# DEMOLITION CONTRACTORS' PERCEPTIONS OF IMPEDIMENTS TO SALVAGE AND REUSE OF WOOD STRUCTURAL COMPONENTS

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## ABSTRACT

*The study was conducted to ascertain demolition contractors' perceptions of the primary impediments to the widespread salvage of wood structural components for reuse or recycling. Assessment of the attitudes of demolition contractors was chosen since their participation in the salvage and reuse of materials is a key component necessary for any program to reduce the waste disposal rate of demolition debris. The insights obtained from the study can be used to facilitate future planning and design of programs and research that advance the recycling of demolition debris. A sample of contractor members of the National Demolition Association was surveyed for the study. In addition to demolition contractors' perception of impediments to salvage of wood structural components, the survey instrument provided a significant volume of descriptive information about demolition companies operating in the continental United States.*

## INTRODUCTION

A significant yet unrealized potential for reduction in waste disposal through reuse and recycling of demolition and renovation debris is suggested in recent reporting by the Environmental Protection Agency (EPA). A characterization of waste generated in the United States in 1996 concluded that the waste generated by demolition and renovation activities made up 92% of all construction and demolition (C&D) waste generated in the United States. This represents 124,700,000 tons of debris generated (excluding waste resulting from roadway, bridge, and land clearing operations) or about 2.6 pounds per capita per day (EPA, 1998). When compared to the approximately 4.3 pounds per capita per day of municipal waste generated, the magnitude of this renovation and demolition waste can be grasped. With such a large proportion of waste attributable to demolition and renovation, increasing the proportion that is recycled would reduce significantly the future need for landfill space.

The construction industry lags behind many other industries in the reuse of waste material in new products. When compared to a new BMW automobile containing 70% recycled content, a new building may contain as little as 1%. Case studies of actual demolition projects in the last decade have shown successful rates of recovery of from 50 to 90%, leaving the challenge of changing the industry's attitude toward stronger acceptance of reuse (Kibert & Languell, 2000). One place to start is to determine what the attitudes and perceptions of the industry are as a means to direct policy and research in the future.

Much of the drive to adopt measures that reduce construction and demolition waste comes from the rising cost of landfill tipping fees and the loss of landfill space (Lampo, 2003). Nevertheless, decisions that avoid structural wood salvage and dispose of wood waste in the demolition process impose other substantial environmental impacts. On a national level over 100,000 privately owned homes are demolished every year along with about 7,000 units of public housing (Kibert et al., 2000). A case study sponsored by EPA examined the volume and weight of materials diverted from the landfill in a deconstruction project. Of the material diverted (approx. 70% of the total project), raw wood products made up 29% by volume, the second largest material category of diverted material, exceeded only by rubble (EPA, 1997). When it is considered that an average of 146 million cubic meters (60 billion board feet) of virgin lumber is consumed every year, the impact of a failure to reuse lumber from demolition extends

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beyond the issue of reducing the rate that we are depleting landfill space. The potential to replace a portion of this virgin lumber consumption is quite high if a share of the 7.3 billion cubic meters (3 trillion board feet) of lumber sawn in the United States since the turn of the twentieth century can be harvested for reuse (Chini & Acquaye, 2001).

Recycled lumber products at times have advantages over virgin lumber. Much of the lumber available for reuse was cut from old growth timber. It might have a tighter grain structure, and be relatively dry enhancing its dimensional stability (Falk et al., 1999). Even with these advantages, salvaged dimensional lumber is not easily traded because quality is neither consistent nor easily judged. In the milling and sale of new lumber products, established grading rules and agencies for enforcement are well established. These rules and grading agencies do not specifically address the use of salvaged lumber. As a result, the lack of available grade stamp leaves few options other than selling salvaged lumber as nonstructural, low market value products (Falk, 2002).

The Department of the Army has identified similar barriers to reuse of building materials. They utilize the DOD's Defense Reutilization and Marketing Office (DRMO) to manage the reuse of usable equipment and building materials, yet there is no Army regulation that specifically governs a systematic building material salvage operation (Dolan et al., (1999). At Fort Ord in California nearly 11,000 housing units are in the process of reuse or removal. It has been estimated that the current project will require 25 years to complete (Cook, 2003). To assist in the decision making process for this and other military projects, the Army Corp of Engineers have produced technical bulletins providing guidance on project objectives such as cost, time, quality of results, risk, implementation, and opportunity. Project conditions including project scope, hazardous materials, site accessibility, landfill burden, resources, and markets are also made part of the decision process (USACE, 2001). The issues delineated by the Army do not apply to military projects alone. All of the decision points described in detail for the Army are important for any demolition project. The sample contract documents for consideration alone consist of well over 100 pages. Complexity of choice may be a barrier to reuse and deconstruction.

Numerous other barriers to deconstruction and recycling appear in the literature. Design and building professionals do not always know the materials that have reuse or recycling potential in the projects they design, own, or manage (MACREDO, 2004). The resources and time required to undertake a complete planning and market analysis prior to a deconstruction or reuse project create many challenges for project managers (Dolan et al., (1999). Chemical or environmental exposure of wood products has the potential to weaken the wood, making it toxic, hazardous, or otherwise unusable (Kyanka, 2003). Lead based paint challenges both the deconstruction process, and the potential for reuse of wood products (Lampo, 2003). Safety, primarily from poor preparation, falls, and health hazards is a concern for all demolition activity, amplified by the close hand labor required in deconstruction (Roesler, 2003). Industry attitude (Kibert & Languell, 2000), limited knowledge, logistical complexity, and lack of incentives must be added to the list of barriers (Patterson & Leigh, 2003). The National Demolition Association (formerly known as the National Association of Demolition Contractors) position paper on deconstruction portrays deconstruction as an endeavor limited for the professional demolition contractor by cost issues, time constraints, safety issues, hazardous material issues, site storage and security, the labor intense nature of hand deconstruction, and the complexities of methods and materials used in construction (NADC, 1999).

## PURPOSE OF THE STUDY

The study was conducted to ascertain demolition contractors' perceptions of the primary impediments to the widespread salvage of wood structural components for reuse or recycling. Assessment of the attitudes of demolition contractors was chosen since their participation in the salvage and reuse of materials is a key component necessary for success in any program to reduce the waste disposal rate of demolition debris. The scope of the investigation was limited so that only the perceived impediments to salvage of a specific class of materials were examined. This restriction in the scope of study avoids broad generalizations about reuse and recycling that could prevent accurate determination of demolition contractors' true areas of concern. Structural wood reuse and re-

cycling in particular was chosen for the study due to the substantial anecdotal evidence of high cost and complexity in removal, processing, and marketing of structural wood products as well as its widespread use in residential, commercial, and industrial construction during the nineteenth and early twentieth centuries and therefore its potential for reductions in disposal rates on future demolition projects. The insights obtained from the study can be used to facilitate future planning and design of programs and research that advance the recycling of demolition debris.

