NDCEE

National Defense Center for Environmental Excellence

DoD Executive Agent
Office of the Assistant Secretary of the Army (Installations and Environment)

Conversion of Wood Debris into Alternative Construction Materials

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Presentation Overview

- Background
- Technology Concept
- Process Description
- Preliminary Feasibility Study
- Additional Resources

U.S. Army Construction and Demolition (C&D) Waste

Estimated 27 million ft^2 of surplus wood-framed buildings; $350 million to demolish

Around 20 million tons of building related debris projected over 15 years

Goal to divert minimum 50% by weight of debris from landfills

Army Wood Debris- Potential Quantities

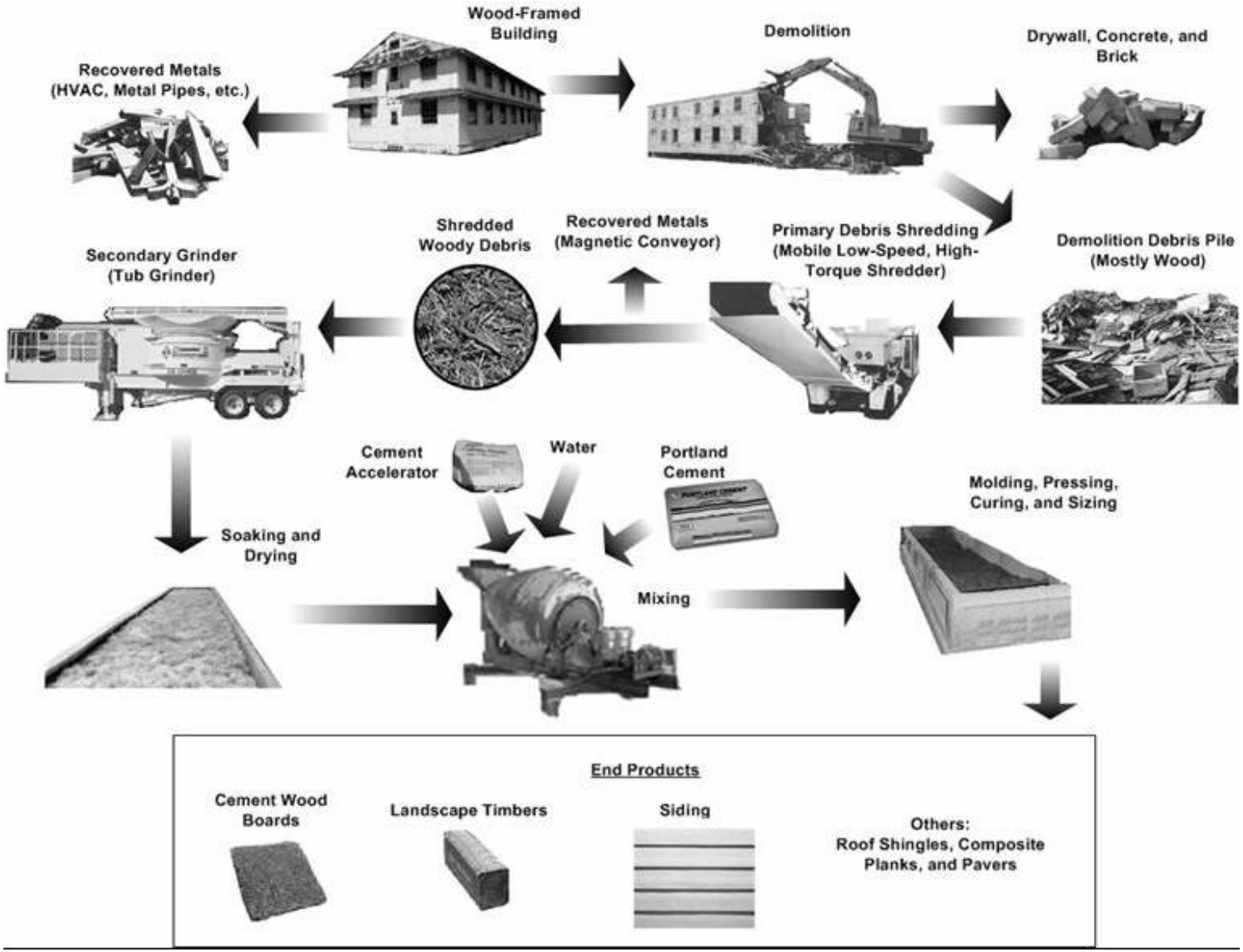
- WWII-era 2-story wood barrack:
  - 30,000 board feet (50,000 linear feet) of total wood materials
- Estimated 250 million board feet of wood available in Army WW-II building inventory slated for removal
- *Army-Wide Survey Numbers*

