EPiC Series in Built Environment
Volume 2, 2021, Pages 127–135
ASC 2021. 57th Annual Associated Schools of Construction International Conference

A Case Study of Reducing the Costs of Deconstructing Blighted Buildings in the City of Milwaukee

Michael Olen, M.S.
City of Milwaukee
Milwaukee, Wisconsin

Chang-Ray Chen, P.E., Ph.D.
University of Wisconsin-Stout
Menomonie, Wisconsin

Chengyi Zhang, P.E., Ph.D.
University of Wyoming
Laramie, Wyoming

Bryan Dyer, P.E., Ph.D.
Eastern Kentucky University
Richmond, Kentucky

Abstract

The cost of deconstruction increased dramatically after the deconstruction ordinance in the City of Milwaukee went into effect on January 1, 2018. This study focused on comparing the cost of deconstruction from 2015 to 2018 and look at reducing the cost of deconstruction. Rising costs of deconstruction caused an increasing backlog of vacant and blighted buildings to remain in place across the City of Milwaukee. The purpose of this study was to analyze the costs associated with the deconstruction of structures in the Milwaukee area and to find areas of cost efficiencies. This study defines the labor and process costs required to deconstruct a structure defined as worker hours per square foot, identifies the environmental regulations and constraints that affect the costs of deconstruction, classifies the economic landscape that benefits deconstruction, defines the marketplace for material salvaged from deconstructions and the best practices for deconstructing houses. Contractors that specialize in deconstruction can benefit this research by creating a lean deconstruction process. Traditional demolition companies that focus on mechanical demolitions can use this research to expand business opportunities into deconstruction work and find the value in a material that has historically been landfilled. Municipalities will be able to control the contract bidding process by understanding the economics of deconstruction and the end market of salvaged materials.

Key Words: Deconstruction, Blight, Salvage, Reuse, Workforce development, Sustainability

Introduction

Prior to 2018, mechanical demolition had been the preferred method for the City of Milwaukee to use when removing blighted and vacant buildings. Deconstruction, on the other hand, was beginning to be seen as an environmentally friendly way to remove a building but cost-prohibitive on a large scale. Milwaukee, along with other cities across the country, began to use deconstruction as a method to raze buildings and reuse the building materials that would normally be placed in a landfill or recycled. Due to an increased focus on and implementation of environmental and safety regulations, the cost of deconstruction increased dramatically. Costs to deconstruct houses in Milwaukee increased 200% to 300% over from 2010 to 2018. After the implementation of the deconstruction ordinance, the city required every property built in 1929 or earlier to be deconstructed as opposed to undergoing mechanical demolition (City of Milwaukee, 2017b). The increased costs of deconstruction caused a backlog of vacant and blighted buildings waiting to be razed. Many of those buildings were owned by the city. From 2010 to 2017, the Department of Neighborhood Services (DNS) would average 150 demolitions a year. The number of demolitions and deconstruction initiated over the first six months of 2018 was less than twenty. The increased costs for deconstruction caused the number of houses that could be razed via demolition and deconstruction to decrease dramatically. These often blighted properties place costs onto the citizens of the community in the form of added code enforcement, fire and police calls, court costs, crime, and lower property tax revenue (Kellum, 2017). Having such a large number of properties in the backlog to be demolished or deconstructed comes at a substantial cost to the city financially.

The purpose of this study was to analyze the costs associated with the deconstruction of structures in the Milwaukee area and to find areas of cost efficiencies. Jurisdictions and contractors can use the research provided as best practice path to follow to deconstruct houses and salvage the value from them at a cost closer to mechanical demolition. This study addresses these five functions related to the costs of deconstruction: 1. Define the labor and process costs required to deconstruct a structure defined as worker hours per square foot; 2. Identify the environmental regulations and constraints that effect the costs of deconstruction; 3. Classify the economic landscape that benefits deconstruction such as rising housing costs, economic development, increase in new permits, and population growth; 4. Define the marketplace for material salvaged from deconstructions; 5. Define the best practices for deconstructing houses. Contractors that specialize in deconstruction can benefit from this research by creating a lean deconstruction process. Traditional demolition companies that focus on mechanical demolitions can use this research to expand business opportunities into deconstruction work and find the value in material that has historically been landfilled. Municipalities will be able to manage the contract bidding process by understanding the economics of deconstruction and the end market of salvaged materials. Deconstruction can have a dramatic social and economic impact on the construction industry as part of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) building rating system. The LEED system can provide guidance to contractors on developing a more sustainable and heathlier built environment for communities. Removing the blighted structures from neighborhoods has been documented to reduce crime and improve quality of life (Branas et al., 2016).

