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UPDATE OF DECONSTRUCTION ALTERNATIVES FOR WORLD WAR II-ERA BUILDINGS

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UPDATE OF DECONSTRUCTION ALTERNATIVES FOR WORLD WAR II-ERA BUILDINGS

1. Purpose

a. This Public Works Technical Bulletin (PWTB) reports on deconstruction options for World War II (WWII)-era Army buildings, in addition to three case studies that document deconstruction practices, problems, and lessons learned.

b. This PWTB updates and replaces PWTB 200-1-45, “Deconstruction of WWII-Era Wood Framed Buildings” and PWTB 420-49-30, “Alternatives to Demolition for Facility Reduction.” Those two PWTBs are now obsolete and should not be used for current guidance, but the information they contain might remain available for reference in the archives of the website below.

c. All PWTBs are available electronically at the National Institute of Building Sciences’ Whole Building Design Guide webpage, which is accessible through this link:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability

This PWTB applies to all U.S. Army facility engineering activities in the continental United States (CONUS), the non-contiguous states of Alaska and Hawaii, and offshore U.S. territories and possessions.

3. References

a. Army Regulation (AR) 200-1, “Environmental Protection and Enhancement,” 13 December 2007.

b. AR 420-1, “Army Facilities Management,” 12 February 2008; rapid-action revision, 24 August 2012.

c. Department of Defense (DoD), “Strategic Sustainability and Performance Plan (SSPP),” FY2013, 14 August 2013.

d. Unified Facilities Guide Specifications (UFGS) 01 74 19, “Construction and Demolition Waste Management,” January 2007.

e. UFGS 02 41 00 “Demolition and Deconstruction,” May 2010.

4. Discussion

a. In Chapter 10 (“Waste Management”) of AR 200-1, items 10-2.a(3) and 10-2.a(4) specifically call for maximizing the recovery, recycling, and reuse of solid waste and for integrating waste management into C&D activities such that a significant amount of materials generated can be reused in their original form.

b. Section 23-11 of AR 420-1 gives the Army’s guidelines for solid waste reduction, resource recovery, re-use, recycling, and composting practices. Subsection 23-11.e says that all construction, renovation, and demolition projects shall require a 50% minimum diversion of C&D waste from landfills, by weight.

c. In the DoD SSPP, Sub-goal 5.3 calls for 60% of construction and demolition (C&D) debris to be diverted from landfills by FY 2015 and thereafter through FY 2020.

d. The UFGS specifications provide sample contract language to be inserted into government construction contracts. UFGS 01 74 19 and 02 41 00 call for plans that describe how materials will be managed and reporting requirements.

e. Results of construction-related initiatives such as the Residential Communities Initiative (RCI), Facilities Reduction, Barracks Modernization, and Motor Pool Modernization have caused C&D debris to comprise the majority of the total solid waste stream. For FY 2013, C&D was 68% of the total of the DoD’s solid waste stream per its Solid Waste Annual Reporting (SWAR) system (http://denix.osd.mil/swarweb).

f. None of the available methods of reducing C&D debris are thoroughly integrated into the military construction process. Army installations have demonstrated in the past the efficacy and cost savings to be had through deconstruction. Other methods of reducing C&D debris include recycling and building relocation.

g. Appendix A provides an introduction to deconstruction processes for WWII-era buildings including panelization and mechanical deconstruction methods.

h. Appendix B reviews deconstruction case studies at three current or former Army installations.

i. Appendix C provides lessons learned for better deconstruction which are summarized here:(a) getting command support and having participation of all building-related elements; (b) understanding that deconstruction may require more time than demolition; (c) obtaining complete site utility information and properly configuring work site needs; (d) preplanning for identification and sourcing of materials saves time; (e) removing material promptly increases efficiency and safety; (f) using proper tools can increase efficiency and salvage potential; and (g) balancing worker efficiency with proper salvage methods is important.

j. Appendix D includes the references cited in this document and resources for further reading. Appendix E provides a list of abbreviations used along with their spelled-out meanings.

5. Points of Contact

a. Headquarters, US Army Corps of Engineers (HQUSACE) is the proponent for this document. The point of contact (POC) at HQUSACE is Mr. Malcolm E. McLeod, CEMP-CEP, 202-761-5696, or e-mail: Malcolm.E.Mcleod@usace.army.mil.

b. Questions and/or comments regarding this subject should be directed to the technical POC:

US Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
ATTN: CEERD-CN-E (Stephen D. Cosper)
2902 Newmark Drive
PO Box 9005
Champaign, IL 61826-9005
Tel. (217) 398-5569
FAX: (217) 398-5509
e-mail: Stephen.D.Cosper@usace.army.mil

FOR THE COMMANDER:

JAMES C. DALTON, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

APPENDIX A:
INTRODUCTION TO DECONSTRUCTION OF WWII BUILDINGS

The Army typically uses conventional methods to remove surplus buildings from its real property inventory and then landfills the demolished debris. Deconstruction, on the other hand, is the disassembly of a building in order to maximize the recovery of its salvageable materials. Deconstruction also can achieve a significant reduction in the solid waste volume going to landfill.

The deconstruction process at Army installations can vary widely, depending on which of the four options outlined below is chosen.

1. An installation can contract the deconstruction work to a private firm but retain ownership of the salvaged materials which are often valuable.

