off or on the ground.
- Understanding load bearing components and stresses produced by gravity, including awareness of damaged components and weak points caused by termite, water damage, etc.

All workers were required to have their own work boots, long pants and shirts. Safety glasses, hardhats, eye plugs, and gloves were provided to the workers. Cleanup of debris on all work surfaces occurred after each phase of deconstruction. Piles of debris were not allowed to accumulate in work areas where they could generate a hazard or impediment to the workers.

Technical Issues

Deconstruction is the dismantling of a structure in the reverse order in which was constructed. Entire additions to a building will be removed at one time, and within each addition or the core structure, materials will be removed in the reverse order of their construction. Numerous issues were found to be relevant to the deconstruction process.

- The working platform or area and how well that assisted or impeded the deconstruction of an adjoining, overhead, or element below.

- Clearing a work site around the building, particularly so that roll-offs and the movement and stacking of materials was not impeded, was found to be critical.

- Timely removal and drop-off of the roll-offs in order to not impede the removal of components directly into the roll-off, while having them as close as possible to where the major deconstruction effort might be occurring. For example, having a roll-off next to the structure to capture asphalt roofing shingles, but removing it and placing the next roll-off to not impede the removal of exterior siding.

- Removing both reuseable / recyclable and disposable materials in a timely manner is critical to the safety of the job-site and the efficiency of both the deconstruction and the processing activities.

- Many nails are placed in such a way as to not be readily accessible to a prying device. Wood is sometimes damaged in the extraction process. In all cases, a material will be removable by use of levering and should not require a sledgehammer or other smashing tool.

- Arranging on-site removal of materials as they are processed in order to minimize the effort invested in loading, transporting and storing materials in another location, while at the same time insuring that materials left at the site are not stolen.

- Good deconstruction sites require sufficient room to work around the building, including de-nailing and stacking areas away from the structure, space for roll-off delivery and pick-ups, but that are also highly visible to attract potential customers for the salvaged materials.

- Coordinating workers and increasing their awareness of how materials must be removed and the importance of balancing efficiency with minimal damage to the materials is critical. Maintaining awareness of what is salvage and what is disposal requires a high degree of supervision.

Economic Data

Deconstruction costs were collected for labor, other costs, disposal costs, environmental assessment and remediation costs. Demolition total weight and disposal costs were estimated based upon observations of demolitions, case studies, the EPA Report “Characterization of Construction and Demolition Wastes in the United States” and information provided by local demolition contractors. Local labor and equipment costs for demolition were provided as estimates by local contractors. In the “real world” of small house demolition it was found that most demolitions did not include an asbestos and lead survey or abatement. Since the US EPA does not require single residential building demolitions to undergo an asbestos survey, deconstruction practices face an economic disadvantage when asbestos is abated for worker safety. For the purposes of this study, an equivalent LBP and ACM survey and abatement was assumed for demolition.

2930 NW 6th Street

This was a one-story house with a detached garage, the garage was approximately 500 SF of the total 2014 SF. The house was wood raised on brick piers, the garage was a CMU wall construction on concrete slab. This building had several additions and several layers of interior finishes, i.e. two wood floors and two roof finishes, a metal roof laid over an asphalt roof. The interior walls were predominantly plaster and lathe. The plaster was separated from the lathe to see if the lathe could be recycled or used for fuel in pottery kilns. This project was affected by a Summer heat wave and several rain days. The site had ample room for the layout of denailing areas and roll-offs, and did not require extensive sitework to make space around the building.