## METHODOLOGY

The study surveyed a representative sample of contractor members of the National Demolition Association (formerly the NADC) located in the continental United States. Demolition contractors are a geographically diverse group of primarily small companies in terms of both company annual revenue and employment. Table 2 in the appendix displays a comparison of U.S. Economic Census data with the 2003 membership of the National Demolition Association. This data confirms the small size and geographic distribution of the industry. By utilizing the National Demolition Association membership as a sample frame for all demolition contractors in the United States, sampling decisions were made to minimize variance between National Demolition Association membership and the full population of demolition contractors.

One possible sample variance was the geographic representation of the National Demolition Association membership. It was assumed that regional variations in economic conditions, type of construction, age of original construction, market dynamics, and regulatory environment could have some influence on the responses of demolition contractors. To ascertain if National Demolition Association membership adequately represented the geographic diversity of the industry, a comparison was made between the proportion of National Demolition Association membership by region and the proportion on a national level. Nine regions in the continental United States which represent contiguous areas of similar climate and potential for economic interaction were utilized to aggregate census and National Demolition Association membership data. A tenth region made up of Alaska and Hawaii was also examined but not utilized because it represent less than 1% of demolition activity and payroll while sharing little geographically with the other nine regions. Table 3 in the appendix shows the proportion by region that National Demolition Association membership represents of the U.S. Economic Census for wrecking and demolition contractor establishments.

The range of National Demolition Association representation by region varies from 26% to 71% (excluding Alaska and Hawaii). This range becomes 26% to 47% if the West Central region is eliminated. The West central region is one of the smallest regions by activity. Since the regional combinations are somewhat arbitrary, the West Central and East Central regions could be combined. When this combination is made the proportion of National Demolition Association membership becomes 38%. Overall, the range of NADC representation does not vary greatly from the national proportion of 34% highlighted on Table 3. Since the need for precision is not far reaching in this exploratory study, it was assumed that National Demolition Association membership adequately represented the geographic diversity of the total population.

A second variable likely to impact the sample design was the size of organizations represented by National Demolition Association membership. Although the aggregate data represented by the census sample shows levels of activity and employment by demolition contractors to be small on average, many large demolition contractors are known to exist throughout the country. It is possible that the National Demolition Association membership represents firms that are larger than typical of the total population of demolition contractors. Inadequate information was available to determine if the National Demolition Association membership characterized a true representation of the population by size or volume of work performed. To overcome this limitation, a stratified sample of the National Demolition Association membership was taken. National Demolition Association membership levels for contractors are determined by annual volume. The category for smaller contractors encompasses those involved in less than $5,000,000 in annual demolition activity. The higher volume category is for contractors doing in excess of $5,000,000 in annual volume. By stratifying the sample to each of these volume levels, it was

possible to obtain some indication of variance in attitudes between contractors according to their size.

A completed survey from 50–60 companies was considered to be desirable. Since response rates for mail surveys of 25–30% are considered acceptable (Sekaran, 2003), approximately 300 surveys were mailed. To obtain geographic diversity within the sample, the National Demolition Association membership list at each volume level was divided into the 9 regions described previously. A sample of 296 companies (approximately half of the contractor membership of the National Demolition Association) was systematically chosen so that survey instruments were mailed to a number of contractors in each region that is proportional to the number of establishments identified by the 1997 U.S. Economic Census within each region.

The survey design included four types of questions. The first group of questions was descriptive, designed to obtain information about the variety and volume of demolition performed by the responding organization, their experience with salvage if any, and basic demographic information about the organization (questions A–K). The second type of question attempted to ascertain if the respondent possesses adequate knowledge of salvage and reuse of wood structural components to provide meaningful responses (questions L–O). The third group of questions sought the respondent's perceptions about the impediments to salvage and reuse of wood structural components (questions 1–21). A Likert scale was utilized for these questions since the scale is well suited to assessment of attitudes and perceptions, yielding interval data that is appropriate for statistical analysis. There were at least two questions pertaining to each identified impediment to allow comparison for reliability. The last question provided an open-ended opportunity for response about the subject. A copy of the questionnaire is included in the appendix.

The questionnaire was validated through review by an expert panel comprised of three representatives from the Purdue University Department of Building Construction Management, a representative from the National Demolition Association membership, and the Executive Director of the National Demolition Association.

Bias from non-respondents was minimized through use of several techniques. To improve response rate, sponsorship by the National Demolition Association was utilized including the attachment of a joint Purdue University and National Demolition Association cover letter. Another procedure to improve response rate was the use of an advance broadcast e-mail to the membership from the Executive Director of the National Demolition Association. Numbered return address envelopes were used as a tracking tool for responses to assure that the responses adequately represented the geographic diversity of the demolition industry.

## RESULTS

### *Survey Response*

A total of 28% of the surveys mailed were returned. A greater proportion of large contractors (38%) than small contractors (26%) returned the survey. All of the geographic regions of the continental United States were represented. Small contractors in California responded less frequently than most areas of the country (14%), but large contractors from the same area responded well (38%). Overall the response rate was fairly uniform geographically, providing a sample that appears to represent the population of demolition contractors in the continental United States as described by the 1997 U.S. Economic Census.

### *Data Analysis*

Analysis of the data began with the assembly of all responses in a spreadsheet that was totaled by contractor size and region. Each demographic question was converted to a percentage and the Likert perception question responses were converted to a numerical score. Mean scores for each perception question were calculated and listed in a table along with the most frequently chosen response and standard deviation for scores of each perception question. Simple comparisons of scores by region and contractor size were made and graphs of data were produced where appropriate.

This survey was intended to be an exploratory study with little statistical analysis. Nevertheless, the resulting sample appeared to be representative of the population of demolition contractors in the continental United States, lending itself to some additional comparison. Inadequate sample size prevented comparisons by region, but response comparisons for large and small contractors were possible.

### *Respondent Demographics*

The demographic data collected from the survey provides descriptive information about demolition contractors and their reuse and recycling practices. The responding demolition contractors can be characterized as small to medium sized companies both by annual revenue and employment (Figures 1 & 2). The majority of the respondents reported revenues of less than $10 million per year and fewer than 50 employees. Of the 18 large contractors responding, only 4 reported annual revenue that exceeded $25 million.