2. A deconstruction contractor can retain salvaged materials as payment-in-kind for deconstruction, resulting in zero cost to the installation for deconstruction.

3. A third option is for the installation to allow a deconstruction contractor to retain all salvaged material in exchange for reducing the contract price by an amount equivalent to the value of the resale of the materials.

4. Finally, an installation can donate their salvaged materials to a nonprofit organization such as Habitat for Humanity (HfH) in return for the charity removing the buildings at a price competitive with commercial contractors.

Even though steel-framed buildings are often disassembled, the deconstruction process is used mostly on wood-frame buildings. The deconstruction contract’s cost may affect the viability of using deconstruction, depending on the value of the building’s contents and materials. Usually, a high-value project for the Army is demolishing an average two-story World War II (WWII)-era barracks (Figure A-1). Since much of the debris is valuable old-growth wood, deconstructing a WWII building will usually provide a higher return for the time and effort expended.

Figure A-1. Typical WWII-era, wood-framed buildings at Fort Hood in 2000.

Deconstruction Process

Deconstruction refers to the actual disassembly of a building and the processing and cleaning of the salvaged materials. The deconstruction process roughly follows the reverse of the construction process, meaning the materials that have been put on last will come off first. Focusing on removing each material type in reverse order of the construction process means greater efficiency when separating materials for reuse, recycling, and disposal.

Examples of building deconstruction activities are the removal of siding, sheetrock, windows, wall studs, flooring, trusses, and wood trim. Some of these indoor and outdoor deconstruction activities are depicted in Figure A-2 through Figure A-4.

Post-removal processing includes activities such as removing nails from wood items and the cutting, sorting, and stacking of items. Cleaning may be required of some items, and they may be removed from the building footprint to a staging area. Trash and unusable materials that cannot be recycled may be removed and placed in dumpsters located on the job site. A third option is for the installation to allow a deconstruction contractor to retain all salvaged material in exchange for reducing the contract price by an amount equivalent to the value of the resale of the materials. The contractor is still responsible for properly disposing of all nonrecyclable materials.

Deconstruction methods can be manual, panelized, mechanical, or a combination thereof. Selection of the deconstruction method is usually determined by such considerations as the accessibility of building materials, the effort required to salvage materials and the condition of building components (e.g., presence of lead-based paint or rotted wood). Typically, deconstruction is accomplished with a combination of methods.

Panelization Deconstruction

An example of panel deconstruction is the removal of large sections of roof decking by cutting the decking between the rafters into panels and removing the panels all at once. Figure A-5 shows the "panelization" method of deconstruction. Panelization allows roof, wall, and floor sections to be removed more quickly than manual methods but will reduce salvage yields.

Manual Deconstruction

Manual deconstruction, on the other hand, generally yields a higher percentage of salvaged materials than panel deconstruction but takes longer.

Mechanical Deconstruction

An example of mechanical deconstruction is the use of a bucket truck or an aerial manlift to provide an aerial work platform. During a 2004 Fort Hood deconstruction project, a 45-ft manlift was used to safely remove windows, soffits, and siding.

Figure A-2. Removing drywall in 2003 at Fort McClellan (Joyce Baird, ERDC-CERL).

Figure A-3. Removing eaves at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Figure A-4. Removing windows at Fort Campbell in 2002 (Joyce Baird, ERDC-CERL).

Figure A-5. Floor panelization at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Salvageable Materials

Lumber is typically the most sought-after material once a building is deconstructed. Installed items such as sinks, toilets, tubs, wood flooring and carpeting, furnaces, and other products and equipment are also valuable in some salvaged material markets. The following lists present materials that can either be salvaged for recycling (i.e., further processing required) or marketed for reuse (i.e., used again substantially intact).

Typically Recovered for Reuse:

- large, heavy timbers
- larger dimensional lumber[1] (e.g., 2x10, 2x8, 2x6)
- metals, structural steel
- concrete
- brick/masonry
- wood paneling, molding, and trim

[1] In the U.S. construction industry, dimensional lumber is identified by the nominal cross-section dimensions (e.g., a "2x4") has a cross-section of nominal 2 in. x 4 in., when the actual measurement is 1 ½ x 3 ½ in.).

- hardwood flooring
- siding
- cabinets and casework
- electric equipment and light fixtures
- plumbing fixtures and brass fittings
- windows, doors, and frames
- heating ducts
- architectural antiques

Typically Recovered for Recycling:

- smaller dimensional lumber (2x4 or smaller)
- gypsum drywall
- carpet/carpet pad
- structural concrete
- rebar
- brick/masonry
- roofing material
- insulation
- ceiling tiles
- glass
- fluorescent tubes
- scrap metal
- electrical cable
- copper and metal pipe

Salvage Value

Salvage value is the estimated value an asset will realize when sold at the end of its useful life. The salvage value of deconstruction materials depends on the type and quantity of each material removed, on each material’s quality or condition, and each material’s current market value.

Salvage values fluctuate frequently and often depend on local market conditions or other economic factors. For example, some areas may not have a market for certain materials, or an installation may not generate enough of a particular material to make recycling cost effective. If no market exists, then an installation may have to pay for removal of at least some of the unwanted materials. This form of deconstruction can still prove cost-effective as landfill disposal costs are avoided.

For approximate salvage values of materials recovered during a deconstruction project refer to PWTB 200-1-128, “Market Valuation of Demolition Salvage Materials” (USACE in process).

