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RECYCLING EXTERIOR BUILDING FINISH MATERIALS

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Facilities Engineering
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RECYCLING EXTERIOR BUILDING FINISH MATERIALS

1. Purpose.

a. This Public Works Technical Bulletin (PWTB) transmits recycling and reuse options for exterior building finish materials (e.g., roofing and siding) used on Army structures.

b. All PWTBs are available electronically (in Adobe® Acrobat® portable document format [PDF]) through the World Wide Web (WWW) at the National Institute of Building Sciences' Whole Building Design Guide web page, which is accessible through URL: http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability. This PWTB applies to all U.S. Army facilities engineering activities.

3. References.

a. Army Regulation (AR) 200-1, *Environmental Protection and Enhancement*, 21 February 1997. AR 200-1, para. 5-10 contains policy for solid waste management, including participation in recycling programs and the sale of recyclables.

b. Other references and resources are listed in Appendix A beginning on page A-42.

4. Discussion.

a. The need for multiple roofs and roof replacement makes roofing one of the largest contributors of solid waste (Oak Ridge National Laboratory <http://www.ornl.gov>). Every year an estimated 9 to 10 million tons of asphalt roofing waste goes to U.S. landfills, costing more than $400 million in disposal fees. Recycling waste roofing materials can save not only money but also landfill space. Statistics show that 7 to 10 percent of U.S. landfill space has gone to roofing waste over the last 40 years (ADPSR 1998). Although no nationwide programs exist to recycle roofing or siding, the technologies to recover and process these materials for reuse are available.

b. AR 420-49, Chapter 3 discusses solid waste management in general terms. Construction projects on active troop installations generate enormous quantities of waste materials, as much as 80 percent of the total solid waste generated. While most of these materials are structural, an appreciable fraction is exterior finish materials, e.g., roofing and siding.

c. Appendix A to this PWTB describes recycling and reuse options for many different types of siding and roofing materials. Section 4 of this appendix discusses sustainable choices in new building products. Appendix B lists organizations that can provide further information about recycling exterior building finish materials.

d. Points of Contact. HQUSACE is the proponent for this document. The POC at HQUSACE is Malcolm E. McLeod, CEMP-II, 202-761-0632, or e-mail: malcolm.e.mcleod@usace.army.mil.

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APPENDIX A: RECYCLING EXTERIOR BUILDING FINISH MATERIALS

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1 INTRODUCTION

1.1 Waste Generation

Exterior finish materials such as roofing and siding are expected to protect Army buildings from the elements and must prevent rain and snow from penetrating the buildings and causing moisture damage. Exterior finishes are often removed and replaced when necessary to preserve the durability and structure of the building. Existing structures are also demolished. Through renovation or demolition, exterior finish materials are removed and require disposal.

The need for multiple roofs and roof replacement makes roofing one of the largest contributors of solid waste (Oak Ridge National Laboratory <http://www.ornl.gov>). Every year an estimated 9 to 10 million tons of asphalt roofing waste goes to U.S. landfills, costing more than $400 million in disposal fees. Recycling waste roofing materials can save not only money but also landfill space. Statistics show that 7 to 10 percent of U.S. landfill space has gone to roofing waste over the last 40 years (ADPSR 1998). Although no nationwide programs exist to recycle roofing or siding, the technologies to recover and process these materials for reuse are available.

1.2 Sustainable Choices in New Construction

Every building product we use, including wood, steel, aluminum, plastic, and concrete, comes from a natural resource. More durable materials such as 30-year shingles, metal, slate, or tile roofing can save resources and costs, especially when the costs of reinstallation are considered. Unlike interior wall treatments and floor coverings, which are subject to change based on fashion trends, siding in most cases is permanent. Selecting the right product, however, is not easy. Many options are available, and choosing wrong can be disappointing and costly. Durability is important and, although durable products can be more expensive initially, they offer many long-term benefits through avoided maintenance and replacement costs.

Across the country, national and local government agencies are promoting recycling on every level by establishing programs that give preference in specifications to recyclable building materials. Executive Order 13101, “Greening the Government Through Waste Recycling and Federal Acquisition,” directs

Federal agencies to use recycled content and environmentally preferable products (edcmag.com).

Choosing building products that reduce pollution, prevent waste, and reuse recycled materials significantly helps to reduce the impact that buildings have on the environment. By building structures that are energy and resource efficient, the world's supply of natural resources can be extended. Building "green" conserves renewable resources like trees, as well as nonrenewable minerals and petroleum. Additionally, it helps prevent waste by producing and applying products efficiently, and by diverting waste for recycling.

Waste reduction opportunities begin with the earliest choices made in the building process including design and material selection. By specifying more durable building products, maintenance and replacement costs associated with many conventional building materials can be avoided. This saves both time and money. Also, through careful ordering and application of materials, disposal costs can be reduced by preventing waste. In addition, recycling C&D waste and selling salvaged building materials not only prevents waste disposal costs but can actually provide income.

2 ROOFING

2.1 SUSTAINABLE CHOICES

Building codes often govern or limit roofing material choices. Roofing materials for roof replacement should be durable with few maintenance requirements. Look for manufacturers who use recovered material in their product or who process post-consumer roofing material into other products. There is a wide variety of roofing products such as tiles and panels that incorporate both manufacturing and post-consumer waste.

Waste generation should be reduced throughout the life cycle of a building - from design, through construction and final disposal (ORNL). Recyclability should not be the only concern when choosing a material for re-roofing. Energy efficiency should also be at the top of the list of roofing requirements. Environmentally correct alternatives are becoming prominent in the roofing industry. Table 1 describes common roofing types. These types are discussed in more detail in the following sections.

Table 1. Comparison of common roofing alternatives.

ROOFING MATERIAL	COST*	WARRANTY	MAINTENANCE REQUIREMENTS	COMMENTS
Asphalt shingles	$	20-25 years	None	Economical and easy to install and repair.
Architectural shingles (dimensional)	$$	25-50 years	None	Thicker textured shingles, best for reproofing over existing shingles. May be available with recycled content.
Cedar shakes (nontreated)	$$$	None	Clean and treat every 3-5 years	Poor fire rating. High maintenance.
Treated shakes	$$$	30-50 years	Regular cleaning	Relatively inexpensive upgrade for nontreated shakes.
Metal	$$$	20-50 years	None	Durable and corrosion resistant.
Clay and slate tile	$$$	50-100 years	Replacement of broken slate or tile	Heavy and may require roof reinforcement. Fireproof.
Built-Up Roofing	$	20-25 years	Resurface bare spots	The redundancy of plies provides effective protection against ultraviolet rays, adverse weather, and foot traffic.
*Dollar symbols refer to initial cost of purchase and installation of these roofing materials relative to other materials. No numerical dollar values are implied.				