COSTS	**Total Net Demolition**			**Total Net Deconstruct**		
Permit	50.00			50.00		
Asbestos survey	1,200.00			1,200.00		
Asbestos abatement	740.00			740.00		
Disposal	5,873.67	96.67	tons	1,344.01	22.12	tons
Toilet	63.00			63.00		
Supplies	10.00			637.93		
Labor and Equipment	3,504.36			8,469.38		
Total Costs	11,441.03	**5.68**	**per SF**	12,504.32	**6.21**	**per SF**
REVENUES						
Salvage	0.00			9,415.00	**4.67**	**per SF**
Total Net Costs	11,441.03	**5.68**	**per SF**	3,089.32	**1.53**	**per SF**
Average disposal costs are $60.76 / ton, including drop fee, hauling and tipping fee.						
Demolition weight estimated as 96#/sf, 1/4 of house is CMU on slab						

Table Four – Economic Summary for 2930 NW 6th Street

COSTS	**Total Net Demolition**			**Total Net Deconstruct**		
Permit	50.00			50.00		
Asbestos survey	853.00			853.00		
Disposal	2,103.61	24.76	tons	671.18	7.90	tons
Metal recycling	0.00			100.00		
Truck	62.00			517.00		
Toilet	74.00			74.00		
Gas	10.00			55.00		
Supplies	10.00			155.00		
Labor and Equipment	2,154.12	**1.74**	**per SF**	6,967.38	**5.63**	**per SF**
Total Costs	5,316.73	**4.29**	**per SF**	9,442.56	**7.63**	**per SF**
REVENUES						
Salvage	0.00			4,613.25	**3.73**	**per SF**
Total Net Costs	5,316.73	**4.29**	**per SF**	4,829.31	**3.90**	**per SF**

Average disposal costs are $84.96 / ton, including drop fee, hauling and tipping fee.

Demolition weight estimated as average of typical houses at 40#/sf

Table Five – Economic Summary for 2812 NW 6th Street

COSTS	**Total Net Demolition**			**Total Net Deconstruct**		
Permit	100.00			100.00		
Asbestos survey	1180.00			1180.00		
Disposal	3229.85	28.72	tons	2700.20	20.83	tons
Toilet	63.00			63.00		
Supplies	10.00			601.59		
Labor and Equipment	2498.64			2544.13		
Total Costs	7081.49	**4.93**	**per SF**	7188.92	**5.01**	**per SF**
REVENUES						
Salvage	0.00			555.73	**0.39**	**per SF**
Total Net Costs	7081.49	**4.93**	**per SF**	6633.19	**4.62**	**per SF**
Average disposal costs are $67.13 / ton, including drop fee, hauling and tipping fee.						
Demolition weight estimated as average of previous houses at 40#/sf						

Table Six – Economic Summary for 711 NW 7th Avenue

COSTS	**Total Net Demolition**			**Total Net Deconstruct**		
Permit	100.00			100.00		
Asbestos survey	1,200.00			1,200.00		
Asbestos abatement	2,637.00			2,637.00		
Disposal	2,233.86	36.03	tons	1,174.28	18.94	tons
Toilet	63.00			63.00		
Supplies	20.00			347.24		
Labor and Equipment	3,582.66			5,972.38		
Total Costs	9,836.52	**4.78**	**per SF**	11,493.90	**5.58**	**per SF**
REVENUES						
Salvage	0.00			5,795.30	**2.81**	**per SF**
Total Net Costs	9,836.52	**4.78**	**per SF**	5,698.60	**2.77**	**per SF**
Average disposal costs are $62.00 / ton, including drop fee, hauling and tipping fee.						
Demolition weight estimated as average of similar houses at 35#/sf						

Table Seven – Economic Summary for 14 NE 4th Street

COSTS		Total Net Demolition			Total Net Deconstruct		
Permit		50.00			50.00		
Asbestos survey		700.00			700.00		
Disposal		1,874.88	22.32	tons	445.20	5.30	tons
Truck		62.00			293.13		
Toilet		74.00			74.00		
Gas		10.00			80.00		
Supplies		10.00			100.00		
Labor and Equipment		1,726.08			3,262.50		
Total Costs		4,506.96	**4.54**	**per SF**	5,004.83	**5.05**	**per SF**
REVENUES							
Salvage		0.00			4,613.95	**4.65**	**per SF**
Total Net Costs		4,506.96	**4.54**	**per SF**	390.88	**0.39**	**per SF**
Average disposal costs are $84.00 / ton, including drop fee, hauling and tipping fee.							
Demolition weight estimated as average of previous houses at 45#/sf							