When asked for the primary type of demolition activity that their company was involved in, the majority of respondents indicated that they performed all types of demolition (Figure 3). Building demolition at 32% was also a prominent response as the company's primary area work. A major proportion of large contractors (78%) perform all types of demolition with building demolition and plant dismantling as the next most frequent choice (11% for each). It is interesting to note that when asked what other demolition activities they participated in, over half listed

**FIGURE 1.**

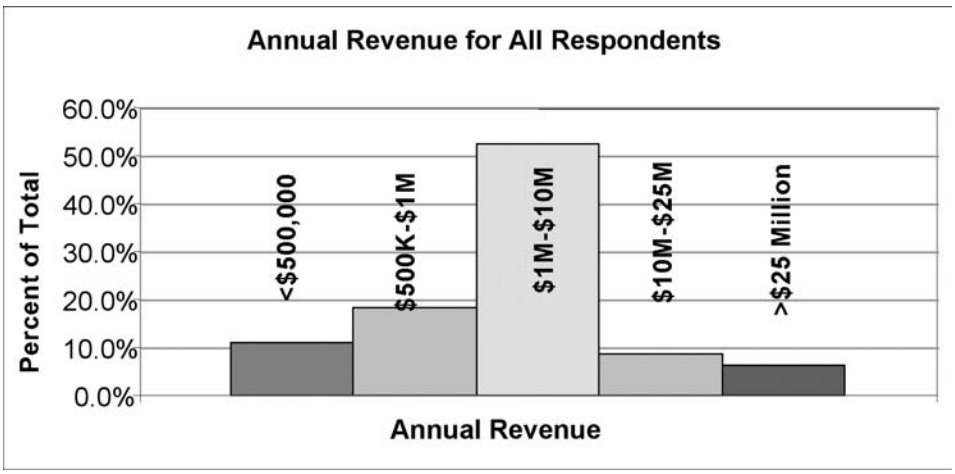
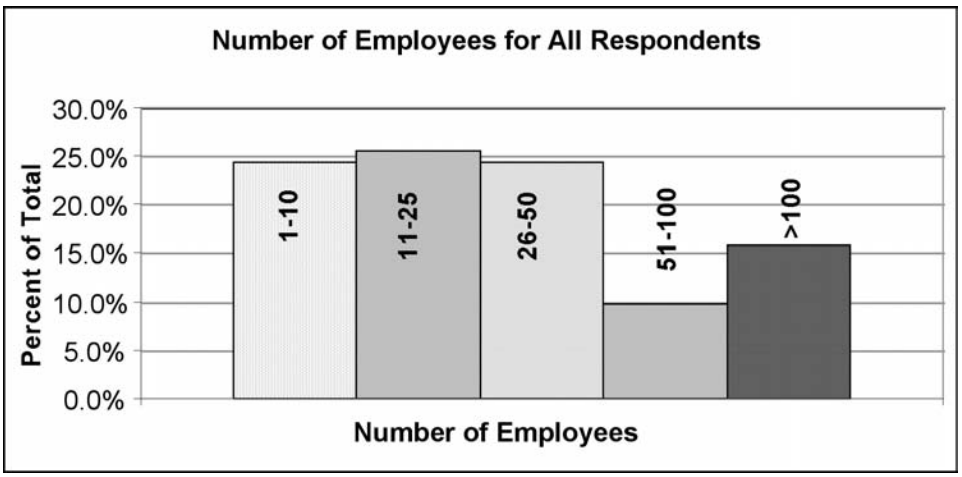



**FIGURE 2.**



salvage (Figure 4). This was by far the most prominent response for other demolition activity. Large contractors also indicated that hazardous waste removal and debris disposal were significant contributors to their demolition activity.

Even though demolition contractors are small businesses, they must cover a relatively large territory to maintain their business activity. Of all respondents, 44% listed a multi-state or national work territory (Figure 5). For large contractors, 56% have a multi-state or national territory and even 41% of small contractors indicated a multi-state or national territory.

Only 55% of respondents indicated that they subcontract any of their demolition activity, and of those that do subcontract work, they seldom subcontract more than 25% of their work (Figure 6).

Almost all demolition contractors both large (89%) and small (94%) report involvement in some way with salvage for material reuse or recycling (Figures 7 and 8). The majority of demolition contractors have salvaged historical/architectural components, steel, concrete, asphalt, and wood. Large contractors indicated a greater likelihood of processing wood for reuse 67%, and a smaller participation