2.2 ASPHALT SHINGLES

Asphalt shingle waste is abundant. Roof replacement can generate shingle waste at a rate of at least 2 to 5 pounds per square foot of roof area (NAHB 1998). For WWII-era buildings, the Army's typical practice has been to tear off old shingles before installing new roofing felt ("tar" paper) and shingles. The removal of the roof of a typical WWII wood Army barracks generates more than 7,000 pounds of waste during re-roofing (Figure 1).

For roof replacement, the old roof is torn off and replaced or covered over (up to three layers). Re-roofing produces much larger quantities of waste than the installation of a new asphalt shingle roof, and the waste typically contains small percentages of foreign materials such as nails, felt underlayment, metal flashings, wood, and waterproofing and insulation materials (Table 2).

Figure 1. Removal of asphalt shingles during deconstruction of a WWII Army barracks.

Table 2. Re-roofing waste stream (NAHB 1998).

MATERIAL	% BY WEIGHT
tear-off waste shingles	85-90
metal flashing/detailing	5-10
wood sheathing	<5
“tar” paper	<5
paper packaging	<1
nails	<1

The steep-slope roofing market is dominated by shingle roofing products, especially asphalt-based shingles. Asphalt shingles are made from three basic materials – asphalt, sand, and fiber (Table 3).

Table 3. Components of asphalt shingles (Newcomb 1993).

COMPONENT	APPROXIMATE AMOUNT BY WEIGHT
Asphalt cement	25-35%
Granular material (aggregate)	60-70%
Fiberglass or cellulose felt backing	5-15%

The exact composition of a particular shingle depends on the manufacturer and the roofing application, but the manufacturing process is similar in each instance.

2.2.1 Recycling

For years, disposal of old roofing was simple: load up all the debris into a truck, haul it to the nearest landfill site, and never think about it again (Ramsey 1992). The procedure was once cheap and simple, but no longer. Each year in the United States, more than $12 billion is spent on re-roofing including the costs for the tear-off, disposal, and new roofing materials. Nationwide, tear-off/replacement represents 67 percent of the residential and commercial markets combined; re-covering represents 33 percent.

With diminishing landfill space, more and more asphalt roofing waste is being recycled. Virtually the entire roof can be recycled, whether the project is re-roofing or demolition. A separate and identifiable waste material is generated (Figure 2). The asphalt shingles as well as the other roofing wastes such as wood sheathing, nails, metal flashing and gutters are all potentially recyclable.

While tear-off roofing shingle scrap can potentially be recycled, it is difficult to process because of contaminants and debris such as nails, wood, insulation, etc. Any debris must be removed prior to processing to prevent equipment damage during size reduction. A rotating magnet can remove metals while wood and other contaminants can be removed by hand or floated off in a water flotation unit.

Shingles are very abrasive and tough to grind. Water is often added during shredding to both keep the shingles cool and to limit dust. Tear-off roofing is easier to shred than manufacturing scrap because factory scrap tends to become plastic from the heat and mechanical action of the shredding process. Tear-off roofing hardens with age and is less likely to agglomerate during processing. If the shingles begin to stick together from the warm weather or from the heat of the equipment, spraying with water or blending with sand or gravel may help. Grinding the shingles may be easier in the winter when asphalt is more brittle.

Most processors will use simple equipment that has been modified. Crushers, hammer mills, and rotary shredders have been used with various success to process waste shingles. With the proper equipment design and operating personnel involved, some grinders can produce up to 80 tons of 3/8-inch minus shingles an hour. Typically, a good effort for an efficient operation is probably in the 40 to 50 tons per hour range.

Depending on the equipment used, primary grinding may yield 2-inch and smaller size pieces. Often the shingles are passed through the processing equipment twice for size reduction. Secondary grinding may be required to make smaller pieces, one-quarter inch plus, depending on the intended use. The shingles may also have to be screened after grinding to conform to grading requirements (Figure 3).

Figure 2. Tear-off shingle waste.

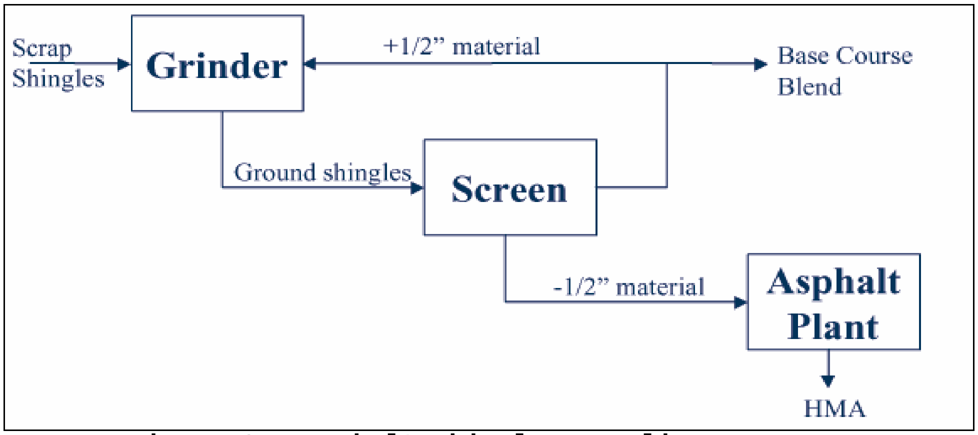

Figure 3. Asphalt shingle recycling process.

2.2.2 Markets

Asphalt roofing shingles have a high potential for recycling because they can be used in a variety of products, including:

- aggregate base
- asphalt pavement
- cold patch for potholes, sidewalks, utility cuts, driveways, ramps, bridges, and parking lots
- road and ground cover
- new roofing
- fuel oil.

2.2.2.1 Aggregate Base

Since asphalt roofing shingles are comprised of asphalt, sand, and fiber, it makes sense to use shingle waste in a related bituminous material. The largest shingle market is aggregate base for road construction. Shingles are not commonly used alone as base, but are processed and mixed with recycled asphalt pavement (RAP) and concrete by some recyclers to make a road base product. Course-ground shingles (2-1/2 inch minus) can be added to aggregate materials as part of the lower pavement layers—the sub-base or binder courses.