Literature Review

This review brings the factors of deconstruction together and provides an understanding how these six elements affect the whole of deconstruction and how they work together as a system. These factors include material reuse, economic, environmental, deconstruction process, employment, and social capital. With this information, the construction industry can understand how the upfront costs of deconstruction but industry can also help create opportunities to reduce ancillary costs. Material reuse is the reason deconstruction is taking place in the City of Milwaukee as evidenced by being listed in the administrative rules at the top of the hierarchy of deconstruction materials (City of Milwaukee, 2017a). Berghorn (2018) suggests that lowering deconstruction costs and increasing markets for salvaged material could help feed the pipeline to a highly skilled construction workforce. The plan for Milwaukee was to get the material out of a blighted structure using deconstruction and fuel the pipeline for young men and women to get higher wage construction jobs (City of Milwaukee, 2018a). The typical 2,400 square foot house in Milwaukee will average 7,000 board feet (BF) of lumber (Olen, 2018). This includes framing, finish flooring, subfloors, and sheathing. Berghorn (2018) states that average Michigan home can has 6,000 BF of lumber. Framing material used to construct houses in Milwaukee prior to 1930 was predominately Douglas fir. Calculations used in this research to determine Douglas fir board feet weight is 3.25 lbs per BF (Olen, 2018). A typical demolition project for the City can reach a 40% to 50% diversion rate by recycling material including, but not limited to, concrete, asphalt shingles, and the larger framing material. Schroeder (2017) states that the wood material that cannot be reused or repurposed can be recycled into wood pellets that are used for heating. Recycling the unuseable material is the third choice on the hierarchy of salvaged material after reuse and repurpose, but recycling the material into pellets, mulch, or for use in a bio-refinery does divert it from the landfill. The EPA (2010), Berghorn (2018), and the City of Milwaukee (2018b) put a high value on material reuse for the economic benefit of bringing down the cost of deconstruction by partially offsetting the higher labor cost compared to mechanical demolition. The more material that deconstruction can yield from a building should mean a lower net cost for deconstruction after the material is sold at retail.

Zahir (2015) states that economic development often requires demolition and unfortunately, although it is efficient, it creates a great deal of waste. In a deconstruction pilot fact sheet, EPA stated that the high labor costs associated with deconstruction was a barrier to a City of Philadelphia neighborhood transformation initiative (EPA 2010). In this instance, EPA awarded an innovation grant to a Philadelphia non-profit with the goal of harvesting the framing lumber from the buildings. A study found the typical row house demolition in Philadelphia required an even greater amount of hand demolition and less use of heavy machinery (EPA, 2010). A row house will often have shared walls and the use of large machinery risked causing damage to the neighboring structures. The project was to incorporate a mechanized deconstruction to reduce labor cost from standard deconstruction and increase the amount of material salvaged over mechanical demolition. Research exists on the environmental factors associated with deconstruction and demolition including, but not limited to, information on sustainability, asbestos, and lead-based paint (LBP). Sustainability and green construction are still in a bit of infancy in many parts of the construction sector. Contractors and architectural firms of all sizes are working with USGBC and finding ways to improve the life-time performance of new buildings. There is even a movement to design specifically for deconstruction, so the structure could be more efficiently taken apart at the end of the building's lifecycle (EPA, 2008). Greenhouse gas emissions and embodied energy can be reduced with the implementation of a comprehensive deconstruction plan (Zahir, 2015). The key point is not just the comprehensive implementation, but getting the reclaimed materials from deconstructionm into an end use. Without the end market, the effects will be negligible.

OSHA requires an engineering plan regardless of whether a structure is to be demolished mechanically or deconstructed. An engineering plan for the safe deconstruction of the building is critical to establish a safe process (OSHA, 2018a). Designing for Deconstruction (DFD) is a concept that the industry is pushing and should therefore be a part of deconstruction plans especially as the industry attempts to find outlets for the old growth material (Pulaski et al., 2004). Knowing how the material will be used could direct how the building is deconstructed. Pulaski et al. (2004) stated in order to understand the challenges of DFD, it is important to understand the deconstruction process. Unfortunately, many demolition contractors of residential buildings are fairly removed from the design process.