Table Eight – Economic Summary for 901 SR 301

COSTS		Total Net Demolition			Total Net Deconstruct		
Permit		60.00			60.00		
Asbestos survey		835.00			835.00		
Asbestos abatement		1,841.00			1,841.00		
Disposal		3,532.65	32.42	tons	1,937.44	12.00	tons
Truck		62.00			713.00		
Toilet		74.00			74.00		
Labor and Equipment		1,945.32			4,488.75		
Septic cap		490.00			490.00		
Total Costs		8,839.97	**7.91**	**per SF**	10,439.19	**9.34**	**per SF**
REVENUES							
Salvage		0.00			3,819.65	**3.42**	**per SF**
Total Net Costs		8,839.97	**7.91**	**per SF**	6,619.54	**5.92**	**per SF**
Average disposal costs are $78.12 / ton, including drop fee, hauling and tipping fees.							
Demolition weight estimated as average of similar houses at 58#/sf							

Table Nine – Economic Summary for 3650 SW 24th Avenue

Costs and Salvage Summary

Demolition Costs							
Address	**2930**	**711**	**14**	***2812***	**901**	***3650***	**Average**
Size SF	2014	*1436*	2059	*1238*	992	*1118*	**1476.17**
Stories	1	*2*	2	*1*	1	*1*	
Demolition labor $/SF	1.74	*1.74*	1.74	*1.74*	1.74	*1.74*	**1.74**
Demolition labor/equip % of costs	30.63	*35.29*	36.40	*40.56*	38.33	*22.00*	**32.49**
Asbestos and lead $/SF	0.96	*0.82*	1.86	*0.69*	0.71	*0.75*	**0.97**
Disposal $/SF	2.91	*2.25*	1.09	*1.70*	1.89	*3.16*	**2.17**
Disposal #/SF	96.00	*40.00*	35.00	*40.00*	45.00	*58.00*	**52.33**
Disposal % of costs	51.23	*45.64*	22.80	*39.63*	41.63	*39.95*	**40.46**
Demolition $/SF	**5.68**	***4.93***	**4.78**	***4.29***	**4.54**	***7.91***	5.36
Deconstruction Costs							
Deconstruction labor $/SF	4.21	*1.77*	2.90	*5.63*	3.29	*4.02*	**3.64**
Deconstruction labor hr/SF	0.34	*0.14*	0.23	*0.45*	0.26	*0.32*	**0.29**
Deconstruction labor % of costs	67.79	*35.33*	51.97	*73.79*	65.15	*43.04*	**56.21**
Asbestos and lead $/SF	0.96	*0.82*	1.86	*0.69*	0.71	*0.75*	**0.97**
Disposal $/SF	0.67	*1.88*	0.57	*0.54*	0.45	*1.73*	**0.97**
Disposal #/SF	21.97	*29.01*	18.40	*12.76*	10.69	*21.47*	**19.05**
Disposal % of costs	10.79	*37.52*	10.22	*7.08*	8.91	*18.52*	**15.04**
Diversion from landfill % by weight	**77.12**	***27.47***	**47.43**	***68.10***	**76.25**	***62.99***	59.89
Gross Deconstruction $/SF	**6.21**	***5.01***	**5.58**	***7.63***	**5.05**	***9.34***	6.47
Salvage $/SF	**4.67**	***0.39***	**2.81**	***3.73***	**4.65**	***3.42***	3.28
Salvage $/SF at 50%	**2.34**	***0.20***	**1.41**	***1.87***	**2.33**	***1.71***	1.64
Net Deconstruction $/SF	**1.54**	***4.62***	**2.77**	***3.90***	**0.40**	***5.92***	3.19
Net Deconstruction $/SF w/ 50%	**3.88**	***4.82***	**4.18**	***5.77***	**2.73**	***7.63***	4.83
Demolition - Gross Deconstruction $/SF	**-0.53**	***-0.08***	**-0.80**	***-3.34***	**-0.51**	***-1.43***	**-1.12**
Demolition - Net Deconstruction $/SF	**4.14**	***0.31***	**2.01**	***0.39***	**4.14**	***1.99***	2.16
Demolition - Net Decon. W/ 50%	**1.81**	***0.12***	**0.61**	***-1.48***	**1.82**	***0.28***	**0.52**