It is suspected that the addition of recycled asphalt shingles may improve the compaction of the sub-base. Testing by the California Department of Transportation (Caltrans) has shown that, when up to 10 percent recycled asphalt shingles were substituted for virgin aggregate in the blend, the mixture met Caltrans specifications for durability (CIWMB 1999). Allowing asphalt shingles in construction specifications for road base would open large markets for tear-off shingle waste.

2.2.2.2 Hot-Mix Asphalt

Ground asphalt shingles can be easily incorporated into hot-mix asphalt (HMA) and other patching materials and is considered by many to be the best potential market for recycled asphalt shingles (Figure 4). Limited laboratory and field testing has shown that both manufacturer's scrap and tear-off scrap can be used successfully in HMA. The technology is widely available and cost effective for recycling asphalt shingles back into pavement. The asphalt and aggregate content components of shingles are very similar to those of asphalt paving materials, therefore making recycled shingles a desirable additive or feedstock substitute in pavement materials.

Figure 4. Hot-mix asphalt.

Generally, the smaller the shreds, the better they will be incorporated into the HMA mix. Finely ground shingles smaller than one-half inch are typically added to the HMA at 5 to 10 percent by weight (Decker 2002). This substitution, however, usually requires the use of a softer virgin asphalt to offset the effect of adding the harder asphalt of the recycled shingles.

A typical HMA plant can produce several hundred tons of mix per hour. If the plant is using shingles in a 5 percent by weight formula, during a typical working day, the total amount of shingles required could be 50 tons or more (Decker 2003). It has been said that, if all HMA produced in the United States were required to have only a 2 to 3 percent recycled shingle content, which is well below the current maximum of 5 percent, there would not be enough shingles to fill the need. Logistically there are some difficulties as well, because the technology is not yet totally in place to handle this. By setting this requirement, however, all recyclable shingles would be diverted away from landfills and into a product where they can be used again and again (Turley 2001).

Numerous potential benefits can result from the use of waste shingle material in asphalt mixtures. Some of these benefits include:

- a reduction in the cost of shingle waste disposal
- an environmental benefit resulting from the conservation of landfill space

- a reduced cost in the production of HMA concrete because of reduced use of new materials
- an improved resistance to pavement cracking and rutting.

Recycling asphalt shingle waste saves both money and landfill space. Taking roofing waste to a recycling facility for a lower tipping fee can reduce disposal costs. Recycler’s tipping fees are typically $5 to $20 less than at landfills. With the high cost of transportation, roofers cannot afford to haul waste long distances. This, along with local landfill capacity and tipping fees, will affect disposal choices. If tipping fees are large enough, there will be an economical incentive for waste generators to change their practice from landfill disposal to recycling.

Replacing a percentage of virgin asphalt with recycled shingles can reduce the amount of raw materials needed to produce new pavement. This is an efficient use of resources and an economic advantage to the producers of HMA. Less expensive recycled shingles can replace a percentage of the virgin asphalt and/or aggregate in pavements, reducing the demand for mined aggregate and reducing the costs for contractors.

Certain properties of asphalt pavement have been shown to improve with the addition of recycled asphalt shingles. Mixing shingles and paving asphalt can increase a pavement's resistance to wear and moisture, decrease rutting, and reduce both thermal and fatigue cracking. It is suspected that the added fibers and harder asphalt used in the shingles help reinforce the matrix and apparently add to the structural integrity. (93-09.pdf)

Recycled asphalt shingles may be ground and mixed into gravel used to cover rural, unpaved roads to minimize dust, reduce the loss of gravel into side ditches, and reduce noise. Research is ongoing into developing a product specification for gravel roads that will substantially reduce erosion, dust, and grading maintenance. Specifications for these types of applications are less strict than those for HMA.

The processed shingles are spread over bare ground and compacted for an easily installed surface on which to drive. Post-consumer shingles often contain nails and other metals that need to be removed from the mix if it is going to be used for temporary pavement. A magnet on the grinder will typically remove these metals, however some roofing nails may get through. To avoid tire punctures, the product should be ground to one-quarter inch rather than three-eighths inch size to keep nails from getting through the screen (Turley 2001).

2.2.2.3 Cold Patch

Recycled asphalt shingles have been used extensively as an ingredient in cold-applied maintenance mixtures. One of the primary uses of “cold patch” is to fill potholes, but it can also be used to construct sidewalks, fill utility cuts, and repair driveways, ramps, bridges, and parking lots. Cold patch consists of asphalt, aggregate, and a solvent and can be made with either manufacturing scrap or up to 25 percent recycled tear-off roofing shingles. The fibers in the asphalt shingles add to the structural integrity of the patch resulting in performance higher than HMA and traditional cold mixes (CIWMB 2001).

Shingles can be ground to one-quarter to one-half inch minus size and used as a cold patch material alone or combined with virgin asphalt or other materials, including recycled asphalt pavement (RAP). When tear-off shingles are used, a solvent is added to rejuvenate the old, oxidized asphalt. In some instances, these patches last longer than virgin patch materials and are less expensive.

Recycled-shingle cold patch is also easier to use than traditional patches because of its lighter weight, slow set-up time, and no requirement for equipment. Because of its lower weight-to-volume ratio, it is easier to handle. The crack or pothole is simply filled with the cold patch and tamped down with a shovel (Figure 5). It hardens more slowly than HMA does, so there is no hurry to use it, and traffic is able to drive over it right away (CIWMB 2001).

Figure 5. Pot hole filled with cold-patch.

2.2.2.4 Fuel

Recovering the energy content of waste shingles is a well-established market in Europe. This concept has been tried only recently in the United States. In the 1980s, researchers tried to burn roofing waste to recover the energy as a steam. However, equipment production efficiencies posed significant hurdles (Snyder 2000). Due to the concerns over air pollution, this market is very limited. Yet with safe technology existing in Europe and the rising fuel costs in the United States, this may become a more lucrative market in the future.

2.2.2.5 New Shingles

Using finely ground shingles as feedstock in the manufacture of new roofing shingles is still in the experimental phase. Problems surround the control of the quality of recycled shingles as a feedstock and the assimilation of recycled shingles into the manufacturing process (NAHB 1998).

A report prepared for the U.S. Department of Energy (Shepard et al. 1989) showed that the addition of up to 20 percent recycled shingles did not affect the production of new shingles. Significant energy savings were shown by using recycled asphalt shingles. As virgin asphalt prices increase, recycling shingles may become an attractive option.