APPENDIX B: DECONSTRUCTION CASE STUDIES

This section presents three relevant deconstruction case studies. The first study concerns a controlled research project (side-by-side methods comparison) that was performed at Fort McClellan in Alabama, the second is a commercial project conducted at Fort Carson in Colorado, and the third involved building removal as part of the decommissioning process at Twin Cities Army Ammunition Plant in Minnesota.

Fort McClellan, Alabama

In 2003, the University of Florida’s Powell Center for Construction and Environment (PCCE) completed a deconstruction research project at the former Fort McClellan.[2] The deconstruction project was part of a larger DoD and the U.S. Environmental Protection Agency (EPA) Region 4 Pollution Prevention grant program. The purpose of the project was to investigate different methods by which deconstruction can prove an economically viable option to demolition. The results of the research are reported in “The Optimization of Building Deconstruction for DoD Facilities: Fort McClellan Deconstruction Project” (Guy 2006).[3]

Building Types and Quantities Deconstructed

Three WWII-era barracks were dismantled: Buildings 829, 830, and 844. Each building was 4,450 sq ft, and each of the buildings had a brick chimney which Fort McClellan had hoped could be partly salvaged. The brick chimneys were originally about 8 ft tall and were added to the buildings in the 1970s. Bricks in the upper part of the chimneys were firmly in place, and initial attempts at knocking them down were unsuccessful. The buildings were of balloon construction (i.e., the studs went up two floors). These buildings were 70 ft long x 30 ft wide and about 8 ft high.

[2] The site is now a 26,000-acre former military base, having officially closed in 1999 as a result of Base Realignment and Closure (BRAC) decisions.

[3] Most data in this section is taken from Guy’s 2006 report of the project.

Figure B-1. Building 829 at Fort McClellan.

Contracting Arrangements

A private company (Costello Dismantling,[4] based in Wareham, Massachusetts) was contracted to perform the physical deconstruction as directed by the PCCE. The contractor was responsible for most of the deconstruction labor, equipment rental, licensing and bonds, and disposal of waste materials.

Deconstruction Process

One goal of the project was to identify the optimal combination of manual and mechanical deconstruction methods. The study identified that the barracks deconstructed by a combination of manual and mechanical methods had a 22% reduction in overall deconstruction time but recovered nearly one-third less (31%) in salvage when compared to a strictly manual process. The barracks dismantled using mechanical labor took 90% less time to complete but also resulted in an 83% lower salvage rate than manual methods (Kentucky Pollution Prevention Center 2003, 6).

Because Building 829 at Fort McClellan had considerable water damage and a severe mold problem, not much was salvageable. Thus, it was dismantled using mechanical means. By contrast, manual methods were used to deconstruct Building 830, and

[4]The University of Florida's PCCE selected the Costello firm for their expertise in a variety of removal techniques (http://www.costellodismantling.com/pages/cfRecyclingSalvage.cfm).

Building 844 was dismantled using the panelization method. The panelization method involved cutting roof assemblies, walls, and floors into 10 x 10 ft (or larger) panels which were then carried by a skid steer to a salvage area.

Figure B-2 through Figure B-7 illustrate mechanical-assisted dismantling processes demonstrated during this project.

Figure B-2. Removing roof panels at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Figure B-3. Removing upper floor wall panels at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Figure B-4. Cutting floor panels at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Figure B-5. Moving floor panels with skid steer at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Figure B-6. Using a track hoe to tip remnant building shell after salvage at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Figure B-7. Tipping chimney separately with track hoe to break apart bricks for potential recycling at Fort McClellan in 2003 (Joyce Baird, ERDC-CERL).

Salvaged Materials

Metal from boilers and piping, concrete from the floors, and bathroom fittings were salvaged from the demolished building boiler room and bathroom sections. A total of 32.75 tons of building materials were salvaged from the three barracks deconstructed for the study.

Problems

The barracks selected for the study had extensive amounts of lead-based paint (LBP) and severe water damage. Building 829, in particular, had a mold and water damage problem. Little could be salvaged from Building 829 except bathroom and plumbing fixtures, boiler room items for scrap metal, and concrete supports from bathroom and boiler room floors. Thus, material recovery rates were significantly lower than what was expected from typical barrack deconstructions.

Lessons Learned

The Fort McClellan deconstruction study (Guy 2006) indicated that the maximum practical amount of materials that can be salvaged from these types of building deconstructions using hand deconstruction techniques is about 39%. This low salvage percentage is due to the poor conditions of the buildings (i.e., they had many interior partitions and drywall [materials that are never suitable for reclamation] and small-dimension lumber). Another impediment was the presence of LBP on all exterior siding and on the inside surfaces of exterior walls including all of the 2x4 wall framing.

Manual labor cost was higher per hour than mechanical labor; however, salvage potential is usually greater with manual deconstruction. The higher salvage potential is an important consideration if time is not a constraint. Guy (2006) showed that if attempting to maximize salvage on a net dollar per-square-foot basis (net dollars = gross costs - salvage value), a specific combination of mechanical and hand labor for deconstruction was most effective. In the demolition of the buildings, the mechanical and hand labor combination scenario was almost equal to that of hand deconstruction in realizing salvage value per unit of cost. In fact, it took almost half the total labor-hours as did hand deconstruction, making it the more cost-effective deconstruction method between the two procedures.