Approximately 26% higher first costs for deconstruction over demolition
Approximately 37% savings for deconstruction over demolition with conservative salvage value
This model represents a situation where there are no materials storage, inventory, and sales personnel costs. Materials are given a retail value and deducted from the deconstruction costs for a net deconstruction costs without the additional costs for overhead on the materials themselves.

Table Ten – Project Economic Summary

Disposal Costs

For the purposes of this study, all data was normalized to a weight-based disposal cost. Some of the project wastes were disposed of through an entity that used a volume-based fee system and other building wastes went to an entity using a weight-based fee system. It was apparent when comparing the difference in disposal costs based on weight versus volume, and the relatively light weights of the wood-framed houses and their commensurately low density wastes materials, that disposal fees are a larger percentage of costs if based on volume. This is a greater incentive for deconstruction of wood framed buildings than masonry buildings.

2 tons per 20 CY pull
2 tons x $34/ton x 4 loads + $480 + $50 = $100.25/ton
(4 loads x $154/load + $480 + $50) / 8 tons = $143.25/ton
3 tons per 20 CY pull
3 tons x $34/ton x 4 loads + $480 + $50 = $78.17/ton
(4 loads x $154/load + $480 + $50) / 12 tons = $95.50/ton
4 ton per 20 CY pull
4 tons x $34/ton x 4 loads + $480 + $50 = $67.13/ton
(4 loads x $154/load + $480 + $50) / 16 tons = $76.40/ton
5 ton per 20 CY pull
5 tons x $34/ton x 4 loads + $480 + $50 = $62.00/ton
(4 loads x $154/load + $480 + $50) / 20 tons = $57.30/ton
6 ton per 20 CY pull
6 tons x $34/ton x 4 loads + $480 + $50 = $56.08/ton
(4 loads x $154/load + $480 + $50) / 24 tons = $47.75/ton
7 tons per 20 CY pull
7 tons x $34/ton x 4 loads + $480 + $50 = $52.93/ton
(4 loads x $154/load + $480 + $50) / 28 tons = $40.93/ton
8 tons per 20 CY pull
8 tons x $34/ton x 4 loads + $480 + $50 = $50.56/ton
(4 loads x $154/load + $480 + $50) / 32 = $35.81/ton

Table Eleven - Variations in Weight and Volume Disposal Fees

C& D wastes has been estimated at:

Wood wastes	3 tons / 20 CY
Drywall	3.5 tons / 20 CY
Asphalt shingles	7 tons / 20 CY
Mixed rubble	14 tons / 20 CY

(NAHB, 1995)

Weight-based disposal is $34.00/ton in the Gainesville, Florida area. Volume-based disposal is $7.70/CY x 20CY roll-off = $154.00 and is therefore a flat fee for each 20 CY roll-off used. Each haul is a flat fee of $120.00/haul.

As noted in the Table Eleven above, 20 CY roll-off disposals of lower weight are more expensive per ton when charged by weight, but the discrepancy is even greater when charging by volume. As the weight increases per 20 CY roll-off, from 2 to 8 tons, the total weight-based fee is 50% less per ton, i.e., $100/ton for 2 tons / 20 CY and $50/ton for 8 tons / 20 CY. The hauling fee is also reduced approximately 50% per ton over this range. The difference in total price using a volume-based fee between a 2 ton / 20 CY and an 8 ton / 20 CY roll-off is a 75% reduction. In a volume-based disposal fee system, the hauling fee remains a constant percentage of costs, in this case 42% of the costs per ton.