The Institute for Local Self-Reliance (ILSR) (2008) and others have referenced that municipalities including, but not limited to Milwaukee, have used the prospect of increase employment to adopt deconstruction initiatives and ordinances. The EPA (2010) that the high labor costs can also be a constraint to deconstruction, especially if the use of prevailing wages are required (ISLR, 2008). Deconstruction is more labor intensive in theory and could have the effect of creating jobs and even creating a new industry of skilled jobs (Zahir 2015). Berghorn (2018) stated that a deconstruction operation in a moderate-size market could support 12 full time jobs per 100 homes. Considering the ever increasing labor shortage in construction and the skilled trades, deconstruction should be considered a pipeline to construction work in the existing construction industry and not an end goal.

Aldrich (2018) defines social capital as the social ties and networks that communities rely on to function and recover from disruptions. The process of removing blighted properties from urban areas leaves a vacant lot that will likely sit vacant for a period of time. Vacant lots in Milwaukee have little value as the high cost of new construction does not make infill construction an economically viable option for many developers. As a result of this lack of development, the social fabric of the community weakens as neighbors are spaced further apart. When neighbors lose the social capital, the ability to rely on that network to recovery after a disruption becomes more difficult (Aldrich, 2018). Where Aldrich's research has a focus on resilience and how communities overcome disasters like the Fukushima earthquake, social capital used during and after disasters can work for other types of community disruptions. Lead poisoning in water pipes, blighted buildings, and the underlying economics of low-income areas can be the stressors or disruptions that the community struggles to overcome. The industry needs to understand that economic factors are different in different areas of the country and deconstruction plays a different role in some situations. Deconstruction can work in both economic situations, but it needs to be tailored and specific.

Case Study

The DNS for the City of Milwaukee inspected and monitored all the demolitions and deconstructions in the city. In cases where the Department of City Development (DCD) decided to raze a city-owned structure in the past, the department acted as the general contractor for the demolition/deconstruction. This research collected the data from the previous deconstructions and mechanical demolitions done in the City to get a representation of the costs associated with both and costs that are specific to each. Data were also collected on deconstructions performed as part of projects done by peer cities across the country to compare with the data from Milwaukee. The initial research on the topic showed a wide range of costs per square foot that vary across the country. Interviews were conducted with experts from various fields ranging from building officials, academics, trade group representative, to designers and architects. Data on the deconstruction process was collected during job site inspections from 2015 to 2018. Permission to collect information was granted from City of Milwaukee DNS. This study examined the data on the costs of deconstructions as well as the worker hours needed to complete the projects. The data was obtained from records kept by the organizations sponsoring the deconstruction projects as well as data from deconstructions done in the city. Contract and cost breakdown data was gathered from records on deconstructions in the city from 2010 to 2018. Records contain information on costs and material reuse, repurpose, recycle, or landfill. Data on deconstruction include information from the nonprofit and profit contractors. Worker hours were tracked under the Residents Preference Program for deconstruction packages with the component.

Limitations

This analysis of past deconstructions focused on publicly owned buildings with the understanding that the tax benefits of donating salvaged material would not be available to the City of Milwaukee or other public entity. The city owns buildings that have been taken over by tax foreclosure. Over 500 of these buildings are scheduled to be razed, and most fall under the requirement of the deconstruction ordinance of being built in 1929 or earlier. The typical annual demolition budget of $3 millions allows for 200 properties to be mechanically demolished or 120 builings to be deconstructed each year. Thses numbers can move as budgets and priorities fluctuate. These buildings get marketed for resale by DCD for several years in some cases. In cases where the building cannot be for sale due to whatever reason(s), DCD will refer the structure to DNS for demolition or deconstruction. At this point of a building's lifecycle, the condition of the building is from partially to severely deteriorated. The structures could then stay on the list of properties for an additional few years before a raze might be finalized. Metal that made up the mechanical systems would have been removed by the salvage operators who are not affiliated with the city. The windows and doors could be broken and the house could be left open to the surrounding elements. The framing lumber, sub-floor, and sheathing might be the only valuable material left to salvage from the structure. Building elements containing any hazardous material are to be disposed of properly according to the city deconstruction contract specifications. These items do not need to be removed and prepared for sale and can instead be placed directly into the proper dumpster. Records created by the City of Milwaukee or submitted as part of the bidding process are considered open records and are available to the public under an open records request.