Data Sources:

1. Draft ESCTP Demonstration Plan: Reclamation of Wood Materials Coated with LBP, ERDC-CERL, 2004.
2. Alternatives To Demotion: Opportunities to Reduce Solid Waste through Deconstruction, Reuse, & Recycling of Building Materials, ERDC-CERL Presentation, 2002.
3. Alternatives to Demolition: Opportunities to Deconstruct, Reuse, & Recycle Materials from Army Building, DoD Deconstruction Training SWANA ERDC-CERL, 2003.
4. Falk, R., Janowiak J., Beakler, B., Lampo, R., and Napier, T., "Remilling of Salvaged Wood Siding Coated with Lead-Based Paint, Part II. Wood Product Yield," Forests Products Journal, Vol 55, No. 7/8, July/August 2005, pp. 81-86

CEHNC Concept:

- Rapid removal of Army wood buildings with a means to divert large volumes of C&D debris materials
- NDCEE was tasked to:
  - Define technology concept
  - Conduct preliminary feasibility study


Wood-Framed Building
Demolition
Drywall, Concrete, and Brick
Recovered Metals (HVAC, Metal Pipes, etc.)
Shredded Woody Debris
Recovered Metals (Magnetic Conveyor)
Primary Debris Shredding (Mobile Low-Speed, High-Torque Shredder)
Demolition Debris Pile (Mostly Wood)
Secondary Grinder (Tub Grinder)
Cement Accelerator
Water
Portland Cement
Molding, Pressing, Curing, and Sizing
Soaking and Drying
Mixing
End Products
Cement Wood Boards
Landscape Timbers
Siding
Others: Roof Shingles, Composite Planks, and Pavers

Typical Material Composition of 2-Story WWII-Era Wood-Framed Army Barrack

Materials	Total Quantities		Composition
	(tons) [1]	(lbs)	By Weight
Asphalt Shingles	3	6,000	3%
Brick	9	18,000	8%
Concrete	22	44,000	20%
Drywall	20	40,000	18%
Metals	2	4,000	2%
Miscellaneous[2]	1	2,000	1%
Plastics	1	2,000	1%
Wood	52	103,000	47%
Total	**110**	**219,000**	**100%**

Feedstock: Woody Demolition Debris

Process Input Composition Following Demolition and Material Segregation

Materials	Material Input Quantities Per Demolished Barrack (lbs)	Weight Composition
Asphalt	6,000	4%
Brick	*	--
Concrete	*	--
Drywall	40,000	26%
Metal	800	0.5%
Miscellaneous	2,000	1%
Plastic	2,000	1%
Wood	103,000	67%
Total	**153,800**	**100%**

* Normally recycled for reuse.