This analysis indicates that wood C&D recycling would be encouraged through volume-based disposal fees in lieu of weight-based fees. If a municipality wished to encourage concrete and masonry, drywall, asphalt shingle recycling, then a weight-based disposal fee system will provide a slight incentive for recycling of these materials, but less incentive for site separation of the lighter wood materials from heavier materials, and less incentive overall.

A reduced hauling fee but a higher cost per cubic yard, using a volume-based fee for disposal, provides an appropriate incentive to encourage deconstruction for wood materials reuse and recycling.

Economic Summary and Recommendations

The average estimated demolition cost using all six (6) houses, was $5.36/SF and disposal was an average of 40% of the total costs. The average "gross" deconstruction cost was $6.47/SF, which is approximately 26% higher average cost than demolition. Disposal costs for deconstruction were on average 15% of the total costs. Gross deconstruction is the first cost of the deconstruction which includes all labor and disposal but does not include any salvage revenues. Asbestos and lead surveys and remediation was an average of $0.97/SF for both demolition and deconstruction. This is 18% of the costs for demolition and 15% of the costs for deconstruction. Avoiding this cost on a consistent basis for small scale demolitions makes deconstruction un-competitive with demolition.

The average salvage value was $3.28/SF. The "price" of salvaged lumber was estimated at between 25-50% of new lumber retail value in local stores. The price of other items were estimated as very low costs used goods, based on the experience of an used building materials store owner/operator in Gainesville, Florida. Subtracting average salvage from gross deconstruction, the average net deconstruction costs were $3.19/SF which is approximately 37% lower cost per square foot than traditional demolition. It is important to note that the cost calculations for demolition to an Owner or Contractor end with the disposal of materials in a landfill. There are future costs which accrue to the municipality or to the owner of the landfill that are not included in the costs of disposal. The costs and savings for deconstruction include the deconstruction (including disposal) and any additional costs to handle the materials until they are redistributed. Upon redistribution, (sale) the net deconstruction costs can be fully calculated. This study did not include a calculation of the operating costs of a redistribution center or business that could be added as a costs per unit of material to the total costs of deconstruction.

An estimate can be made using a consignment scenario. This scenario supposes that the deconstruction contractor places all materials in consignment at a separate reused materials facility at 50% of the used material price, in effect using a price of 12.5-25% of the price of new lumber and halving the used goods prices. In this scenario the average salvage values estimated in this project were $1.64/SF or half of $3.28/SF. Using this calculation, the net deconstruction costs were approximately 10% lower than traditional demolition.

Costs	Demolition	Deconstruction	Savings	Costs / Total Costs
Labor	$1.74 (33%)	$3.64 (56%)	- $1.90	+35%
Disposal	$2.17 (40%)	$0.97 (15%)	**$1.20**	- 22%
Hazardous	$0.97 (18%)	$0.97 (15%)	$0.00	0%
Other	$0.48 (9%)	$0.89 (14%)	- $0.41	+ 8%
Total	$5.36	$6.47	- $1.11	+21%
Salvage	$0.00	$3.28/$1.64	**$3.28/$1.64**	-61-31%
Net Costs	**$5.36**	**$3.19/$4.83**	**$2.17/$0.53**	

Table Twelve – Comparison Between Demolition and Deconstruction Costs
(%) – percentage of the total costs

The added investment for deconstruction over demolition was $2.31/SF for a total net savings of from $2.17 to $0.53/SF. From this added $2.31/SF investment, the benefit-cost ratio for disposal savings were $1.20 / $2.31 = 0.52 while the benefit-cost ratio for savings from salvage was $3.28 or $1.64 / $2.31 = 1.42 or 0.71. The revenues from salvaged materials is a greater proportion of the "return on investment" of deconstruction than the reduction in disposal costs when compared to demolition by a ratio of from 2.73 to 1.36, depending on the method of pricing the salvage. The economic analysis of this project provides insight into some preferred means for encouraging the use of deconstruction to remove structures from a piece of property.