2.2.3 Asbestos Contamination and Barriers to Recycling

Asphalt scrap produced during the manufacturing process is of a uniform and guaranteed content. In contrast, tear-off waste may be composed of shingles of varying asphalt and aggregate composition and may be from multiple manufacturers. Because a few brands of shingles contained small amounts of asbestos when they were manufactured decades ago, traces of asbestos sometimes show up when tests of shingle waste are conducted. As a percentage of the overall materials mix, recyclers contend that asbestos is insignificant. However, the perception that shingles contain asbestos remains a barrier to asphalt shingle recycling.

Among the challenges facing asphalt shingles are the regulatory issues concerning the presence of asbestos. The National Emission Standards for Hazardous Air Pollutants (NESHAP) regulates how asbestos-containing material (ACM) is handled during building demolition or renovation. The Asbestos NESHAP lists asphalt roofing products as materials that may possibly contain asbestos and provides some guidance on the recycling of asbestos-containing roofing material (ACRM).

The following asphalt roofing products are listed by NESHAP as possibly containing asbestos:

- built-up roofing
- asphalt-containing single-ply membrane systems
- asphalt shingles
- asphalt-containing underlayment felts
- asphalt-containing roof coatings and mastics
- asphalt-containing base flashings.

Between 1963 and 1977, three of the largest shingle manufacturers used asbestos in the fiber mat of their shingles. The amount of asbestos used in shingles was between 0.02 and 0.00016 percent, and was used in just a portion of production. Although only a small percentage of shingle production over a limited number of years involved asbestos, ACRM is a potential hazard that recyclers must face. As some shingles last up to 20 years and some roofs are covered by more than one layer, re-roofing projects may encounter ACM through approximately 2016.

In some states, the processing of tear-off shingles is banned because it can be a health risk to workers handling the material. While the shingle is still intact, the material is benign and non-friable. When the shingle is ground, however, the asbestos can become friable and airborne. Rather than deal with the asbestos issue, some state and local regulators are requiring that all post-consumer shingles go straight to a landfill and will not consider recycling alternatives. However, several states have done feasibility studies that have found shingle recycling workable.

Worker environmental safety is regulated under Occupational Safety and Health Administration (OSHA) and U.S. Environmental Protection Agency (EPA) guidelines regardless of the construction activity. Because deconstruction poses a greater worker exposure than mechanical demolition, it is prudent to remove all ACM no matter the condition, whether or not it is regulated. Any materials containing asbestos are not viable for recycling or reuse.

2.2.4 Specifications for Use of Recycled Shingles

Recycled asphalt shingles have been used as an additive in HMA in the United States for more than 15 years. Presently, only about ten states specify its use. Most state Departments of Transportation (DOTs) do not allow tear-scrap use for a variety of reasons including:

- adequate supply of manufacturer scrap
- potential asbestos content in tear-off waste
- quality-control concerns regarding content and condition variability for tear-off waste.

Pavement standards vary from state to state and specifications are based on local climatic conditions and other engineering qualifications determined through independent testing by state DOTs. Several states have developed specifications for shingle use in HMA mixes, and some HMA plant operators have created their own mix designs using post-consumer shingle waste for doing "off-spec," non-highway jobs.

Those states that have incorporated recycled asphalt shingles into HMA specifications include:

- Georgia (5 percent, no restriction as to the use or mixing of manufacturing scrap and tear-off shingle scrap)
- Maryland (5 percent, manufacturing scrap only)
- Michigan (50 percent recycled asphalt specification routinely allows old and new shingles, though shingles are not specifically mentioned)
- Minnesota (5 percent, manufacturing scrap only)

- New Jersey (5 percent in “supplemental spec,” manufacturing scrap only)
- North Carolina (5 percent, manufacturing scrap only)
- Ohio (allows “certain percentage of recycled material”)
- Indiana (5 percent, manufacturing scrap only)
- Florida (15 to 25 percent by mass of manufacturing scrap or tear-off shingle scrap)
- Texas (manufacturing scrap and tear-off shingle scrap, but does not allow the mixing of the two types)
- Pennsylvania (provisional specifications allowing limited amounts of manufacturing scrap only).

The key to opening large markets for recycled asphalt shingles is to allow the shingles in DOT specifications. The American Association of State Highway and Transportation Officials (AASHTO) whose mission is to advocate transportation policies and facilitate institutional change, has drafted a specification that focuses specifically on this application, “Recycled Asphalt Shingle as an Additive in Hot Mix Asphalt” (rmrc.unh.edu).

2.2.5 Asphalt

Asphalt is one of the most common steep-slope roofing materials. For the low-slope commercial market, modified bitumen and conventional built-up roofs are still the best performing systems. Asphalt shingles are a good choice for a clean look at an affordable price. On the negative side, asphalt shingles do not have the life span of other materials such as tile or metal.

Asphalt used for roofing shingles usually does not contain post-consumer materials. While shingles can be recycled into other asphalt products, they are typically not recycled back into roofing materials because the cost of doing so is not reasonable and demand is minimal in the United States. Higher-quality versions of shingles made from asphalt and fiberglass offer a more durable option and may be available with recycled content.

Millions of barrels of crude oil are used in the production of asphalt shingles. The Asphalt Roofing Manufacturers Association (ARMA), however, claims that the asphalt itself is a recovered material, because it is a necessary by-product of the oil refining process. According to the Asphalt Institute, asphalt would have to be disposed of as a solid waste if it was not sold for use in other products. Most, if not all, refineries sell their asphalt because a market exists.

2.2.6 Organizations and Associations that Support Shingle Recycling

To help the asphalt recycling effort, the Construction Materials Recycling Association (CMRA) and other industrial and manufacturing organizations, such as the Asphalt Roofing Manufacturers Association (ARMA), the National Asphalt Pavement Association (NAPA), the Asphalt Emulsions Manufacturers Association, and the Asphalt Recycling and Reclaiming Association (ARRA), aggressively promote waste-reduction and recycling programs. Appendix B contains contact information for these and other organizations related to asphalt shingle recycling.

2.3 BUILT-UP ROOFS

Commercial roofs tend to be made of continuous roofing materials such as built-up-roofing (BUR). Built-up roofs are used most commonly on commercial, low-slope buildings. This simple yet effective system consists of several multiple layers of asphalt or coal tar and felt alternating layers of felt or fiberglass treated with asphalt. The final surface layer is commonly covered with pea gravel or slap. A built-up roof can generally be expected to last 10 to 20 years.