Material Assessment

Understanding the building that is to be deconstructed and how the material can be removed to obtain the highest yield. Vacant buildings were inspected as a part of this research and Milwaukee's assessment tool, that quantifies the value of the material inside the building, was updated to include material such as the wood lathe which was not harvested from buildings in a significant number prior to 2018. Table 1 lists the materials at retail value, or what the private owner might be able to write off in tax deduction if the materials were to be donated to a non-profit. Table 2 calculates the value of materials at the contractor value, or what the contactor can expect the materials to sell for on-site with minimal preparation work. This assessment can be used on a variety of building types by plugging in square footage and wall heights into the assessment spreadsheet. Historically a percentage of material is expected to be damaged during deconstruction, and those percentages were factored into the spreadsheet. Hardwood flooring for example can be difficult to remove cleanly and up to 25% of a floor can be damaged during deconstruction. Additionally, hardwood flooring under kitchen tile or laminate is not expected to be harvested. The estimated value of the materials for the proposed project in Tables 1 and 2 illustrates two important factors in the deconstruction infrastructure. Contractors willing to hold on to the material in a storage facility can get a higher price but at risk of the added costs to store the material until it is sold.

The estimated total value of materials which is of $84,641 for the seven houses described in Table 2 is a number for the jurisdiction to show potential contractors the value anticipated in the bidding process. Retail value of the materials, estimated at $221,731 and shown in Table 1, is equal to the donated value a private owner could expect from an assessment. These values represent the investment of a jurisdiction like the City of Milwaukee is making from the cost of hiring the contractors, in the workforce and the adjacent property values within the neighbourhoods affected by deconstructions. The amount of materials listed in the description column can help a jurisdiction to gauge a contractor's efficiency in harvesting the materials. Maintaining records of contractor performance will drive continuous improvement but would require contractors to submit material reports that can be verified by field observations from city inspectors.

Table 1

Framing Material Assessment, Retail Value

Material	Description	Value per unit	Total value
2 x 4 Studs	9,384 BF	$2.50 BF	$23,460
2 x 6 Rafters	4,658 BF	$2.50 BF	$11,645
2 x 8 Floor joists	12,468 BF	$2.50 BF	$31,170
2 x 6 Attic floor joists	4,938 BF	$2.50 BF	$12,345
1 x 6 Sub floor	10,717 sq ft	$2.50 BF	$35,723
¾" x 2 ¼" Hardwood	3,689 sq ft	$2.50 BF	$12,298
1 x 6 Sheathing	9,416 sq ft	$2.50 BF	$31,388
Beams	1,419 BF	$3.50 BF	$4,965
Lathe	22,027 sq ft	$2.00 BF	$58,738
		Total estimated value =	$221,731
		Estimated value per house =	$31,676
		Estimated value per sq ft =	$17.56

Table 2

Framing Material Assessment, Contractor Value

Material	Description	Value per unit	Total value
2 x 4 Studs	9,384 BF	$0.50 BF	$4,692
2 x 6 Rafters	4,658 BF	$0.75 BF	$3,494
2 x 8 Floor joists	12,468 BF	$1.00 BF	$12,468
2 x 6 Attic floor joists	4,938 BF	$0.75 BF	$3,704
1 x 6 Sub floor	10,717 sq ft	$1.50 BF	$21,434
¾" x 2 ¼"Hardwood	3.689 sq ft	$2.50 BF	$9,838
1 x 6 Sheathing	9.416 sq ft	$1.50 BF	$18,833
Beams	1,419 BF	$2.00 BF	$2,387
Lathe	22,027 sq ft	$0.25 BF	$7.342
		Total estimated value =	$84,641
		Estimated value per house =	$12,092
		Estimated value per sq ft. =	$6.07

Typically, the first and second floors had similar trim and built-in cabinetry although years of use and painting can vary the quality of the material. In many cases, the units were either painted or vandalized like the missing column. Additionally, damage and theft may occur in the intervening months between an assessment and the beginning of deconstruction. For those reasons, although the value exists for the unpainted built-in cabinetry, the estimated values were left off the assessments of building material and are instead included in the deconstruction matrix, where it can be included as part of the historical context of the structure.

The regression analysis of square feet, worker hours, and costs was performed on the deconstructions conducted in the City of Milwaukee from 2015 through 2018. Five separate contractors were under contract to deconstruct the 34 structures. The results from the regression analysis indicate that inputs like square feet and worker hours do not result in costs falling in the predicted range.