Since the savings from salvage are greater, and a social benefit to deconstruction is creating low-costs building materials, increasing tipping fees, and using volume-based fees may be more important to encourage deconstruction for a combination of social, community economic and environmental benefits, than value-adding for the salvaged materials.

On-site sales considerably reduce off-site materials handling costs (increasing salvage revenues) and will also aid in reducing on-site time for the deconstruction, when time spent processing can be used in the actual deconstruction activity.

Where off-site sales are needed, or value-adding desirable, a deconstruction entity that also operates a reused materials facility will enable the combined entity to be more profitable and maintain a consistent work force. The off-site facility/staff allows for flexibility in responding quickly to deconstruction projects when they present themselves, and processing the materials, and deconstruction provides a diversity of materials for the reuse facility.

Enforcement of hazardous materials regulations for asbestos surveying and handling will insure that small scale demolition projects do not receive an economic advantage based upon avoiding hazardous materials management costs.

The costs of time delays for deconstruction at a large redevelopment site may exceed savings from deconstruction based upon the deconstruction contractor's lower net costs.

Bidding lower than demolition will reduce the deconstructor's profit, which is mostly based on resale of the materials, a less certain added cost than the deconstruction work itself.

Permitting should be created for "deconstruction permits" that allows time for deconstruction with a reduced time delay overall than would be allowed for a demolition permit. Permit fees for deconstruction should be waived and demolition fees should be based not on the value of the work or other arbitrary factors such as number of stories, but on the projected volume of wastes. Fees can then be rebated based upon proof of diversion of the materials to an accepted recycling or reuse end use..

Materials Processing and Redistribution

In several instances, mainly at the 901 project and the 14 project, materials were mostly redistributed directly off the site. The viability of this strategy was borne out by the high profile locations of these sites and, perceptually, by the demographics of the immediate areas. In one case, 14, was at edge of the Downtown area, a historic district, and lower income neighborhoods. The 901 house was in a predominantly lower income rural community, at the site of the one shopping center in the community, and on the main highway. Other sites were either within a residential area or in more rural areas within the community and had little pass-by traffic. This was an advantage when materials or roll-offs were left on site, such that pilfering was minimized.

Wood Grading

Lumber					
Size		**Pieces**	**%**	**Volume BF**	**%**
2x4		210	40.31	1620.81	31.21
2x6		186	35.70	2172.00	41.82
2x8		117	22.46	1285.01	24.74
4x6		8	1.54	116.00	2.23
Total		**521**		**5193.82**	

Table 1

Usage of Lumber	**Pieces**	**%**	**Volume BF**	**%**
Floor joists	137	26.30	2011.98	38.74
Wall studs	64	12.28	375.52	7.23
Ceiling joists	78	14.97	1041.35	20.05
Roof rafters	133	25.53	1405.6	27.06
Unknown	109	20.92	359.37	6.92
Total	**521**		**5193.82**	

Table 2

Untrimmed Grade	**2x4**	**2x6**	**2x8**	**4x6**	**Total**	**%**	**%**
dss	33	10		1	44	8.45	
ss	20	23	4		47	9.02	17.4
#1	6	2	9		17	3.26	
#2	64	25	14		103	19.77	23.03
#3	33	6	6		45	8.64	
#4	51	110	82		243	46.64	
No grade	3	10	2	7	22	4.22	59.5
Total pieces	**210**	**186**	**117**	**8**	**521**		

Table 3

Reason for Lower Grade	**2x4**	**2x6**	**2x8**	**4x6**	**Total**	**%**	
Shake	17	2	1		20	4.65	
Split	2		3		5	1.16	
knots	11	10	4		25	5.81	
Damage	92	115	82	7	296	68.84	
Wane	12	14	4		30	6.98	
Slope of grain	1	1	1		3	0.70	
Warp	3	1	2		6	1.40	
Twist/other	17	8	4		29	6.74	
Unknown					16	3.72	
Total					**430**		

of the 296 pieces graded for damage, 96 (32%) were for termite damage, the a dss remainder were typically end damage or human-made notches. 91 pieces received dss or ss, therefore, 430 pieces had a reason for a downgrade