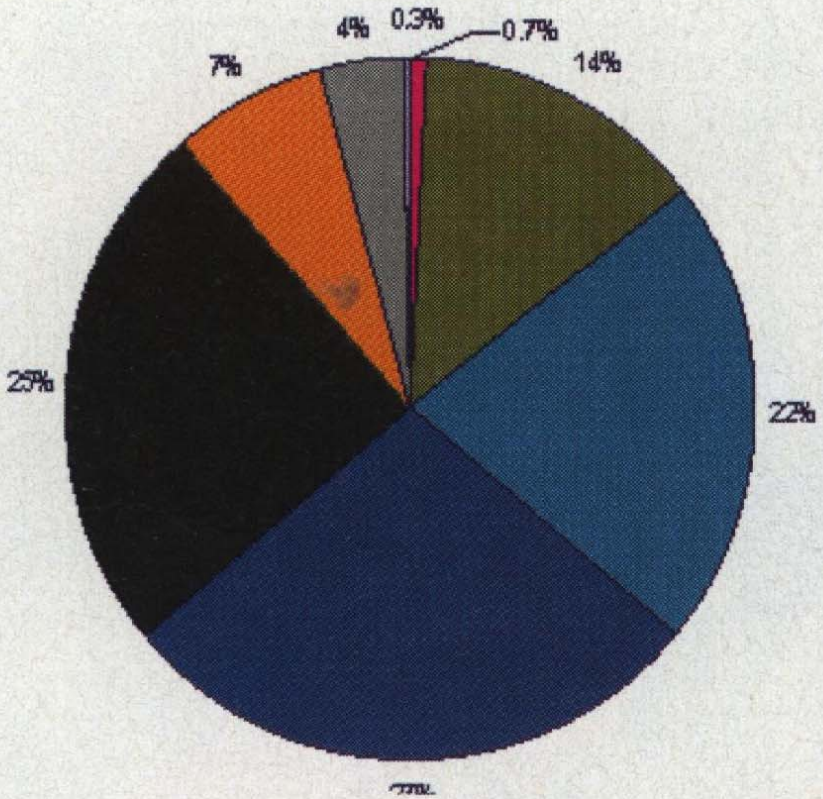
Demolition

Mobile Low Speed High Torque Grinder

Tub Grinder

Feedstock: Wood Debris from Disaster Areas

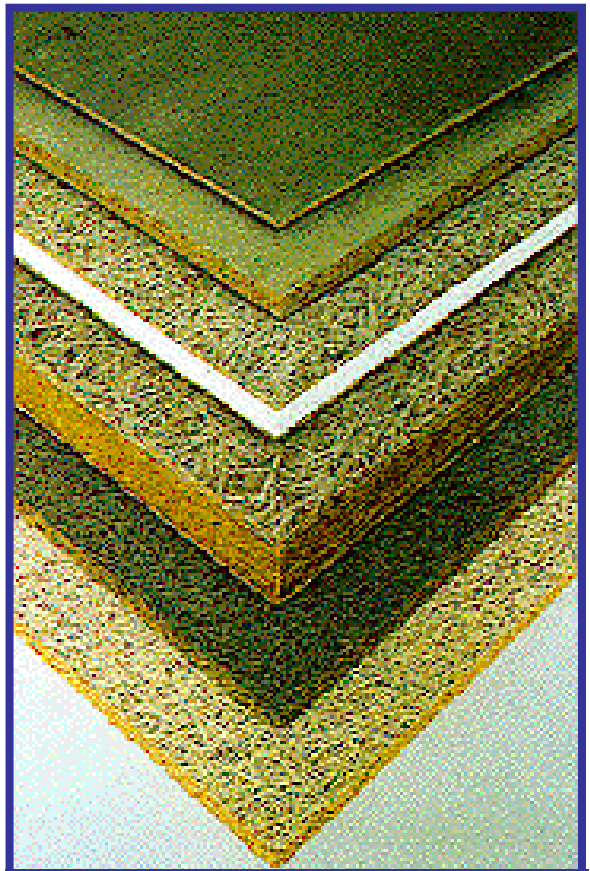
Figure 1. Markets for Hurricane-Generated Mulch (2004)*



Source:
Burgeil, J., McLendon, C., "Green Sweep: Florida Communities Reel From Hurricanes, Learn Valuable Lessons, MSW Management, Sep/Oct 2005.

Alternative Market

- **End Product: Cement-Bonded Wood Composite**
  - Alternative concrete products made by combining Portland cement with wood particles in place of conventional aggregate
  - Properties
    - Lighter than conventional concrete
    - High insulating value
    - Resistant to frost, rot, water, fire, and termites
    - Good sound absorption
  - Produced using rudimentary tools and unskilled labor



Wood Wool Cement Boards

- **End Product: Cement-Bonded Wood (Cont'd)**
  - Wide range of external and internal uses, including as substitutes to:
    - Plywood
    - Drywall
    - Non-structural applications such as siding and sheathing
  - Easily molded into a variety of common construction forms
    - Planks, blocks, lumber
    - More complex shapes may require the use of an extruder