Built-up roofs are preferred when heavy traffic is expected or the potential exists for mechanical abuse on the roof, because the roof membrane tends to be thicker and more substantial than other systems. Gravel surfacing makes the roof highly resistant to normal traffic. Multiple layers mean redundancy in the roof. Low-slope roofs on some warehouse designs have been roofed with various types of membrane roofing, which is difficult to remove if it is fully adhered. As these materials have no value, their removal represents all cost with no economic return. During re-roofing, both the insulation and the built-up membrane are typically landfilled.

2.4 METAL ROOFING

Asphalt has been the material of choice for new roofs due to its low initial cost. However, metal roofs are growing in popularity for new and re-roofing applications. Metal roofing is environmentally friendly due to its recyclability and recycled content. Metal roofs can last 50 years or more compared with 20 years for asphalt-shingle roofs. There is also a wide range of material choices – copper, galvanized steel, stainless steel, steel alloys, aluminum, and other coated metals as well (wbdg.org).

Some metal roofing is corrugated and used like fiberglass, and some metal shingles are designed to look like other types of roofing materials. Normally these types of roof coverings have a galvanized coating, or are factory-coated with a highly durable finish. A coated metal roof can last indefinitely, depending on the materials and coatings used.

Metal roofing is lightweight, allowing it, in many cases, to be installed over existing roofs. This minimizes the need to tear off and dispose of existing materials, which can have monetary and ecological savings. In addition to being lightweight and durable, these materials are nearly 100 percent recyclable. At the end of their useful lives, they are easily recycled, which saves landfill space and natural resources. In fact, as steel is recycled, it maintains its strength and integrity so it can be made into one quality product after another.

Metal roofing, usually made of steel or copper, is available in several forms and can be used for many types of roofs. Vertically installed steel panels joined together edge-to-edge onsite, called standing-seam roofing, is among the most popular metal roofing options. While metal roofing can cost a little more initially compared with asphalt shingles and some other types of roofing, building owners are seeing a payoff in the form of lower maintenance costs and longer life (cdrecycler, 6/18/2003). In many cases, metal roofing can be installed over existing roofing, saving costly tear off and disposal charges (wbdg.org). The sheet metal roofing panel industry has a number of new products that provide not only increased life expectancy (relative to traditional metal roofing) but a greater choice of color and patterns (IRC).

2.4.1 Steel Roofing

Steel is unique among exterior building materials because all steel products, including steel roofing, contain recycled steel. Steel roofing contains a minimum of 25 percent recycled steel. For the steel industry, using old steel products to produce new steel lowers costs by reducing the amount of energy used in the steel-making process by 75 percent. That is why more than 65 million tons of steel scrap is recycled each year.

In contrast to many other building materials, steel is routinely collected from construction and demolition sites and recycled into new steel products. Recycling scrap metal from a construction site is usually a day-to day occurrence. Scrap metal is separated and taken to dealers for recycling, and revenue is received for these materials. Local scrap dealers often have collection systems in place for large-scale scrap recycling. If there is enough volume, a scrap metal dealer may provide for collection bins and pick up at the site.

The scrap market offers a much better sustainability outcome for a metal roof compared with a roof of asphalt shingles, which is more likely to head for a landfill. After demolition, steel roofing scrap can be sold to processors who buy the scrap from building dismantlers and a variety of other sources including industrial plants, government facilities, farms, auto dismantlers, railroads, shipyards, and municipalities (ISRI 1993).

2.4.2 Copper Roofing

Copper roofs have been used for many years in the United States. Before the 1800s when the first shingle machine was invented, the building industry used copper and flat tin for roofing. Sheet metal and copper roofs are still being installed today as well as “pre-painted” metal roofs, which are treated and painted prior to being installed (*San Antonio Business Journal* 2002).

The United States has historically been a steady but modest market for copper roofing. Until fairly recently, copper was used mainly for churches, synagogues, and other public buildings — but that is changing rapidly. In addition to its traditional uses in public buildings, copper is now gaining popularity in small office structures, shopping malls, sports arenas, and even residential homes.

Copper roofing sheet is predominately made from recycled copper scrap. A lot of recycled copper scrap is bought directly by mills that produce roofing sheet. Copper that is no longer useable, such as old wiring, plumbing tube, and roofing from demolished or renovated buildings, is collected by scrap dealers who sort and prepare it for market. Refineries buy the recycled metal and convert it back to pure copper. The United States has three primary roofing sheet producers who all rely heavily on scrap copper as one of their raw materials.

In 1997, 1.45 million tons of copper scrap was recovered and processed in the United States. Recovery and consumption of old scrap was highest during WWII, the 1950s, and 1960s — years of high copper demand and prices. Copper, like other metals, has an infinite recyclable life. Copper, by itself or in any of its alloys such as brass or bronze, is used over and over again. Because of its long life, and because older homes have less copper in them than today's structures, only a small amount of scrap copper is available from the building and construction sector. This limits the supply of copper scrap to be used for recycling.

Recycled copper scrap is used for making wrought copper and copper alloys. These alloys are then fabricated into products such as sheets, tubes, rods, and pipes. The amount of scrap used to make roofing sheet varies depending on the availability and price of scrap and new copper as well as the melting and refining processes used by the various producers. Because of these factors, scrap use can range between 50 and 100 percent, but averages close to 60 percent (copper.org).

2.5 WOOD SHINGLES AND SHAKES

Wood shingles and shakes come in a variety of sizes and styles. These are more difficult to install than asphalt shingles. Wood shingles are long lasting — up to 40 years — and are made from a renewable resource.

Wood is harvested and replanted in a continually regenerating cycle, while nonrenewable resources such as iron ore are mined on a depleting basis. Wood requires less energy to manufacture, it produces much less air and water pollution, and it helps combat the greenhouse effect. Specifying a product that can be easily recycled or reused minimizes the environmental impact.

Unfortunately, wood roofing is not cheap and can typically cost up to three times more than a premium asphalt roof. It also requires periodic treatment with preservatives to keep the wood from drying out, warping, and cracking. Wood is also more susceptible to discoloration, mildew, fungus, rot, and wind-driven fire.

2.6 SLATE AND CLAY

Slate shingles and clay tile are durable, attractive, environmentally benign, and can be easily recycled or salvaged for reuse. Although the initial costs for materials and installation are high, the long-term cost is low. A tile roof can last more than 50 years. The biggest consideration for re-roofing with slate or clay is the weight of the tile itself. Roof trusses may need to be re-engineered to handle the extra weight of the tiles. Roofs often need to be built up to hold the extra weight.