**FIGURE 3.**

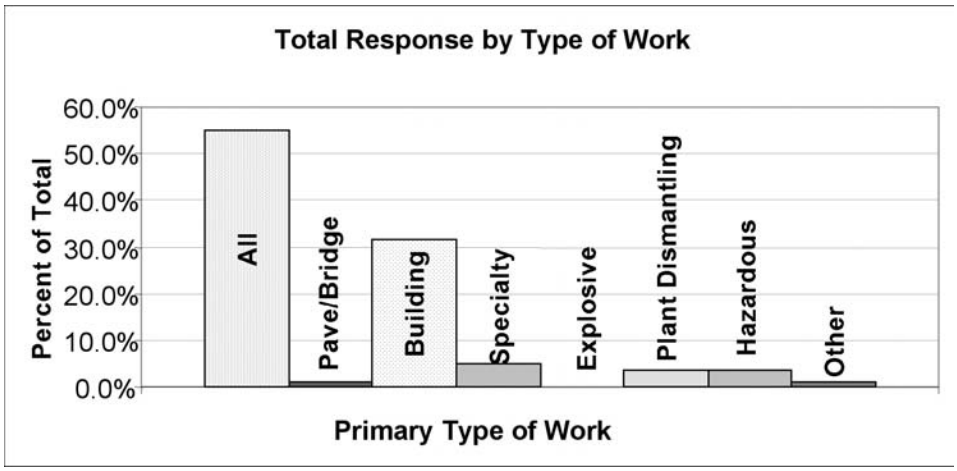



**FIGURE 4.**

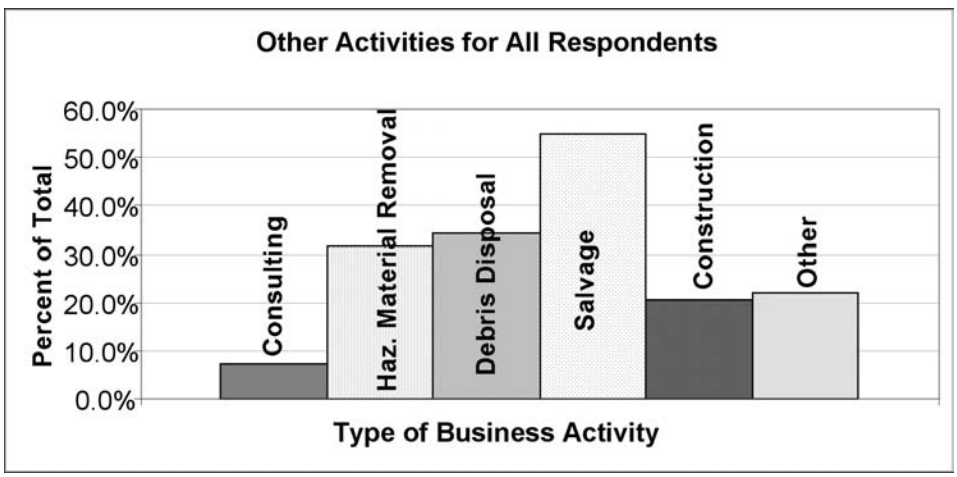


**FIGURE 5.**

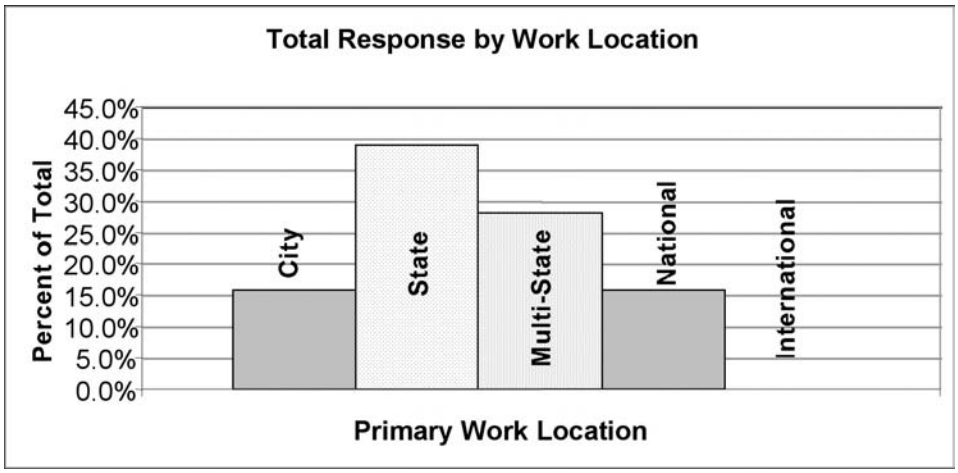
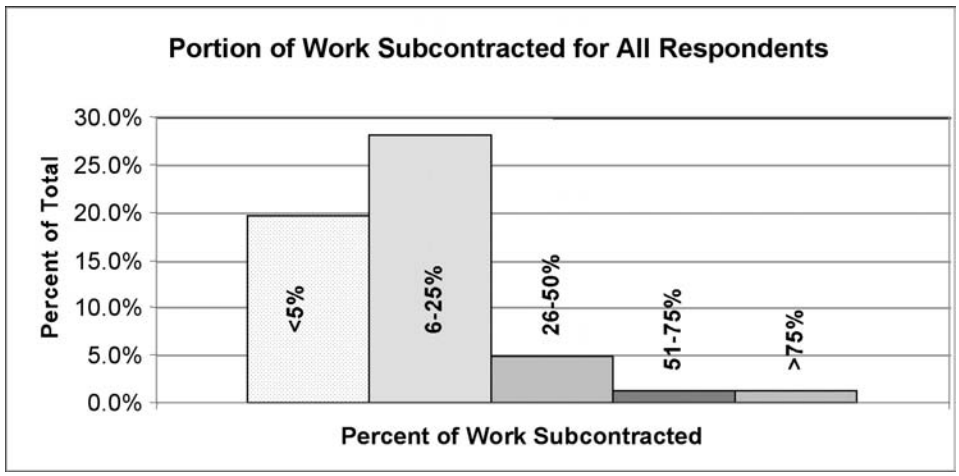



**FIGURE 6.**




in architectural/historical component reuse. Large contractors also tended to recycle roofing materials at a higher level (22%). Overall, the level of reuse or recycling of drywall, carpet, and roofing were rather low.

One common form of material reuse comes from a process called soft-stripping or non-structural deconstruction. Soft-stripping refers to the removal of specific building components that are determined to have a significant resale value. These components are removed prior to the demolition of the structure (HUD, 2000). The soft-strip category of reuse may include an array of materials, and the survey question reflected in Figure 7 did not provide adequate detail to identify possible double-counting of soft-strip and other categories within the figure. The most frequently listed "other" materials contactors salvage for reuse and recycling were plant or process equipment, brick, and scrap metals.

When asked if they were aware of market outlets where various materials could be sold for reuse or recycling, the response levels were somewhat lower than the indicated levels for reuse and recycling participation

**FIGURE 7.**

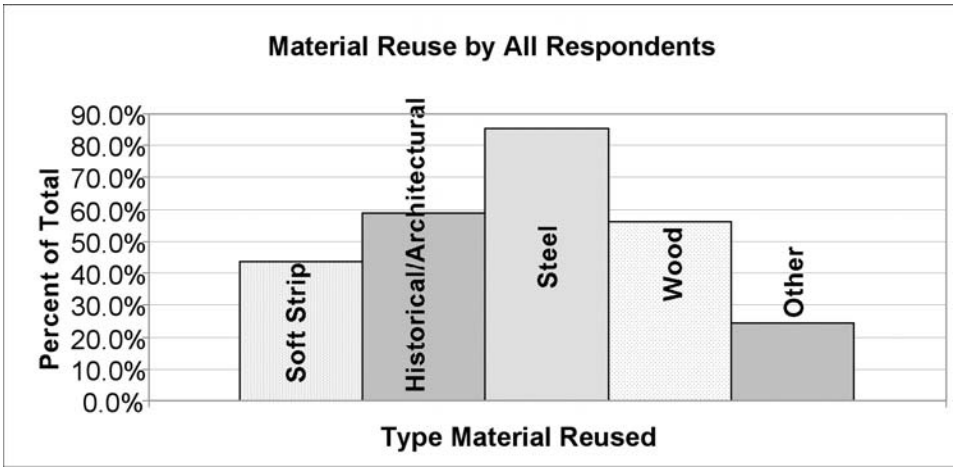
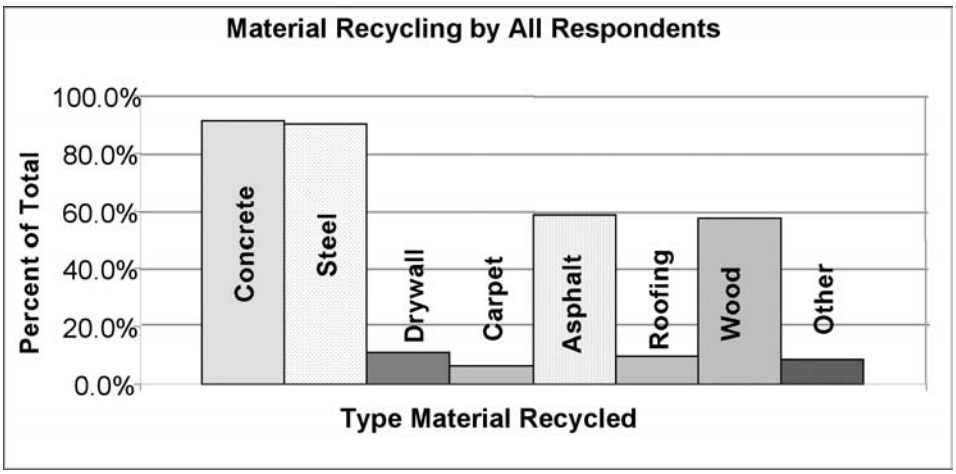



**FIGURE 8.**



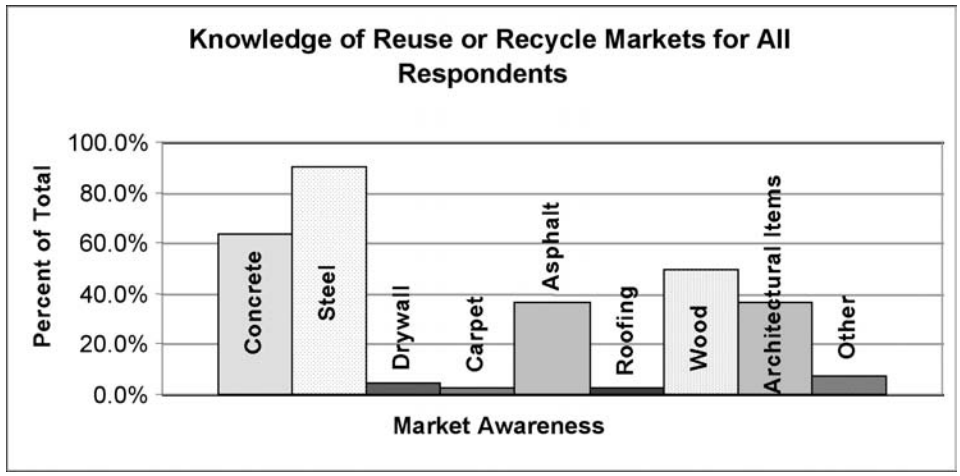

(Figure 9). It is assumed that the lower levels reflect the practice of offering salvage materials at no cost to avoid the cost of disposal. Only small contractors were aware of markets for drywall, carpet, or roofing materials and no more than 6% of the small contractors indicated knowledge of these markets.