Houses Made With Cement Wood

Properties of Cement-Bonded Wood Composite Boards

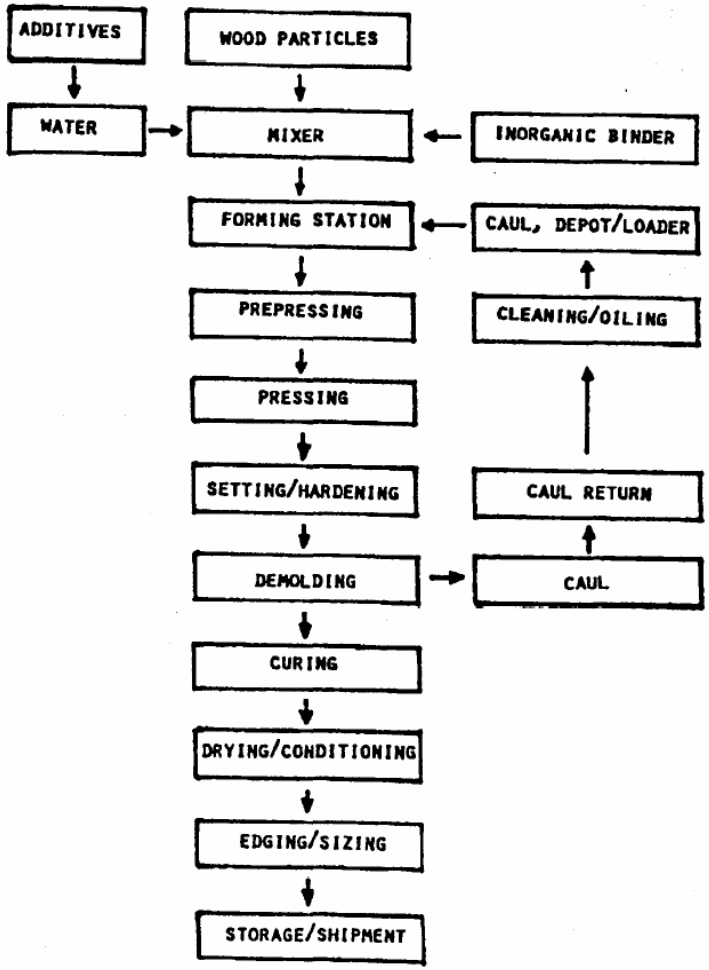
Density:	450 kg/m^3 (medium density) to 750 kg/m^3 (high density)
Acoustic Insulation:	Sound reduction of 10 mm thick board = 31 dB
	Sound reduction of 20 mm thick board= 33 dB
Fire Resistance:	5 cm thick board = 1 hour of resistance
	10 cm thick board = 2 hours of resistance
Thermal Resistance:	Thermal conductivity (k value)=0.35 W/m.K;Linear thermal expansion=0.01 W/m.K
Water Resistance:	Thickness swelling:
	<1.0% after 2 hours of soaking
	<1.5% after 24 hours of soaking
	<2.0% after >24 hours of soaking
Bending Strength:	10–15 N per cubic mm
Load Capacity:	Design Load = 50 psf, Ultimate Load = 200 psf
Compressive Strength:	15 N per cubic mm
Modulus of Elasticity:	4500 Nm

Source: http://sres.anu.edu.au/associated/fpt/cfb/properties.html#org, December 2005.

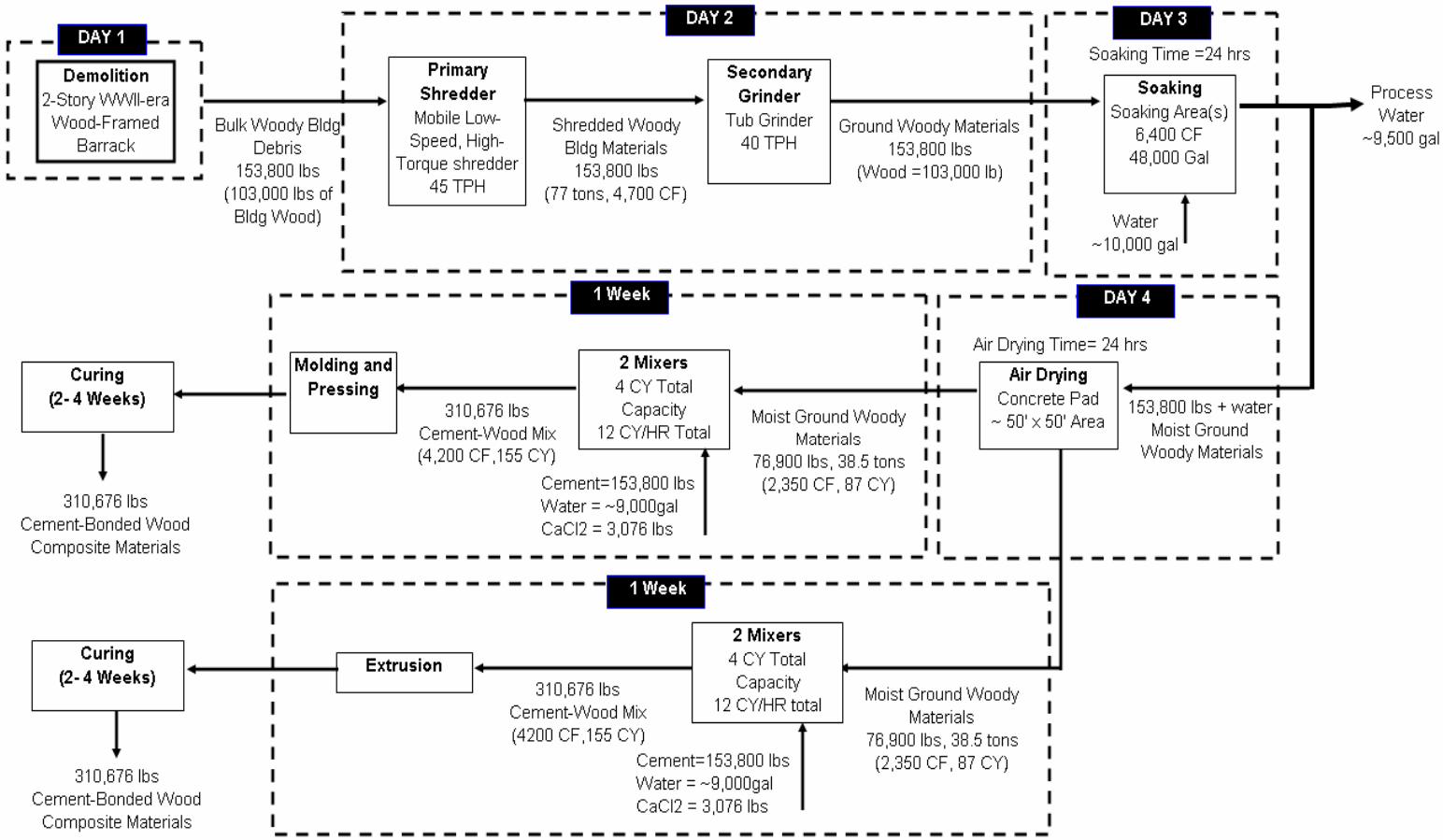
Manufacturing of Cement-Bonded Wood Composites