It rarely makes sense to replace a roof with tile unless historical authenticity is critical. Salvaged tiles will be more affordable, and composites made from stone and concrete conserve natural resources. If a slate or clay roof needs replacement, some of the expense of re-roofing can be avoided by locating companies that will salvage and resell the slate and clay tiles. Firms that stock clay tile or slate roofing are always looking to purchase tiles being removed during a tear-off job.

3 SIDING

When specifying exterior building materials, the tendency to select natural materials should not overlook the long-term benefits of other materials. Affordability, Environmental Performance, and durability are all important in the selection of siding.

There are many choices when it comes to siding—wood, vinyl, stucco, fiber-cement, and others. Because it forms the protective exterior of your house, as well as the part of your house that is the most visible, the decision as to what siding to use is not one to take lightly. Table 4 describes common siding type. These types are discussed in more detail in the following sections.

In recent years, vinyl has become the siding market leader. Vinyl is virtually maintenance free. The color does not peel, blister or flake, so there is never the need to paint. A thicker and more rigid vinyl product better resists warping and cracks from impact. If properly installed, maintenance is minimal. Other advantages are that vinyl siding does not contribute to termite infestation, rotting, or moisture buildup. Its popularity continues to grow because of new product offerings and features such as wood-like textures, shingle- and shake-style panels, more appealing trim components and a wide range of colors.

Table 4. Comparison of common siding alternatives.

SIDING MATERIAL	COST*	WARRANTY	MAINTENANCE REQUIREMENTS	COMMENTS
Vinyl	$	40 years to life of the building	Periodic cleaning	Inexpensive, dent resistant, will not rust. Can be installed over most existing siding.
Wood	$$$	15 years	Painting/staining every 3-5 years. Two-coat system may last as long as 10 years.	Natural material. High maintenance. Susceptible to termite damage.
Brick	$$-$$$	Lifetime	Repairs to brick and mortar. Tuck pointing	Expensive, but long lifespan.
Aluminum	$	40 years to life of the building	Periodic cleaning and may need to be painted after 15-20 years.	Lightweight. Will not rust. Can be installed over most existing siding. Dents easily.
Steel	$$	40 years to life of the building	Low maintenance.	Fireproof. Strong – resists denting.
Dollar symbols refer to initial cost of purchase and installation of these materials relative to other roofing materials. No numerical dollar values are implied.				

3.1 ALUMINUM SIDING

Nearly 40 percent of all aluminum used today is re-melted metal. However, this does not give a true picture of the recovery rate that can be achieved in the construction and demolition industry, as the durability of aluminum building materials makes the material unavailable for recycling for many years (www.azom.com). Aluminum has been used by the building industry for more than 50 years due to its strength, durability, corrosion resistance, and recyclability. In North America, aluminum facades have been popular for residential buildings for some decades. Aluminum siding appeared on houses in the late 1950s, but most of this material was being used to cover previous siding materials. It is an easily fabricated metal that is often used for flashing in conjunction with other roofing materials. Other common uses of aluminum for building and construction include:

- doors and windows
- screen frames and screening
- awnings and canopies

- siding, soffits, and facia
- roofing and siding
- flashing
- pre-engineered buildings and structures
- manufactured housing
- ducting
- louvers and vents
- other heating and ventilating equipment
- curtain wall, store front, and entrances
- structural framing profiles
- highway and street signs
- lighting and parking meter pipe stands
- gutters and downspouts
- shower and tub enclosures
- builder’s hardware
- venetian blinds
- swimming pools.

Aluminum construction materials require less maintenance than do traditional materials. In addition to a particularly long service life, aluminum can be either reused or recycled. Thus, rather than contributing to the diminishing landfill space problem, aluminum can be recycled indefinitely to produce a new generation of building materials. Every pound of aluminum recycled saves 4 pounds of bauxite ore, aluminum’s main ingredient. Much of its recycling value comes from the energy saved when making new aluminum with recycled material.

3.1.1 Aluminum Recycling

Although aluminum is less than one percent of the nation’s solid waste stream, it remains one of the most valuable recyclable materials. Used aluminum beverage cans remain the most recycled item in the United States, but other types of aluminum, such as siding, gutters, storm window frames, and lawn furniture, can also be recycled. Aluminum has a high scrap value that can contribute significantly towards reducing demolition costs.

Aluminum doors, windows, and siding are major sources of recycled aluminum, and recycled aluminum is increasingly used in their production. In general, aluminum construction products do not need protective coatings that other materials may require. They are therefore a good source of metal for recycling without any pre-processing.

Aluminum is easily separated from other metal scrap. The infrastructure required for collection and recycling of scrap aluminum is already well established. Once ferrous scrap is removed using magnetic devices, aluminum scrap can then be sorted. Specialized equipment and sorting machines separate according to density or by magnets that repel metals such as aluminum and copper.

Aluminum has a high market value and continues to provide an economic incentive to recycle. Aluminum scrap from building construction products typically go to secondary aluminum smelters who sell to the beverage or automotive industry.

Building construction is the third biggest market for aluminum, accounting for 13.1 percent of shipments in 1999 (Ohio DNR 1999, 2003). With aluminum continuing to make significant inroads into the building and construction markets, prospects are bright for the continued growth of the secondary aluminum market. Aluminum is also being considered for infrastructure applications, such as bridges. The light weight, high strength, and durability of aluminum makes it attractive to specifiers and contractors in many cases.

3.1.2 New Construction

Aluminum and steel siding is considered to be a step up from vinyl in durability. The material and installation costs of aluminum are less expensive than steel, but both materials cost more than vinyl. Both metals are 100 percent recyclable, making them environmentally friendly choices for siding and other exterior building products (Figure 11).

Aluminum products make efficient use of energy and resources. The material’s light weight results in low energy usage during machining, transportation, and handling. Aluminum’s excellent resistance to corrosion and weathering reduces maintenance and extends the lifetime of the building product. Finally, when used materials are recycled, re-melting uses only 5 percent of the energy that is required to produce primary metal (azom.com).

Figure 11. Salvaged aluminum windows.