As part of the salvage knowledge section, respondents were asked about their experience with haul restrictions. Of all respondents, 54% indicated that their company had experienced noncompetitive haul restrictions (such as conditions that favor a single waste hauler or landfill), regulatory barriers to demolition waste disposal, or challenges in finding adequate affordable landfill space. Although the responses did not vary significantly by contractor size, Midwestern respondents indicated a substantially lower level of experience with hauling restrictions (33%).

### *Contractor Perceptions*

Twenty one questions utilizing a five choice Likert scale were included in the questionnaire to ascertain the perceptions of demolition contractors about the impediments to reuse and recycling of structural wood components. The Likert questions covered nine types of possible impediments with two to four questions designed to measure perceptions of each

**FIGURE 9.**




impediment. Values of one for strongly disagree to five for strongly agree were assigned to each response to arrive at a mean response value for each question. The basic statistics for all respondents are shown in Table 1. It should be noted that the questions marked with an asterisk in Table 1 have been reworded from a negative question (as used on the survey instrument to check response reliability) to a positive question, allowing more easily understood comparisons between the mean response values in the table.

Question response values of greater than three indicate a positive perception, and response values of less than three indicate a negative perception. Since most of the mean response values are not strongly positive or negative, the most frequent response is listed to provide an additional indication of the direction of sentiment among the respondents. Standard deviation values contribute a measure of variation in the responses.

Respondents were clear in their perception of labor as an impediment to salvage of structural wood components. The strong negative responses to questions 15 and 18 and the fairly low variation in response values would suggest a strong preference for the use of equipment in reuse and recycling operations.

Questions 13 and 19 indicated that demolition contractors believe storage and site security can also be an impediment to salvage of structural wood components. Both of these questions had a large number (12–17%) of strongly agree responses or strongly disagree responses (both were negative responses since question 13 was worded in the negative) which explains the relatively high standard deviation. Only the labor related questions had a greater number of responses that represented strong negative sentiment.

Marketing and cost issues also yielded relatively negative response values. A fairly high variation in response values was noted in these questions. Question two with the most negative mean value for marketing issues had a very wide range of responses. There were nearly an equal number of responses for each choice in the range from strongly disagree to agree. The cost related questions also yielded a high degree of variation in response. The mean response value for cost question 7 appears to be more negative for large contractors than for small contractors. This relationship is explored in greater depth in the following section.

The time constraint and material condition questions indicated mixed attitudes. The widest variation in responses of all of the perception questions was for question 4 concerning project time constraints. When taken together, the time constraint question responses appear to indicate that time is an impediment, but not necessarily due to project related constraints. Responses to the material condition questions indicate that poor material condition prevents reuse or recycling of structural wood components, but lack of grading rules may not.

**TABLE 1.**

| Question by impediment category | Mean response value | Most freq. response value | Stand. deviation |
|---|---|---|---|
| ***Cost*** | | | |
| 1. Removal of structural wood components for resale or reuse is profitable on most of my company's demolition projects. | 2.68 | 2 | 1.15 |
| 7. In most cases processing wood products for resale is less costly than sending them to a landfill. | 2.72 | 2 | 1.07 |
| ***Labor*** | | | |
| 15. *The use of heavy equipment is NOT the only economical way to accomplish most of our demolition projects. | 1.87 | 2 | .72 |
| 18. *Labor cost on the majority of our demolition projects is low enough to justify salvage of structural wood products. | 2.06 | 2 | .79 |
| ***Marketing*** | | | |
| 2. Salvaged wood products have a good market for resale in the cities that we operate. | 2.54 | 2 | 1.15 |
| 6. Buyers of salvaged wood located close enough to our projects are easy to locate. | 2.86 | 2 | 1.02 |
| 12. Salvaged wood is an expanding market in the areas where my company operates. | 2.69 | 3 | 1.02 |
| 14. Salvaged wood seldom needs much processing to make it marketable to resellers. | 2.81 | 2 | .96 |
| ***Planning*** | | | |
| 3. We generally have adequate information on our projects to make informed decisions about the profitability of removing wood products for resale. | 3.33 | 4 | .97 |
| 21. The complex planning needed to carefully remove and market structural wood components for resale is typical of the project planning we perform. | 2.97 | 4 | 1.03 |
| ***Time constraints*** | | | |
| 4. Our project time constraints seldom prohibit disassembly of wood components for reuse. | 2.98 | 4 | 1.21 |
| 9. *It is worth taking the time to carefully remove wood structural components for resale on most of my company's projects. | 2.36 | 2 | .94 |
| ***Contract limits*** | | | |
| 8. The owners we work with seldom try to influence the salvage of material from projects through contractual language. | 3.34 | 4 | 1.08 |
| 20. Our demolition contracts seldom limit our ability to salvage all or part of the wood available on a project. | 3.28 | 4 | 1.1 |
| ***Hazardous conditions and safety*** | | | |
| 5. Careful removal of wood products to preserve their quality and marketability is no more hazardous to our employees than any other demolition activity. | 2.99 | 4 | 1.05 |
| 17. *Wood products we see on our jobs are not usually contaminated or hazardous, so they are safe to handle in preparation for resale. | 3.27 | 4 | .95 |
| ***Material condition and grading*** | | | |
| 10. * Not much of the wood that is available for removal from our projects is too badly weathered, aged, or contaminated to be reused. | 2.53 | 2 | .94 |
| 11. Lack of grading rules for salvaged lumber does NOT prevent me from reselling structural wood. | 3.45 | 4 | .76 |
| 16. *Not much of the wood that is available for removal from our projects is too contaminated with paint, oil, mold, industrial byproducts, etc. to be reused. | 2.78 | 2 | 1.00 |
| ***Storage and security*** | | | |
| 13. *Space and security does not limit the storage of salvaged materials at our project sites. | 2.35 | 2 | 1.06 |
| 19. Salvaged wood products are easily stored at most of our project sites until they can be transported to a buyer. | 2.61 | 2 | 1.01 |

*Negative questions reworded to positive to improve comparison of values

Questions dealing with planning, contract limits, and hazardous conditions yielded neutral or slightly positive attitudes. It is interesting to note that even though the mean scores for these questions imply a neutral response in most cases, in no case is undecided the most frequent response. Many contractors responded that these issues were not an impediment to reuse and recycling. Nevertheless, there were a number of negative responses to these questions that prevented the mean score from reflecting a strongly positive attitude.