Fort Carson, Colorado

Fort Carson initiated an installation sustainability program in 2002 with the goal of adopting practices that support long-term sustainability for their region. One of the program goals was to reduce the waste leaving Fort Carson to zero by the year 2027 and thereafter (Fort Carson 2013). Subsequently, Fort Carson became a pilot installation under the Assistant Secretary of the Army for Installations, Energy, and Environment [ASA(IE&E)] Net Zero Waste program.[5]

In June 2004, The Fort Carson Directorate of Environmental Compliance and Management (DECAM) in conjunction with the Directorate of Public Works (DPW), performed a pilot deconstruction study on two buildings scheduled for removal. At the time, construction and demolition debris made up about 60-70% of the solid waste stream leaving Fort Carson.

The purpose of the deconstruction project was to analyze data collected on the labor strategies, harvest rates, potential market value of materials harvested, and volume of materials diverted from landfill. This information is important because it can be used on future projects to determine the cost effectiveness of certain types of deconstruction methods and the feasibility of certain techniques.

Building Types and Quantities

Building 6286 and Building 227 were selected for deconstruction primarily because of their distinct building types, each of which required different deconstruction approaches and techniques.

Building 6286 (Figure B-8) was a 13,128 sq ft, single-story, World War II-era structure. It had a concrete masonry unit (CMU) exterior with 2x4 wood interior partition walls. It had wood rafters and “skip-sheet”[6] roofing. The roof sheeting was 1x10 and 1x12 butt-jointed boards with as many as five layers of asphalt roofing (generally three layers of shingles). The roof structure was supported by bolted and web trusses. The exterior of the building consisted of 2x2x10 nailers pinned to the CMU exterior wall. The building had been used in urban warfare training exercises. The building had some flooring comprised of a single

[5] http://army-energy.hqda.pentagon.mil/netzero/default.asp

[6] Skip-sheet roofing means 1x4 boards covering the rafters or roof trusses, with a space between them.

layer of 2.25-in. tongue-and-groove fir. The floor was supported on 2x12 floor joists, beams, and poured-concrete posts.

Building 227 (Figure B-9) was one of six WWII-era warehouse buildings located near the Fort Carson rail yard. The building dimensions were approximately 70 x 130 ft (9,100 sq ft). It was a single-story structure of wood construction with few interior partition walls, and it had wood rafters and skip-sheet roofing covered with four layers of asphalt shingle and rolled roofing material. Brick firewalls separated various building sections. The wood-framed building design of this warehouse was well suited for deconstruction.

Figure B-8. Building 6286 at Fort Carson, showing CMU exterior shortly before deconstruction (Innovar 2005).

Figure B-9. Building 227, a WWII-era warehouse at Fort Carson in 2005 with mostly wood exterior (Tom Napier, ERDC-CERL).

Cost Information/Contracting Arrangements

Fort Carson contracted with Innovar Environmental, Inc. of Denver, Colorado, to manage the deconstruction feasibility assessment and demolition, with Engineering-Environmental Management, Inc. (E2M) of Englewood, Colorado, assisting with the deconstruction effort. E2M subcontracted with Second Chance Deconstruction of Fountain, Colorado, to provide the deconstruction expertise and labor needed to make the project a success. (Note: details of this project are taken from Innovar Environmental 2005).

Fort Carson reported project budgets of $81,158 for Building 6286 and $52,646 for Building 227. Building 6286 final project costs for deconstruction and follow-up demolition were $89,278, which exceeded the original budget by $8,120.

Deconstruction Process at Building 6286

In Building 6286, much of the harvestable product was damaged (e.g., windows, interior doors, and lights), so most of the deconstruction effort focused on the available higher-yield items (i.e., not damaged and more available). Overall, budget and time constraints allowed for only 8,000 sq ft of deconstruction. The remaining 5,128 sq ft was removed by mechanical demolition practices.

One of the harvestable products was the roof sheeting. Relief cuts made by using a circular saw were made from peak to soffit every 16 ft. The reach forklift was used to peel off sections of the roof (Figure B-10). This method was used to preserve the rafter boards. Roof trusses were lowered using the reach forklift so that they could be disassembled after reaching the relative safety of the ground. The 2x6x20 ceiling joists on the north wing were harvested after the exterior walls were removed, and the ceiling was allowed to fall to the decking. On the east wing, however, ceiling joists were only removed after rafter boards were pulled and interior ceiling drywall was loosened and dropped to the floor. In this wing, there was an increase in the debris and labor required to harvest the joists because they were located in an attic space that was finished with drywall. In addition, all the 2x6x20 joists in this wing were notched and, thus, their market value for reuse was significantly reduced.

Fort Carson reported that several hours of labor and effort were expended to access the cinder blocks that were sought for recycling. This work required removal of the lathe and plaster from the inside of the exterior walls. A reach forklift was used to push the interior finish away from the cinder blocks, an action which produced cleaner cinder-block debris.

Wood flooring, concrete pillars, and footers (Figure B-11) were sought for reuse or recycling. In addition, the 2x12 floor joists under the plywood subflooring were removed by hand and denailed either for reuse or recycling. Most of the floor joists in the north and south wings were exposed to extreme heat from the steam pipes located beneath the building. This exposure resulted in dry rot and a subflooring that could only be recycled rather than reused or resold. When the flooring was removed, an excavator retrieved concrete pillars and foundation for recycling. Foundation floor joists were stockpiled.