3.2 VINYL SIDING

Today, aluminum siding has virtually given way to vinyl siding for residential applications. More than half of all vinyl produced annually in the United States is used to manufacture construction or furnishing products. Vinyl is used widely in the construction industry because of its durability, easy installation, and cost effectiveness. It is often applied over existing siding such as masonry or wood to give the building a clean appearance. Buildings within the Army originally built as barracks, administrative facilities, mess halls, recreation buildings, medical buildings, and similar lumber-framed buildings were commonly adapted with vinyl siding on the exterior to cover their neglected wood siding (Figure 6). It takes approximately 4,000 square feet of vinyl siding to cover a typical two-story barracks building.

Compared to traditional building materials, using vinyl products yields significant cost savings. Vinyl is by far the least expensive of the siding options. Of course, prices can vary dramatically among different regions, and installation costs vary even more (see Table 5).

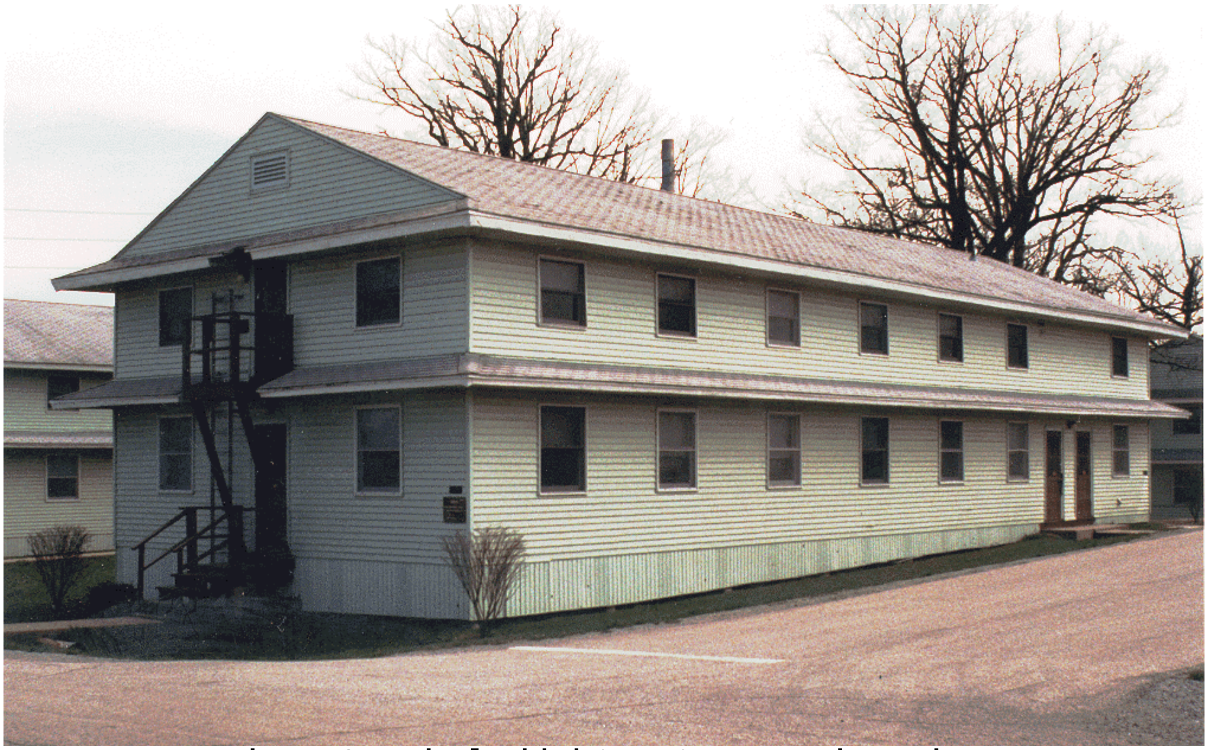

Figure 6. Vinyl-sided two-story Army barracks.

Table 5. Siding materials costs.

Siding Type	Cost[1] per Square[2]
Vinyl	$150
Aluminum	$180
Steel	$220
Composite/engineered board	$240-270

[1] 1998 dollars
[2] "Square" is a unit of measure used in the roofing trade. One square = 100 ft^2

Vinyl siding lends itself to recycling because it is made from polyvinyl chloride (PVC) — a thermoplastic that can be repeatedly ground up, re-melted, and formed into a variety of new products. Because vinyl is used primarily in durable applications like siding, pipe, flooring, and windows, which remain in use much longer, other plastics such as those used in milk jugs and soda bottles have higher recycling rates. In 1997, about 18 million pounds of post-consumer vinyl was diverted from landfills and recycled into second-generation products (principiaconsulting.com).

Contractors, builders, and remodelers generate vinyl siding scrap in large quantities at the construction site. This type of scrap has high recycling potential because it can be kept separate and fairly clean. Approximately six percent of the total weight of vinyl siding used each year at job sites is thrown away. According to the Vinyl Siding Institute, this amounts to as much as 96 million pounds of vinyl siding scrap available for recovery each year. Diverting it can help lower disposal costs and conserve landfill space.

Recycled vinyl siding can be reused in such applications as packaging, pipe, siding, parking stops, outdoor furniture, floor tiles, and traffic cones, or it can be reprocessed to make more siding. In 1997 the National Association of Home Builders (NAHB) formed a project team consisting of several local siding distributors and a waste management firm. The group collected vinyl siding scrap from building sites, separated it from other materials, and processed the material for reuse. The pilot program continued beyond the original one-season and, to date, more than 120,000 pounds of vinyl siding has been recycled and used to produce mobile home skirting with approximately 80 percent recycled content (*CD Recycler*, June 1999).

Several resources are available to help with finding potential markets for vinyl siding scrap. Through the American Plastics Council's (APC's) website at http://www.plasticsresource.com, those interested in recycling can access information on companies across the country that are currently involved in recycling plastics. For example, in the APC National Plastics Handler and Reclaimer Database, a few hundred handlers and reclaimers are listed who currently accept PVC scrap, some of which may accept scrap siding. The APC also has a Recycled Plastic Products Source Book with information on companies using recycled plastic in their products.

Another potential source of information is the Vinyl Institute's Vinyl Environmental Resource Center, also known as the VERCE. It can be reached at 1-800-969-vinyl (8469) or, through the Vinyl Institute’s website at http://www.vinylinfo.org, an online request form can be submitted to receive information about their publications including the “Directory of U.S. and Canadian Companies Manufacturing Products From Recycled Vinyl” and the “Directory of U.S. and Canadian Companies Involved in the Recycling of Vinyl Plastics.”