### *Statistical Analysis*

Statistical analysis of the data was conducted using SAS software. The first statistical procedure employed was for the purpose of determining the reliability of the questionnaire as a survey instrument. Data derived from survey instruments are declared to be reliable when they provide stable responses over repeated administration of the instrument. In the absence of repeated test trials, statistically derived indexes are used as an indicator of data reliability. In this study, Cronbach alpha was calculated using the ALPHA option of the SAS PROC CORR procedure as a measure of reliability. The resultant Cronbach alpha of .77 for all scores of the contractor perception questions of the survey is in a range normally considered to be an acceptable reliability coefficient.

Variation between the responses of large and small contractors was investigated utilizing the CHISQ option of the SAS PROC FREQ procedure. Strongly agree and agree were combined as well as strongly disagree and disagree to minimize the number of cells with values less than five in the $2 \times 3$ expected value tables created by the PROC FREQ procedure. Based on the null hypothesis that contractor perceptions and contractor size are not related, a large probability value for the chi-square statistic indicates a statistical likelihood that the size of the contractor responding to the survey has no effect on the expected attitudes given in their response. A small probability for the chi-square statistic (<.1 used in this study) indicates that there is some relationship between contractor size and perception. This procedure reports the existence of a relationship between size and perception, but does not indicate what effect size has on perception.

Use of the chi-square statistic showed a possible relationship between size and perceptions for questions 7, 8, & 15. Cell values of less than 5 in more than a third of the cells in the expected values tables created for these questions limited the reliability of the statistic. To double-check the hypothesis, a second statistical test was performed using the mean scores for questions 7, 8, & 15. Variation in perceptions by size of contractor for these questions were further examined by utilizing the SAS PROC UNIVARIATE procedure to plot the data and the PROC TTEST procedure to test the null hypothesis that the difference between the mean scores for large and small contractors equals zero.

The t-test for question 7 yielded a probability of .05 allowing the null hypothesis to be rejected. This statistic along with the graph of the data indicate that large contractors have a more negative attitude about the likelihood of cost savings resulting from processing wood products for reuse rather than sending them to the landfill than do small contractors. The t-test and graphs for questions 8 & 15 failed to show any significant differences in the perceptions of large and small contractors.

### *Written Responses*

Nearly a quarter of the respondents took the time to provide written comments at the end of the questionnaire. Space limitations prevent the duplication of the comments, but several recurring themes were apparent in the comments.

- To be successful in the salvage of wood products, there must be an available market outlet ready to purchase the products. It is also beneficial if contractors maintain a relationship with a buyer of salvaged wood products.
- Many contractors believe in salvage—if it does not cost them money, time, risk, or excessive labor.
- Owners (or managers) must have experience in salvage to successfully plan and supervise the process.
- Handwork for the purpose of salvaging materials is not desirable. Use of equipment for salvage is necessary to be profitable. This excerpt from a lengthy comment is a good summary.

  > "If you have a careful competent operator, you will make good money saving structural lumber as you go. If he is rough, you will waste a lot of money and time. It pays to train your operators well. If you salvage lumber by hand, you will lose your proverbial, because the wages are too high and the job is slowed."

Several unique but interesting comments were made. One contractor sells his structural wood products in Mexico. Low cost Mexican laborers complete the hand processing of the materials. He is aware of no market for the same products in his southern California location. Another contractor sees value in wood waste because he is able to sell it for electric co-generation.

## CONCLUSIONS

Demolition contractors regularly participate in salvage operations. Over half report salvage to be a service that their company provides. Well over 90% indicate that they have been involved with reuse and recycling of construction materials. Over half have salvaged steel, wood, and architectural/historical materials for reuse. Over half have also salvaged concrete, steel, asphalt, and wood for recycling. Nevertheless, the survey responses indicate that demolition contractors possess attitudes that impede the expanded reuse and recycling of structural wood components.

There is a strong indication that demolition contractors see a need for the use of equipment for structural wood salvage operations rather than through the use of labor. Closely allied to this attitude is the indication that time is an impediment, but not necessarily due to project related constraints. Implicit in this conclusion may be the underlying premise that time is money. As with the labor issue, development of effective means of equipment based material harvesting may be the key to eliminating extra time for material reuse and recycling. Upgrades in equipment design, improved techniques for equipment based material harvest, and operator training all hold promise for strong demolition contractor support in advancing the level of structural wood component recycling and reuse.

There is also evidence that demolition contractors believe the poor condition of wood available for salvage impedes the reuse or recycling of wood components, but that grading rules may not. If demolition contractors or their field personnel make disposal rather than reuse decisions based on overly restrictive or nonexistent condition assessments, materials with potential for resale or recycling may be needlessly transported to the landfill. Continued research to develop easy to employ condition assessment procedures for wood structural components may be in order.

Site storage and security also appears to be a major impediment to reuse and recycling of structural wood components. The physical nature of the projects involved may create much of the challenge. Possibilities exist for contractors, owners, designers, or even the communities that surround demolition projects to plan and implement enhancements in their projects that reduce the site storage or security impediment to reuse and recycling.

It also appears that there is still a significant need for resale and reuse market development. No more than 50% of the responding contractors were aware of markets for reuse or recycling of wood products. Almost no market outlets are conspicuous to contractors for drywall, carpet, or roofing materials and very few contractors have been involved with salvage of these materials. Marketing and cost are also an impediment to reuse and recycling, but the degree to which contractors see marketing and cost to be an impediment varies greatly. Those contractors who are able to market wood components for reuse and recycling are likely to report a positive attitude while those with no market for these products perceive cost and marketing as an impediment. In situations where market outlets exist and use of equipment to harvest materials is viable (as with steel), the general willingness of contractors to participate in salvage activities appears to eliminate cost and marketing as impediments to reuse and recycling.

Success in reuse and recycling of salvage products depends on supply and demand dynamics as in any material handling business. The question that remains is, will high disposal costs and material disposal restrictions provide adequate impetus to induce the formation of enterprises willing to take the risks necessary in developing salvage material resale and recycling businesses, or will additional incentives be required. Building infrastructure in salvage resale and recycling will likely require a complex combination of policy decisions, incentives, and business planning procedures.

Demolition contractors seldom initiate projects of their own. It is more likely that demolition projects are carried out under the direction of a project owner, general contactor, or construction manager. This fact points to other avenues available for advancement of material salvage. Contractors report that owners do not influence the salvage of materials from their proj-

ects. Although this was taken to be a positive attribute, it is possible that owners who promote reuse and recycling could assist in developing the market infrastructure required to maintain consistent salvage markets and activity. Continued promotion of the benefits resulting from use of locally derived materials and products with reused or recycled content through "green" certification programs such as LEED (Leadership in Energy and Environmental Design) to owners, design professionals, and general contractors will help develop markets for salvaged materials.