Figure B-10. Reach forklift removing a roof section of Building 6286 (Innovar 2005).

Figure B-11. Floor joist and concrete piers exposed during deconstruction of Building 6288 (Innovar 2005).

Deconstruction Process at Building 227

Lumber and plate steel from the deconstruction of Building 227 offered the most potential for reuse or resale. The building was easily accessible from both the inside and outside. The deconstruction approach was from the top down. Shingles, roof decking, rafters, blown-in insulation, siding, framing, and flooring were removed in sequence.

In 5½ weeks, 10,000 sq ft of the structure was deconstructed. Only wood pilings, concrete stairways, and a small portion of wood structure (approx. 450 sq ft) was left for a demolition crew. The remainder of the site was graded and compacted within 1 week after deconstruction.

The roof sheeting was 1x10 and 1x12 butt-jointed boards. The roof had up to five layers of asphalt shingles which were removed by hand labor using mostly claw hammers and flat bars. The roof structure was supported by 8x8 built-up columns extending from the floor joists through the flooring and up to the rafters, spaced 12 ft on center (Figure B-12). Columns were bolted or bracketed to the bottom of the rafters. The interior surface of the roof was sheathed with 3/8-in. fiberboard. Blown-in cellulose insulation that was sandwiched between the fiberboard and roof sheeting was removed using a vacuum truck.

Figure B-12. Interior view of columns and roof structure in Building 227 at Fort Carson (Innovar 2005).

Building 227 had approximately 1,500 sq ft of finished interior partition walls (2x4x10 studs with vinyl-covered sheetrock), a suspended ceiling grid, and fluorescent troffers on the south end. The remainder of the building was open and had four loading dock areas with roll-up doors, one of which had a concrete ramp and docking area.

The fluorescent lights and most of the ceiling tiles were removed and salvaged. The interior studs were not salvaged, because the potential salvage value was not worth the effort. Instead, the interior studs were knocked down by a skid steer and recycled as mulch. The 8x8 wood columns were salvaged and removed using a technique in which each column was pulled free by metal chains attached to the skid-steer loader.

A portion of Building 227's exterior was covered with vinyl siding. The building also had a lead-painted exterior portion made up of 2x6x10 studs and 1x8 lap siding. The interior surface of the exterior walls was made of 1x6 tongue-and-groove wood flooring painted with LBP. The exterior walls were removed using the reach forklift (Figure B-13) and dropped inside the building to keep them within the building footprint for later disassembly.

Figure B-13. Reach forklift removing exterior walls of Building 227 at Fort Carson (Innovar 2005).

The vinyl and lap siding on the exterior was removed using claw hammers and flat bars. Fort Carson reported that the presence of LBP on the siding did not negatively impact the siding removal process. Three members of the workforce were outfitted with lead air-monitoring cassettes for lead exposure. None of the individuals exceeded Occupational Safety and Health Administration (OSHA) action levels. However, precautionary measures were taken to adequately wet the walls prior to removal to keep down lead dust.

The flooring in Building 227 was double-layer 2x6 wood. The aisles were covered in 1/4-in. diamond plate sheet steel. Each steel sheet measured 4 x 8 ft and weighed 365 lb. The plates were bolted through both layers of the floor. The plate steel was removed by grinding the bolt heads; in this way, a total of 45 sheets were recovered for resale.

The first layer of flooring was surface-nailed into the floor joists on square with the joists. The flooring was supported by 2x12 floor joists, built-up beams, and utility poles for posts. A chain saw cut through the first layer of this flooring. The loosened flooring was removed and stockpiled for resale. Floor joists were removed with hand labor using the chain saw and claw hammers.

The second layer of flooring was toe-nailed into the first layer on-diagonal. Steel wedges were used to loosen this second layer. Sledgehammers, first thought to facilitate deconstruction, were initially used to pound the wedges into the flooring, but this method proved slower and less efficient than the skid-steer equipment that could push the wedges into the flooring (Figure B-14).