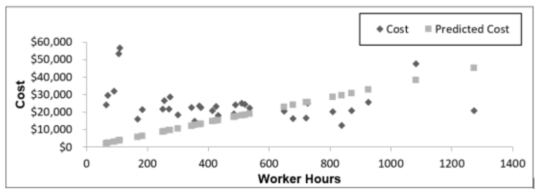

Figure 1. Regression, worker hours to cost.

Figure 1 contains data rerecorded for 34 observations on deconstructions in the City of Milwaukee and the costs of those deconstruction. The R square number of 0.555 for the data in Figure 1 shows that just over 55% of the worker hour inputs for jobs fit the model. The correlation coefficient for this model was 0.745, showing a positive relationship, but not nearly as strong as the researchers would expect.

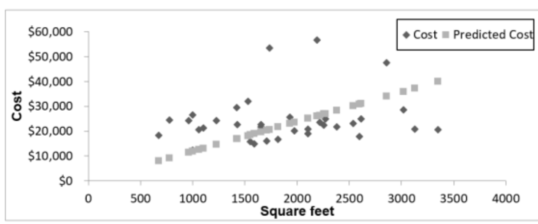

Figure 2. Regression analysis of square feet to cost.

Figure 2 shows data from the same deconstructions used in Figure 1 but shows a tighter relationship of the square feet to the costs. The R square number for this analysis was 0.803 and the correlation coefficient was a much closer to perfect 0.896.

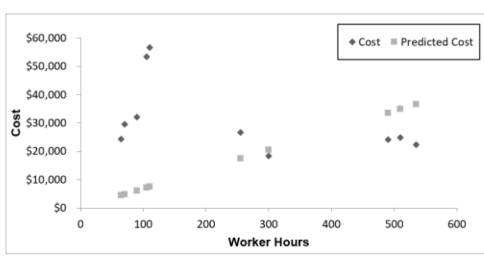

Figure 3. 2017 and 2018 Deconstructions worker hours to cost.

Figure 3 illustrates the widespread of worker hours to costs regression analysis of the most recent ten deconstructions performed in the City of Milwaukee. This information suggests that the smaller houses that are being deconstructed take fewer hours to complete, but the costs are not reflective of the fewer worker hours. For instance, the cost to deconstruct a 600 square foot cottage could be the same as the cost to deconstruct a 2400 square foot duplex. More research would help to understand if this is simply the a result of a limited number of contractors bidding on the work or that the costs will come more in line to a consistent square foot price as the market matures and more houses are deconstructed.

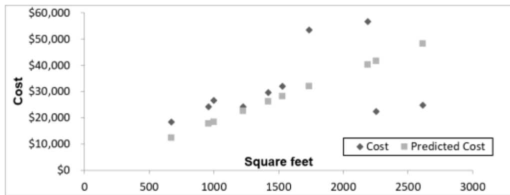

Figure 4. 2017 and 2018 Deconstructions square feet to cost.

The cost to square feet regression analysis of the most recent ten deconstructions performed in the City of Milwaukee shows a much tighter relationship than the 34 deconstructions performed since 2015 that are shown in Figure 4.

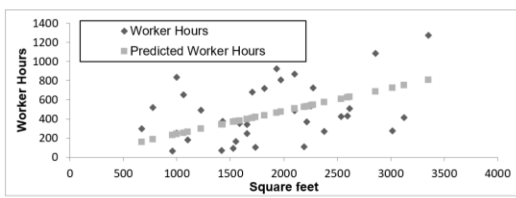

Figure 5. Worker hours to square feet.

Figure 5 illustrates the regression analysis of worker hours to square feet for thirty-four deconstructions since 2015. The R square is 0.739 and the correlation coefficient is 0.86. In this graph, the researchers have a much wider spread of actual worker hours compared to what the predicted worker hours would be. The average worker hours required to deconstruct buildings per square foot in the City of Milwaukee is 0.314. Using this number, the City can get an estimate of the time required to deconstruct properties by simply plugging in the square feet of the property. To put these workforce and assessment numbers into context, a large project to deconstruct 100 properties with an average of 1,800 square feet, would be estimated to take 56,520 worker hours and result in a framing material yield of $1,092,600 at $6.07 average value ofnmaterial yield per square foot. The average cost per square foot of a recent deconstruction bid in the City of Milwaukee was $21.15. This would result in a cost to the City to deconstruct 100 buildings at $3,807,000 with an estimated value of materials of $1,092,600 for the deconstruction contractor.