Leadership from within the demolition industry will also be required. Although contractors as business owners need to be concerned with cost and ultimately profit, there was evidence from the responses to the open ended final survey question that many demolition contractors see salvage as part of their business. They expressed pride in their ability to harvest materials and return them to a new use. More contractors are needed with unique and noteworthy reuse and recycling processes such as the contractor who described how he sells his structural wood products in Mexico where low cost Mexican laborers complete the hand processing of the materials and the contractor who stated that he sells all of his wood waste for electric co-generation.

## ACKNOWLEDGMENTS

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## APPENDIX

**TABLE 2.** Wrecking and demolition contractors.

| | Source: 1997 U.S. economic census | | | | Source: NADC | |
|---|---|---|---|---|---|---|
| State | Establishments | Dollar value of business ($1,000) | Annual payroll ($1,000) | Number of paid employees | NADC regular members 2003 | NADC membership % of census data establishments |
| AL | s | $13,324 | $2,091 | 97 | 6 | Not applicable |
| AK | s | D | 2,601 | 61 | 2 | Not applicable |
| AZ | 19 | 43,359 | 7,489 | 297 | 6 | 32% |
| AR | 4 | D | 1,123 | 40 | 1 | 25% |
| CA | 197 | 397,823 | 102,843 | 3,306 | 78 | 40% |
| CO | 19 | S | 6,343 | 248 | 6 | 32% |
| CT | s | 55,257 | 16,623 | 364 | 12 | Not applicable |
| DC | 1 | D | D | (1000–2499) | 0 | 0% |
| DE | 3 | D | D | (1000–2499) | 3 | 100% |
| FL | 38 | D | 7,605 | 315 | 36 | 95% |
| GA | 28 | 25,712 | 6,742 | 298 | 6 | 21% |
| HI | 3 | D | 2,446 | 97 | 1 | 33% |
| ID | S | D | D | (1000–2499) | 3 | Not applicable |
| IN | 52 | 34,085 | 9,512 | 336 | 7 | 13% |
| IL | 91 | 204,977 | 65,084 | 1,389 | 41 | 45% |
| IA | 8 | 5,892 | 1,432 | 55 | 7 | 88% |
| KS | 12 | D | 2,019 | 80 | 7 | 58% |
| KY | 14 | 13,410 | 3,525 | 125 | 6 | 43% |

*Table 2—continued*

**TABLE 2.** Wrecking and demolition contractors—*continued*

| | Source: 1997 U.S. economic census | | | | Source: NADC | |
|---|---|---|---|---|---|---|
| State | Establishments | Dollar value of business ($1,000) | Annual payroll ($1,000) | Number of paid employees | NADC regular members 2003 | NADC membership % of census data establishments |
| LA | 16 | D | 2,898 | 125 | 5 | 31% |
| ME | 8 | D | 401 | (1000–2499) | 15 | 188% |
| MD | 37 | 69,548 | 18,858 | 625 | 11 | 30% |
| MA | 61 | D | 21,131 | 667 | 3 | 5% |
| MI | 76 | 165,976 | 44,557 | 1,245 | 23 | 30% |
| MN | s | D | 6,521 | 183 | 14 | Not applicable |
| MS | 4 | D | D | (1000–2499) | 0 | 0% |
| MO | 34 | 45,113 | 7,420 | 280 | 13 | 38% |
| MT | 3 | s | s | (100,000+) | 2 | 67% |
| NE | 5 | D | D | 101 | 1 | 20% |
| NV | 7 | S | 2,316 | 76 | 0 | 0% |
| NH | 10 | 16,094 | 4,300 | 115 | 4 | 40% |
| NJ | 63 | 123,433 | 33,150 | 965 | 22 | 35% |
| NM | 5 | D | 1,421 | 56 | 1 | 20% |
| NY | 128 | $221,441 | $52,126 | 1,647 | 34 | 27% |
| NC | 9 | D | D | (1000–2499) | 7 | 78% |
| ND | s | D | D | (1000–2499) | 0 | Not applicable |
| OH | 66 | 88,324 | 23,483 | 764 | 19 | 29% |
| OK | 18 | 20,863 | 5,228 | 194 | 8 | 44% |
| OR | 19 | 17,536 | 4,825 | 143 | 4 | 21% |
| PA | 70 | 67,035 | 15,128 | 598 | 35 | 50% |
| RI | 10 | D | 3,125 | 96 | 1 | 10% |
| SC | 7 | S | S | (1000–2499) | 0 | 0% |
| SD | 0 | 0 | 0 | | 0 | Not applicable |
| TN | 31 | 37,438 | 9,717 | 384 | 0 | 0% |
| TX | 89 | 128,800 | 29,040 | 1,204 | 33 | 37% |
| UT | s | D | S | (1000–2499) | 0 | Not applicable |
| VT | 3 | D | S | (1000–2499) | 0 | 0% |
| VA | 31 | 48,852 | 13,696 | 534 | 14 | 45% |
| WA | 37 | 60,941 | 19,571 | 459 | 12 | 32% |
| WV | s | 5,716 | 973 | (100,000+) | 3 | Not applicable |
| WI | 26 | s | 5,786 | 188 | 8 | 31% |
| WY | 0 | 0 | 0 | | 1 | Not applicable |
| U.S. | 1,541 | $2,304,007 | $592,175 | 18,820 | 521 | 34% |

*Notes:*

Highlight—National proportion of demolition contractors represented by NADC membership

D—Data withheld to avoid disclosing data of individual companies; data are included in higher level totals

S—Data withheld because estimates did not meet census publication standards

s—Census sampling error exceeds 40 percent

**TABLE 3.**

| Source: 1997 U.S. economic census | | | | | | Source: NADC | | |
|---|---|---|---|---|---|---|---|---|
| Region | Description[1] | Establishments | Dollar value of business ($1,000) | Annual payroll ($1,000) | Number of paid employees | NADC regular members 2003 | NADC membership % of census data establishments | |
| 1 | Northeast | 220 | $292,792 | $97,706 | 2,889 | 69 | 31% | |
| 2 | Mid Atlantic | 205 | 314,584 | 81,805 | 2,722 | 88 | 43% | |
| 3 | Southeast | 117 | 76,474 | 26,155 | 1,094 | 55 | 47% | |
| 4 | East Central | 325 | 506,772 | 151,947 | 4,047 | 104 | 32% | Combined[2] |
| 5 | West Central | 59 | 51,005 | 17,392 | 699 | 42 | 71% | 38% |
| 6 | Northwest | 59 | 78,477 | 24,396 | 602 | 22 | 37% | |
| 7 | California | 197 | 397,823 | 102,843 | 3,306 | 78 | 40% | |
| 8 | Southwest | 50 | 43,359 | 17,569 | 677 | 13 | 26% | |
| 9 | South Central | 127 | 149,663 | 38,289 | 1,563 | 47 | 37% | |
| 10 | Alaska and Hawaii | 3 | 0 | 5,047 | 158 | 3 | 100% | |
| Totals | | 1,362 | $1,910,949 | $563,149 | 17,757 | 521 | | |