Table 4

Trimmed Grade						
	2x4	**2x6**	**2x8**	**4x6**	**Total**	**%**
dss	11			1	12	6.98
ss	14	44	24		82	47.67
#1	7				7	4.07
#2	17	28	16		61	35.47
#3		3			3	1.74
#4					0	0.00
No grade				7	7	4.07
Total	**49**	**75**	**40**	**8**	**172**	
Percent of Total					**33.01**	

the typical presumed trim was 12" to 18" from one or both ends

Table 5

Table 6

Conclusions

Deconstruction can be more cost-effective than demolition when considering the reduction in landfill disposal costs and the revenues from salvage. In this study, there were estimates made for storage and personnel costs of a separate resale facility as a means for recouping the value of the materials over time. It was found that sale to a secondary broker will typically be 20% (remanufacturing) to 50% (resale) of the retail price. Salvage value estimated at 50% of retail is equivalent to the deconstructor operating a resale facility and is a “wholesale” price. On average, deconstruction first costs were 26% higher than demolition costs. On average, the net cost of deconstruction with salvage was 37% lower costs than demolition using retail salvage values and 10% lower using “wholesale” prices. The CCE had success with on-site redistribution of the materials when the job-site was either on a busy road, or in the urban core area, near both lower income neighborhoods and a historic district.

Each additional increment of salvage value will have an additional unit of labor cost. The savings in disposal costs between gross deconstruction and demolition were on average 41% per house. Because disposal savings for deconstruction versus demolition are a lower percentage than salvage savings (41% to 53%), there is less of an increment to gain in increasing salvage (100-53 = 47%) than in increasing disposal costs (100-41 = 59%). This would seem to indicate that there is more potential for encouraging deconstruction by raising disposal fees than by attempting to gain more salvage value and that the value of salvaged materials will be well-supported by subsidies targeted towards storage space and retails outlets which in turn create more jobs. Increasing salvage per building will have an additional cost, producing a diminishing return as the more valuable items are stripped more efficiently than harder-to-access materials, and as less damaged materials give way to options for salvaging the more damaged and shorter pieces of lumber, for instance. A longer board may take the same amount of time to remove but has more board feet than a shorter piece. Every building will have this balance point of diminishing returns but that point will be pushed further towards salvage more effectively by increasing disposal costs than in effect working harder to gain more salvage which is more likely a static value per unit of material.

If reused materials, especially wood, increase in value over time, this will provide an additional incentive. Value-adding to salvage materials is being explored in several venues in the US, most notably by the Materials for the Future Foundation. Many specialty wood mills use salvaged materials to manufacture flooring. It is less likely to be effective, however, as older buildings (50 to 150 years old) with more pure and higher value materials are gradually demolished and there is a greater percentage of buildings available for deconstruction that were built in the last 50 years. These more recent buildings already show the effects of resource depletion by containing more composite materials, newer growth wood, little heart pine or weather and insect resistant species, and less materials with architectural salvage value. Materials such as beadboard and 1x sheathing materials were replaced by gypsum wallboard and plywood in this time and the use of asbestos was more prevalent. If salvaged materials do not increase in value the reverse incentive of making it more expensive to throw them away will maintain a market for them and more stability for resale entities. This “subsidy” allows for the maintenance of a lower prices for used materials and provides social and economic benefits for those who cannot readily afford new materials.