Conclusions and Recommendations

This research looks at reducing the cost of deconstruction and increasing the benefit to the community at the same time. The results allow for the use of three key metrics that can help model a cities portfolio of blighted properties, so the decision-makers can make judgments on what buildings to deconstruct and when. Recommendations for the City of Milwaukee include further improvements in funding, building and material assessment, and improving the processes used to deconstruct.

Exploring additional funding streams specific to deconstructions and construction workforce development is recommended to assist in the rapid deconstruction of the large volume of properties that have built up in the city's backlog of blight structures. For building and material assessment, it is recommended that the City of Milwaukee design and implement a standardized assessment process that can identify building materials within a building. This assessment can serve several functions including, but not limited to, advising decision-makers on the value of the material that is embodied in the vacant and blighted structures that are scheduled for demolition. For the deconstruction process, it is essentially the construction of the building in reverse and because of that there are risks involved with deconstruction. For future research study, the authors can consider other unfolded factors that are associated with the environmental and social capital impacts to the community. The will can affect the community going forward through workforce development, property taxes, lead and asbestos abatement, and crime reduction. As a part of city planning, these are the benefits that decision-makers need to understand and incorporate when planning local deconstruction ordinances and determining which houses to deconstruct, mechanically raze, or rehabilitate.

References

Aldrich, D. (2018). "Prep talks: Social capital in disaster mitigation and recovery", FEMA, available at: https://www.fema.gov/preptalks/aldrich.

Berghorn, G. H. (2018). "The dollars and sense of the deconstruction and reuse industry: A look through spartan green colored glasses", available at: https://domicology.msu.edu/upload/Berghorn-DollarsandSenseofDomicology.pdf.

Branas, C. C., Kondo, M. C., Murphy, S. M., South, E. C., Polsky, D., & MacDonald, J. M. (2016). "Urban blight remediation as a cost-beneficial solution to fire arm violence", *American Journal of Public Health*, Vol. 106 (12), pp. 2158 – 2164.

City of Milwaukee (2017a). "Deconstruction Administrative Rules", available at: https://city.milwaukee.gov/ImageLibrary/Groups/dnsAuthors/Decon/DNSDeconRulesAdmin.pdf.

City of Milwaukee (2017b). "Deconstruction Ordinance", available at: https://city.milwaukee.gov/ImageLibrary/Groups/dnsAuthors/Decon/DeconOrdinance170188.pdf.

City of Milwaukee (2018a). "Department of Neighborhood Services: Deconstruction", available at: http://city.milwaukee.gov/Decon#.WycqZadKjIU.

City of Milwaukee (2018b). "2014 Lead poisoning density", available at: https://city.milwaukee.gov/ImageLibrary/Groups/healthAuthors/HEH/PDFs/2014PoisoningDensity-ZIP.pdf.

Environmental Protection Agency (2008). "Lifecycle construction resource guide", available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P1009HH1.PDF?Dockey=P1009HH1.PDF.

Environmental Protection Agency (2010). "Deconstruction for urban revitalization", Office of Solid Waste and Emergency Response (OSWER), available at: https://www.epa.gov/sites/production/files/2016-03/documents/deconstruction_for_urban_revitalitzation.pdf.

Institute for Local Self-Reliance (2008). "Finding value in recovered building materials", Washington D.C. Pennsylvania Department of Environmental Protection.

Kellum, M. (2017). "Vacancy, light, and local governments", available at: https://www.iccsafe.org/app/wp-content/uploads/Vacancy-Blight-and-Local-Governments.pdf.

Olen, M. (2018). "Deconstruction material count", spreadsheet, City of Milwaukee, 03 August 2018.

Pulaski, M, Hewitt, C., Horman, M., and Guy, B. (2004). "Design for deconstruction: Material reuse and constructability", *GreenBuild Conference (2003), 12-14 November, in Pittsburgh, PA.*

Schroeder, L. (2017). "Recycling your home: Can structural wood be reused for the same purpose?", available at: http://greatlakesecho.org/2017/07/12/recycling-your-home-can-structural-wood-be-reused-for-the-same-purpose/.

Zahir, S. (2015). "Approaches and associated costs of building demolition and deconstruction", unpublished thesis, Michigan State University, East Lansing, MI.