*Notes:*

1. Region Composition
   Northeast—CT, MA, ME, NH, NY, RI, VT
   Mid Atlantic—DC, DE, MD, NJ, PA, VA, WV
   Southeast—AL, FL, GA, MS, NC, SC, TN
   East Central—IN, IL, KY, MI, OH, WI
   West Central—IA, KS, MN, MO, NE, ND, SD
   Northwest—ID, MT, OR, WA, WY
   California—CA
   Southwest—AZ, CO, NV, NM, UT
   South Central—AR, LA, OK, TX
   Alaska and Hawaii—AK, HI
2. Highlight—combined region 4 & 5 NADC membership totals 38% of census establishments

Purdue University and NDA Survey of Structural Wood Salvage Practices
**Return to: Knoy Hall, Rm. 453, 401 N. Grant St., West Lafayette, IN 47907**

**Please answer the following questions about your company s demolition activity.**

A. Circle the response the best describes the **Primary** type of demolition activity your company engages in.
1. *Demolition services of all kinds*
2. *Demolition of Paving and Bridge Constr.*
3. *Demolition of Building Construction*
4. *Specialty Demolition specific m aterials, interior strip-out, tank removal, etc.*
5. *Explosive Demolition*
6. *Plant Dismantling*
7. *Hazardous Material Demolition, Removal, or Abatement*
8. *Other* _____

B. Circle the territory that most closely matches where your company typically provides demolition services.
1. *City where your company is located*
2. *State where your company is located*
3. *Multi-State Region*
4. *National*
5. *International*

C. Have you or your company been involved with salvage, either complete or partial, for the purpose of reuse (or resale) of construction material? *Yes No*

D. If yes, what materials? (Circle all that apply)
1. *Soft stripped interior materials*
2. *Historic or architectural materials*
3. *Structural steel components*
4. *Structural wood components*
5. *Other* _____

E. Have you or your company been involved with demolition material recycling, either complete or partial? *Yes No*

*F. If yes, what materials? (Circle all that apply)*
1. *Concrete* 2. *Steel*
3. *Drywall* 4. *Carpet*
5. *Asphalt* 6. *Roofing*
7. *Wood*
8. *Other* _____

G. Circle the range that best describes the annual dollar volume of demolition activity your company completed during the period of January to December 2003.
1. *$0 - $500,000*
2. *$500,001 - $1,000,000*
3. *$1,000,001 $10,000, 000*
4. *$10,000,001 - $25,000,000*
5. *More than $25,000,000*

H. In addition to demolition activity, what other service does your company provide? (Circle all that apply)
1. *Structural Analysis or Consulting*
2. *Hazardous material investigation, mitigation, or removal*
3. *Landfill or other debris disposal*
4. *Material recycling, salvage, or resale*
5. *New construction or renovation*
6. *Other* _____

I. Circle the range that represents the number of employees your company had on payroll for more than half of the year in 2003.
1. *1 10* 2. *11 25*
3. *26 50* 4. *51 100*
5. *101 or more*

J. Does your company subcontract any of your demolition activity? *Yes No*

K. If yes, please circle your estimate of the percentage of 2003 demolition activity your company subcontracted.
1. *Less than 5%*
2. *Between 5% and 25%*
3. *Between 25% and 50%*
4. *Between 50% and 75%*
5. *Greater than 75%*

L. My company has experienced noncompetitive hauling restrictions, regulatory barriers to demolition waste disposal, or challenges in finding adequate affordable landfill space.
*Yes No Don t Know*

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Purdue University and NDA Survey of Structural Wood Salvage Practices
**Return to: Knoy Hall, Rm. 453, 401 N. Grant St., West Lafayette, IN 47907**

M. I am aware of market outlets where I can sell the following recycled or reused materials. (Circle all that apply)

*1. Concrete* *2. Steel*
*3. Drywall* *4. Carpet*
*5. Asphalt* *6. Roofing*
*7. Wood* *8. Architectural Items*

*9. Other* _____

N. When salvaging materials my employees have the experience to separate wood products by grade and quality after removal.
*Yes* *No* *Don't Know*

O. What is the best grade or quality of wood product that is generally available for removal from your projects?

_____

**For each of the following, circle the response to indicate whether you Strongly Disagree with, Disagree with, are Undecided about, Agree with, or Strongly Agree with the statement.**

**Your answer may differ depending on the job situation. Please answer for the job conditions you encounter most of the time.**

| | |
|---|---|
| 1. Removal of structural wood components for resale or reuse is profitable on most of my company's demolition projects. | 1. SD D U A SA |
| 2. Salvaged wood products have a good market for resale in the cities that we operate. | 2. SD D U A SA |
| 3. We generally have adequate information on our projects to make informed decisions about the profitability of removing wood products for resale. | 3. SD D U A SA |
| 4. Our project time constraints seldom prohibit disassembly of wood components for reuse. | 4. SD D U A SA |
| 5. Careful removal of wood products to preserve their quality and marketability is no more hazardous to our employees than any other demolition activity. | 5. SD D U A SA |
| 6. Buyers of salvaged wood located close enough to our projects are easy to locate. | 6. SD D U A SA |
| 7. In most cases processing wood products for resale is less costly than sending them to a landfill. | 7. SD D U A SA |
| 8. The owners we work with seldom try to influence the salvage of material from projects through contractual language. | 8. SD D U A SA |
| 9. It takes more time than it is worth to carefully remove wood structural components for resale on most of my companies' projects. | 9. SD D U A SA |
| 10. Much of the wood that is available for removal from our projects is too badly weathered, aged, or contaminated to be reused. | 10. SD D U A SA |
| 11. Lack of grading rules for salvaged lumber does NOT prevent me from reselling structural wood. | 11. SD D U A SA |
| 12. Salvaged wood is an expanding market in the areas where my company operates. | 12. SD D U A SA |
| 13. We seldom store salvaged materials at our project sites due to space limitations or security reasons. | 13. SD D U A SA |
| 14. Salvaged wood seldom needs much processing to make it marketable to resellers. | 14. SD D U A SA |
| 15. The use of heavy equipment is the only economical way to accomplish most of our demolition projects. | 15. SD D U A SA |
| 16. Much of the wood that is available for removal from our projects is too contaminated with paint, oil, mold, industrial byproducts, etc. to be reused. | 16. SD D U A SA |
| 17. Wood products we see on our jobs are frequently contaminated or hazardous, so they are not safe to handle in preparation for resale. | 17. SD D U A SA |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 18. Due to the high labor costs involved on the majority of our demolition projects, it is costly to remove structural wood products. | 18. | SD | D | U | A | SA |
| 19. Salvaged wood products are easily stored at most of our project sites until they can be transported to a buyer. | 19. | SD | D | U | A | SA |
| 20. Our demolition contracts seldom limit our ability to salvage all or part of the wood available on a project. | 20. | SD | D | U | A | SA |
| 21. The complex planning needed to carefully remove and market structural wood components for resale is typical of the project planning we perform. | 21. | SD | D | U | A | SA |

**Please use this space to comment on any aspect of salvage, deconstruction, recycling, or reuse of structural wood components.**

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