One method of increasing value of deconstruction is the re-grading of salvaged lumber for structural use. The CCE had over 500 pieces (over 5,000 board feet) of 2x4, 2x6, and 2x8 southern pine lumber re-graded by the Southern Pine Inspection Bureau. This sample is not adequate to make any broad conclusions. Approximately 50% of the pieces received a number 4 or lower grade. 40% of the pieces received a number 2 or higher. Approximately 17% of the pieces received a dense select structural (DSS) or select structural (SS) grade. The determining factor for 68% of the non-DSS or SS pieces’ grade was damage, typically for end damage from the deconstructing process, notches or damage from the construction process, for example bird’s mouths in roof members, and lastly termite damage. Of the pieces graded for damage, termites were the determining factor for 32% of them. 172 pieces or approximately 33% of the total pieces were found to be “up-gradeable” with either trimming or ripping to make a shorter or narrower piece. 92% of these pieces were able to be up-graded to a number 2 or better grade. 54% of them (94 pieces) were able to be up-gradable to either DSS or SS.

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40 Code of Federal Regulations (CFR) Part 61 Subpart M, National Emission Standards for Asbestos, Asbestos NESHAP Clarification of Intent. July 28, 1995.

Opportunities and Barriers for Implementing Deconstruction

Background information will include an overview of the potential audience scenarios, opportunities and barriers for deconstruction as a "niche" of the demolition and construction industry. Conclusions will be provided, based on the field research data and the anecdotal experiences of the research team on the barriers to making deconstruction a mainstream practice and some of the potential economic and regulatory measures that will make it competitive with typical demolition. The key to deconstruction is reuse and recycling which is the principal reason to implement deconstruction practices.

The Center for Construction and Environment has completed the deconstruction of four complete houses to-date and deconstruction of a wing of a house which will be completed in the next reporting period. The CCE has also documented one house moving and one house demolition for comparisons to deconstruction in terms of costs and materials. In the previous reporting period the CCE has partnered with Americorps*NCCC to provide labor for the project. Due to a break in the Americorps*NCCC team schedules, the house at 2812 NW 8th St will be completed during the next reporting period. Several candidate houses were not available due to the decision by the property owners to proceed with demolition. These Owners ranged from churches to private developers. In almost every case, time was the limiting factor. Although the City of Gainesville has a 90-day demolition delay, this delay does not differentiate between demolition and deconstruction. Therefore a recommendation to be made is the use of a demolition and deconstruction permitting system, that reduces the delay for a permit stipulating deconstruction such that there is adequate time for deconstruction with a net reduction in the overall delay for a demolition. This permit would require a deconstruction plan submittal stipulating the methods to be employed, the end markets or means of distribution of the materials and minimum targets for salvage.

This permitting ordinance would in no way supersede historic preservation guidelines preventing the demolition of historic structures either contributing or within a historic district. The allowance for a hardship waiver which can be applied for to have the deconstruction and demolition delay removed would not be eliminated, unless deemed appropriate by the regulating organization. Key lessons learned from the current period: time and perceived risk for deconstruction are the most important considerations, adherence to the requirement for environmental assessments for asbestos is rare among the building and demolition industry, (institutions such as the University of Florida, however, do adhere very closely to all requirements). Enforcement of these requirements is extremely difficult due to limited resources. Mechanical demolition will permit the use of a "wet" demolition for non-riable asbestos, the most common form being asbestos floor tile, whereas hand demolition does not permit any asbestos containing materials to be present in the structure. This added cost can be a significant impediment to hand demolition. The presence of lead-based paint is also another significant impediment to both worker safety and the reuse of the materials. The LBP job-site safety protocol developed by the CCE for its projects has been effective. Due to the transient nature of the labor force for this project, the job site supervisor is the only person who has been exposed to job-site conditions and the presence of LBP for the duration of the project.

This person had his blood lead-level tested at the beginning of the project and will have his blood lead-level tested at the duration of the project.

The CCE, the USDA Forest Products Laboratory and the Southern Pine Inspection Bureau conducted a visual wood grading of the accumulated salvaged dimensional lumber to-date on February 17, 2000. The results of the grading are included in this report. A final grading will be conducted at the end of the house deconstruction phase of the project in mid-April.