Molding

Stacking and Storage



Process Time for Cement-Bonded Wood Manufacturing



Commercially Available Cement Wood Products

Wall Boards

Wood Siding

Insulated Concrete Forms

On-Site Applications

Storage Sheds and Emergency Shelters

Housing

Preliminary Economic Analysis

	Cost	Unit	Description
Initial Investment	**$2 million**	Lump Sum	Equipment Costs
Processing Cost	**$66,000**	Per Barrack	Demolition, Utilities, Labor, Materials, and Equipment Operation Costs •Demolition cost of $4 /sq ft ($35/ton landfill fee) •Processing cost rate of $12.70/sq ft
Cost Saving	**$70,000**	Per Barrack	End product value & landfilling cost avoidance Assumes all wood cement board produced (~4000 per barrack) replaces base use of plywood (~$15 each)
Cost Benefit	**$4,000**	Per Barrack	

Caveats

- **Wood feedstock commingled with non-wood (C&D) materials**
  - **Producibility**
  - **Quality**
  - **Properties**
- **Hazardous materials – lead-based paint, asbestos, etc.**
- **Process (soaking) water contaminants**
- **Regulatory requirements and permits**

Further Development

- Proof of Concept Testing
- Material Testing
- Process Refinement
- Regulatory Permitting Survey
- End Product Market Survey
- Additional Cost Analysis

Resources on Cement-Bonded Wood Composites

- **Articles and Studies**
  - **"Cement and Wood-Wool Combine to Improve Philippine Housing," http://www.aciar.gov.au/web.nsf/att/ACIA-5KE7UT/$file/Cement__wood-wooPart14.pdf**
  - **"Wastes Into Wood: Composites Are a Promising," http://www.ehponline.org/docs/1994/102-2/innovations.html**
  - **"Durability and Strength of Cement Bonded Wood Particle Composites Made from Construction Waste," http://www.fpl.fs.fed.us/documnts/pdf1999/wolfe99a.pdf**
  - **"Production, Properties, Applications Of Various Wood Cement Products," http://www.panelworldmag.com/vserver/hb/display.cfm?MagazineKey=6&IssueKey=453&SectionKey=389&ArticleKey=620**

Resources on Cement-Bonded Wood Composites

- **Organizations**
  - **Australian Centre for International Agriculture Research and Australian National University: http://www.aciar.gov.au/**
  - **Philippine Wood Cement Board Industry Website: http://sres.anu.edu.au/associated/fpt/nwfp/woodwool/woodwoolphil.html**
  - **USDA Forests Products Laboratories: http://www.fpl.fs.fed.us**

Questions & Comments

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