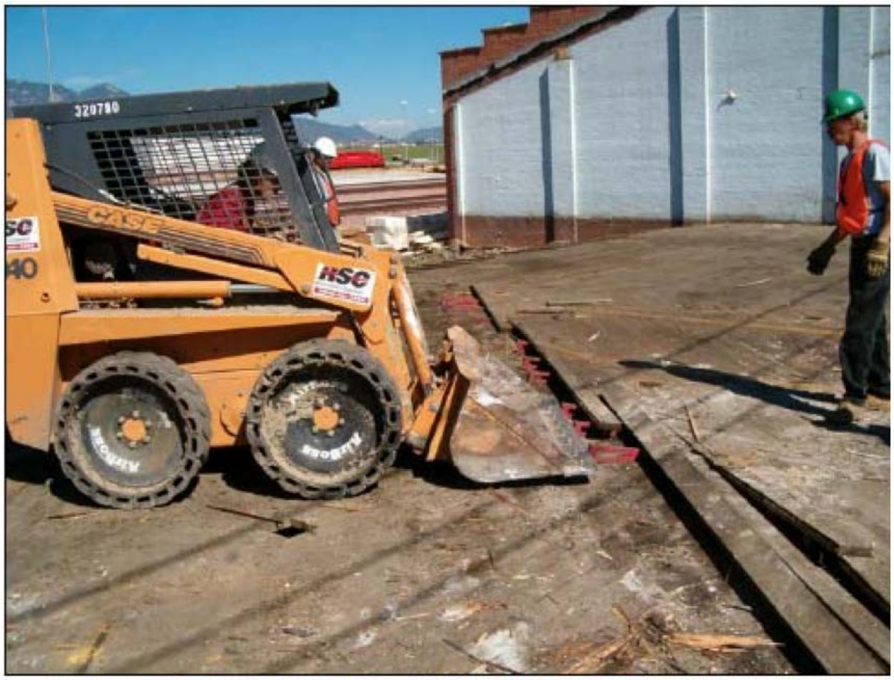

Figure B-14. Removing flooring with skid-steer loader at Building 227 (Innovar 2005).

Salvaged Materials from Deconstruction of Building 6286

Most of the reusable material salvaged for resale was lumber (approximately 18,000 linear feet); this material was bundled for reuse and sale (Figure B-15). Table B-1 summarizes the deconstruction and demolition data for Building 6286.

Figure B-15. Harvested wood, bundled for sale at Fort Carson (Innovar 2005).

Table B-1 Deconstruction and demolition data for Building 6286 at Fort Carson (Innovar 2005, p 14).

Parameter	Deconstructed Section Data	Demolished Section Data
Area	8,000 ft^2	5,128 ft^2
Time required	4 weeks	3 weeks
Labor-hours	897	55
Debris sent to landfill	684 yd^3	756 yd^3
Lumber harvested	18,000 ft	0
Materials salvaged for reuse (lumber, ceiling tiles, windows, fixtures, etc.)	37 tons	0
Clean wood diverted from landfill, including mulch	11.9 tons	0
Roofing material salvaged for study purposed, not marketed	9.8 tons	0

Parameter	Deconstructed Section Data	Demolished Section Data
Ferrous metals diverted	7.9 tons	0
Copper diverted	550 lb	0
Aluminum diverted	1,280 lb	0

The estimated resale value for the used material from Building 6286 was $9,500. Material handling and management costs were not included in this estimate. For Building 227, the used material sales were expected to bring in approximately $10,718. But, because Building 227 was deconstructed for $2,143 below budget, Innovar projected that total revenues realized could be as much as $12,681. Again, this analysis does not include material management costs.

Fort Carson reported that Buildings 227 and 6286 diverted 67.3 tons and approximately 57.7 tons of material from landfill deposition, respectively.

Salvaged Materials from Deconstruction of Building 227

Approximately 80% of all roofing nails in Building 227 were removed during tear-off, minimizing the number of nails that fell to the ground. Although the boards were brittle, care was taken when removing nails which allowed for approximately 75% of the boards to be recovered for resale. The remaining boards were separated for recycling. Fort Carson also reported that several 2x8 rafters were harvested.

Building 227 was almost completely deconstructed. Over 28,618 linear feet of lumber was harvested; thus, almost 58 tons of waste was diverted from landfill, and only six 40-yd^3 dumpsters went to the landfill from this large warehouse project. Table B-2 summarizes the deconstruction data for Building 227.

Table B-2. Deconstruction data from Building 227 at Fort Carson (Innovar 2005, 31).

Parameter	Quantity
Area	10,000 ft^2
Time required	5.5 weeks
Labor-hours	1,012

Parameter	Quantity
Debris sent to landfill	240 yd^3
Lumber harvested	28,618 ft
Materials salvaged for reuse (lumber, ceiling tiles, windows, fixtures, etc.)	58 ton
Clean wood diverted from landfill, including mulch	6.6 ton
Roofing material salvaged for study purposed, not marketed	12.6 ton
Ferrous metals diverted	2.6 ton
Copper diverted	125 lb
Aluminum diverted	0 lb

Problems with Deconstruction of Building 6286

Exterior cinder-block walls and glass block were sought as recyclable products (Figure B-16). Fort Carson had hoped to recycle the cinder-block walls for use as aggregate on its combat roads and trails and to resell the glass. However, the accumulated cinder block had to be disposed of as rubble because the Army Reserve Engineer Unit’s rock crusher was unavailable at the time, and the material could not be accumulated on site. Nevertheless, Fort Carson felt that if the block had been recycled as originally planned, it would have made a significant impact on future removal techniques employed for buildings similar to those of Building 6286.

Building 6286 was being prepared for demolition when Fort Carson decided instead on deconstruction. This quick shift in approach impeded effective preplanning and brought about obstacles that would otherwise have been avoided. For example, Building 6286 had numerous leaking high-temperature water (HTW) pipes under the building (below grade) that had remained in use during the deconstruction project because the pipes distributed heat to several other buildings and could not be shut off. Furthermore, the pipes impeded flooring removal because they were still attached to the floor joist hangers; to remove them required a 2-day work order before the installation’s Operations and Maintenance contractor would perform the work. Finally, the HTW pipe steam leaks generated so much heat that it baked the floor joists, precluding a good harvest of usable boards.

The building materials and construction style of Building 6286 posed another challenge. One wing of the building contained an attic that had been constructed with sheetrock walls. But, because the Colorado Springs area did not offer gypsum recycling opportunities, the sheetrock and roofing materials had to be disposed of as waste. This resulted in additional labor costs and debris generation.

Structural challenges surfaced at Building 6286 when ceiling joists proved to have steel tube cross-bracing as lateral supports. In addition, each 2x6x20 beam was notched, which significantly reduced its reuse value because the beam was weakened by the notch and only portions could be reused.

Figure B-16. Cinder block intended for recycling from Building 6286, but instead disposed as rubble due to unavailability of rock crusher (Innovar 2005).

Problems at Building 227

Roofing and flooring removal required considerably more effort than anticipated, mainly because equipment troubles caused minor delays and added costs to the project. Also, the manual removal of five layers of roofing required a significant effort, as it was nailed very securely. In turn, that fact complicated the shingle and sheeting removal and the denailing process. However, the roof sheeting was of sufficient quality and quantity to warrant the additional work.

The flooring in the warehouse was a challenge as well. It was constructed of double-layer 2x6 decking, and the bolts holding it in place had to be ground down with a hand grinder. Thus removing the floor without damaging it required a significant effort. The top layer of flooring, however, proved easier to remove because it was toe-nailed in contrast to the bottom layer which was face-nailed to the floor joists.

In addition, there were several problems that arose with the skid-steer loader. For instance, the tires were punctured by nails and other sharp objects during the first 1.5 weeks of deconstruction; solid-core tires were later purchased to avoid the problem.

Lessons Learned

The results of the Fort Carson pilot demonstration showed that certain building types are better suited for deconstruction than others. For example, Building 227 deconstruction proved more cost effective by yielding a significant amount of reusable materials, while Building 6286 had characteristics that made it of limited value for deconstruction.

The deconstruction plan for Building 227 was well designed and project execution was smooth. Electricity, water, and telephone services were available for most of the project which allowed for good communication between deconstruction crew and easy access to utilities when necessary for machine use. The right equipment was available and selected correctly – both elements that proved critical to job success; thus, nearly every phase of the deconstruction work used some mechanical equipment that replaced labor costs and improved efficiencies.

The deconstruction techniques used on Building 227 also proved judicious, resulting in the removal of approximately 80% of the roofing nails during tear-off with minimal denailing needed on the ground. Because of the care taken in removing nails from brittle roofing boards, it also was possible to harvest 75% for resale.

Results from the Fort Carson demonstration project proved positive overall and indicated that deconstruction should be considered for each future building removal or renovation at Fort Carson. Building deconstruction has proven to be an effective means to minimize waste and reuse and/or recycle materials. While deconstruction is an obvious choice for wood building removal, a concrete masonry building also has deconstruction potential. The deconstructed concrete from CMU block building exteriors can be used as aggregate on installation combat training roads and trails when a rock crusher is available.

In this case, however, the project revealed that Building 6286 was better suited only for limited deconstruction such as salvaging fixtures and some roofing and flooring materials. The building was not suited for a full deconstruction due to the unavailability of local rock crushing facilities to recycle concrete and the intense labor required to remove the wood furring strips and building material contaminants.

It was expected that a greater number of building material markets would open locally as deconstruction practices became more common. In addition, Fort Carson also expected that contractors working on deconstruction projects would become more efficient and cost effective. In hindsight, the Army has been largely unable to affect the local markets.

Twin Cities Army Ammunition Plant, Minnesota

The Twin Cities Army Ammunition Plant (TCAAP) in Ramsey County, Minnesota, was declared “excess” by the Army in 2002. Several buildings were removed as part of the decommissioning process, including some large timber-frame warehouses. Because the government project managers recognized a valuable resource in the old timber,[7] they established a contracting system that would encourage recycling of the deconstructed building timber (Culpepper 1996, 36).[8]

The first warehouse dismantled had a floor area of 377,000 sq ft. Project managers estimated that it contained 1,250,000 board-feet of timber, and about two-thirds of it was able to be recycled.

At another TCAAP warehouse with a floor area of 548,000 sq ft, they were able to recover about 80% of the timber for recycling. The deconstruction of this building reduced the landfill disposal area by 3,850 yd^3 for a tipping fees savings of about $46,000. Due to the high value of the salvaged timber and avoided disposal cost, deconstruction saved a total of $250,000 over what it would have cost for "smash and trash" landfilling. The key to the success of this project was that the government project managers awarded multiple contracts, thereby contracting with specialized contractors for the portions of work to which

[7] Architecturally speaking, "timber" means wood members of a large thickness, typically greater than 3 in. (e.g., a timber timber-frame house). "Lumber" means dimensional lumber of approximately 1-in. or 2-in. thickness (e.g., 2"x4"). The case study described here was the dismantling of a timber timber-frame warehouse. They were not removing "lumber" from the structure, but rather large timbers which have a high salvage value.

[8] Information in this section comes from either Culpepper 1996 or personal conversation between author Steve Cosper with Culpepper.

they were best suited. Roofing removal and asbestos-containing material (ACM) removal were handled separately. Then, a timber salvage company specializing in dismantling timber buildings was contracted to maximize timber recovery.

Figure B-17 and Figure B-18 show two of the buildings at TCAAP being deconstructed.

Figure B-17. Timber salvage at TCAAP in 1995 (TCAAP).

Figure B-18. Timber salvage at TCAAP in 1995 (TCAAP).

APPENDIX C: SUMMARY OF LESSONS LEARNED

Key Points for a Successful Deconstruction Program

1. *Command support* is necessary including sign-off from the highest level of command such as the Garrison Commander.

2. *Participation by multiple building-related elements* is needed including master planning, legal, safety, real property, environmental, and public works. For example, the need to identify and potentially remove environmental hazards exists whether the building disposal method is deconstruction or conventional demolition; in either case, building preparation must take place to identify and remove contaminants such as LBP, asbestos, or PCBs.

3. *Project duration* must be understood by all participants involved in a deconstruction project — building deconstruction may require more time than mechanical demolition. It is important that the contract include a specific schedule for completion of the deconstruction project.

4. *Using a nontraditional workforce* such as Habitat for Humanity for building removal should be considered, especially for taking reusable items from residential-scale buildings. Many Habitat affiliates operate a “Re-Store” for secondhand construction materials which can come through deconstruction projects.

5. *Installation utility information* (such as maps and locations of underground electrical, water, and gas lines) needs to be complete and on-hand before deconstruction begins. To accurately locate utilities, a dig permit usually has to be requested ahead of time. In one case, a nonprofit deconstruction contractor (and its subcontractors) broke a water pipe during final demolition because they did not have the necessary utility information. The contractor spent valuable man-hours trying to track down the information but found that no single installation office could provide the information needed.

6. *Limit material going to landfill* during deconstruction by identifying items and quantities that local recycling services and markets can take, especially during large deconstruction projects involving several buildings. Additionally, the installation should determine beforehand

how local recycling markets define certain categories of recyclables (e.g., what constitutes “clean wood scrap”).

7. *Uncertainty about what to do with unexpected materials* can lead to extra handling; in turn, extra handling or uncertainty can lead to materials not being salvaged. During one deconstruction project, ceiling insulation which was not protected from weather was lost to water damage. Identifying all materials present, planning for their salvage or disposal, and then protecting them to preserve that value should prevent this type of poor productivity.

Technical Issues for a Successful Deconstruction Project

Based on its experience deconstructing six wood-frame houses in Gainesville, Florida, the PCCE at the University of Florida put together a list of technical issues relevant to the success of the deconstruction process for wood buildings. These technical issues are summarized below (Guy 2006).

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

2. Clearing a work site around a building is critical, particularly so that location of roll-offs (dumpsters) and the movement and stacking of materials is not impeded.

3. Timely removal of full roll-offs and the drop-off of empty ones is necessary for efficient removal of materials – both wastes and salvaged items. Also, it is necessary to place roll-offs near where the deconstruction is occurring. For example, one roll-off may be placed next to the structure to capture asphalt roofing shingles, while the next roll-off could be placed in a different location that is most efficient for the removal of exterior siding.

4. Removing reusable, recyclable, and disposable materials in a timely manner is critical to the safety of the job site and to the efficiency of both deconstruction and processing activities.

5. Although many nails may not be readily accessible to a prying device, in all cases salvageable materials should be removed by levering, unscrewing, or unbolting and not by sledgehammer or other smashing tool.

6. Arranging on-site removal of materials as they are processed is important in order to minimize the effort invested in loading, transporting, and storing materials in other locations, and at the same time, ensuring that materials are not stolen from the site.

7. Good deconstruction sites require sufficient room to work including areas located away from the deconstruction for denailing and stacking, and a space for roll-off deliveries and pick-ups that also is highly visible to potential customers for the salvaged materials.

8. It is critical to coordinate workers’ efforts when salvaging materials. It is also critical to strike a balance with workers between project efficiency versus inflicting minimal damage to salvageable material.

APPENDIX D: REFERENCES AND RESOURCES

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PWTB 200-1-128. 2014 (in progress). *Update of Market Value for Demolition Salvage Materials*. Washington, DC: Headquarters, US Army Corps of Engineers.

PWTB 200-1-146. 2014 (in progress).

[9] All PWTBs are available on the Whole Building Design Guide website: http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215.

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APPENDIX E: ABBREVIATIONS

Term	Spelled-out meaning
AR	Army Regulation
ASA(IE&E)	Assistant Secretary of the Army for Installations, Energy, and Environment
BRAC	base realignment and closure
C&D	construction and demolition
CECW	Directorate of Civil Works, United States Army Corps of Engineers
CEERD-CN-E	Environmental Process branch at ERDC-CERL
CEMP	Directorate of Military Programs, U. S. Army Corps of Engineers
CEP	Corps of Engineers Environmental Support Branch
CERL	Construction Engineering Research Laboratory
CMU	concrete masonry unit
CONUS	Continental United States
DECAM	Directorate of Environmental Compliance and Management
DPW	Directorate of Public Works
DoD	Department of Defense
E2M	Engineering-Environmental Management, Inc.
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
HfH	Habitat for Humanity
HQUSACE	Headquarters, United States Army Corps of Engineers
HTW	high-temperature water

Term	Spelled-out meaning
LBP	lead-based paint
OSHA	Occupational Safety and Health Administration
POC	point of contact
PCCE	Powell Center for Construction and Environment
PWTB	Public Works Technical Bulletin
RCI	Residential Communities Initiative
SSPP	Strategic Sustainability and Performance Plan
SWAR	Solid Waste Annual Reporting
TCAAP	Twin Cities Army Ammunition Plant
UFGS	United Facilities Guide Specification
USACE	United States Army Corps of Engineers
WWII	World War II