The process for recovering and recycling vinyl siding is simple. First, a hauler collects the siding scrap from the construction or demolition site. Then the scrap is taken to a broker that consolidates scrap from a variety of sources and sells it to a processor or end user. Typically, a processor runs a facility where the scrap is turned into a form useable for making a new product, and an end user uses the reprocessed scrap to manufacture recycled goods.

Before being recycled, the vinyl scrap must be cleaned and ground. Contaminants are removed by hand before being fed by conveyor into a granulator, which grinds the vinyl into flakes. The flakes are then fed into an extruder where the vinyl is melted and rolled out or molded to form the new product.

3.3 WOOD SIDING

A significant number of existing military buildings in the United States were constructed with siding manufactured from solid wood. These structures were built before or during World War II, when steel and masonry building materials were being redirected to other parts of the war effort. Most of these buildings are now targeted for removal under Base Realignment and Closure (BRAC) initiatives and the Facility Reduction Plan (FRP) to reduce building inventory.

Generally, WWII-era buildings were built with high quality lumber and, in some cases, “old-growth” materials, especially on the West Coast. Old growth is denser, with tighter rings, than comparable species harvested from today’s second or third generation forests. The most desirable and durable materials come from old-growth trees. Siding was generally of a higher grade than framing lumber. This makes recycled or salvaged siding materials valuable. Some species, such as old-growth long-leaf pine, command much higher prices than similar new lumber.

Most of the buildings targeted for demolition have been well-maintained and contain large quantities of potentially reusable wood siding materials. A typical two-story Army barracks contains approximately 4,000 square feet of 1x8 drop-lap wood siding (23/32-inch thickness; Figure 7).

Figure 7. Two-story WWII wood Army barracks.

3.3.1 Lead-based Paint

The presence of lead-based paint (LBP) on the exterior face poses a challenge in recycling or re-processing this wood siding without exposing both processors and reusers to lead's harmful effects (Falk 2002). Exposed elements of a building, such as wood siding, have often been painted for appearance and protection. If the structure was built before 1978, there is the potential that the paint contains lead. Between 83 and 86 percent of all buildings built in the United States before 1978 have LBP in or on them. The older the building, the more likely it is to contain LBP and to have a higher concentration of lead in the paint. Demolition projects, in particular, generate potentially hazardous contaminants such as lead paint on the wood waste, which can present challenges to processors, workers, and end users (Figure 8).

Processors who are handling wood contaminated with lead-based paint may find it necessary to dispose of scrap materials as a Resource Conservation and Recovery Act (RCRA) hazardous waste. The health of employees must also be protected per OSHA requirements for airborne lead dust.

Figure 8. Salvaged wood siding containing lead-based paint.

Finally, the presence of a hazardous contaminant in a recycled product could create potential liability issues, depending upon the intended use. A good practice used by many salvaged material retailers is to notify purchasers of the lead content and provide a USEPA pamphlet on LBP safety. This notice is similar in concept to the Dept. of Housing and Urban Development (HUD) LBP disclosure requirement for home buyers. CERL and others are working with the Consumer Product Safety Commission (CPSC) and EPA to determine what would constitute a “lead-safe” consumer product and what is appropriate notification.

3.3.2 Wood Salvage and Recycling

Demolition projects generate a far less desirable form of wood waste due to crushing and mixing materials with heavy equipment. A major factor in the success of a recycling operation is the degree of contamination of the material. Each wood waste processor has its own criteria for accepting wood waste. Generally wood processing plants accept only ‘clean’ wood (untreated and unpainted). Usually they look for wood that is free of dirt, rock, concrete, plastic, metal, and other contaminants that can damage wood-waste processing equipment. Some processors will accept loads with contaminants but at a higher fee to accommodate the costs of separation.

Wood waste, once it has been separated from other wastes, is cleaned by removing contaminants and fasteners and then processed through grinding or chipping. The final use of the wood waste often determines how clean and consistent the feedstock must be. Many processors will not accept wood that has been chemically treated with chrome, copper, arsenic (CCA) or coated with LBP. This is because of the health risks posed by CCA and lead. Treated wood is not suitable for incineration or for composting. As recycling technology is improving, however, some recycling centers are now accepting painted wood.

The most desirable option for wood waste would be to reuse the wood again in its original form. It is always best to find another use where the wood waste will undergo the least amount of processing before it is reused. Architectural elements such as casings, banisters, and moldings can be salvaged and reused in new buildings. Salvaged and recycled wood can add character to an existing structure.

If wood siding is not salvageable in its original form, the wood can be recycled and processed for the following uses:

- remilled lumber
- particle board
- pulp and paper product
- mulch and animal bedding
- biofuel.

Through deconstruction, wood siding can be carefully removed by hand and salvaged for reuse. A number of independent lumber mills have retooled their operations to accommodate and process reclaimed lumber (Turley 2002). Salvaged lumber is a high quality material and a good candidate for remilling because it is dry, seasoned, and is not going to twist. The overriding constraint on the potential reuse of wood is the thickness of the siding.

Research has been done to assess the viability of using conventional and specially designed woodworking equipment to remove lead-based paint coatings from wood siding salvaged from military buildings in a manner that could enable the reuse of the wood siding into a marketable new wood product (Falk and Janowiak 2002). Building codes usually consider wood siding a non-structural material and place few restrictions on its use. In addition, model codes do not require that it be grade stamped (WWPA). The results of this study concluded that wood siding covered with lead-based paint could be safely machined into value-added products including tongue and groove flooring (Figure 9), V-groove paneling, and bevel siding.

Flooring is the most promising product, as short pieces of siding can be used without a loss in market value. Additionally, the nail holes present in the salvaged siding do not significantly affect market value of the flooring (Falk and Janowiak 2002). However, if LBP has been chemically or physically removed from the wood siding, then the paint waste should be evaluated independently from the building material to determine if it is hazardous and to identify the proper management practice.

Figure 9. Tongue and groove flooring produced from siding.

3.3.2.1 Particle Board

If reusing the wood is not an option, the next most desirable alternative for wood waste is to grind it into a feedstock for engineered wood products such as particleboard, laminated wood, and plywood. The processing requirements for all these products are similar. These applications require that the wood is clean and free from contaminants and that it meets industry specifications. This is often not the case with wood siding waste.

Generally most of the wood raw material for particleboard and hardboard in the United States has consisted of virgin wood fiber and residues from sawmills and plywood mills and not from demolition waste.

3.3.2.2 Pulp and Paper Production

Pulp and paper applications in certain parts of the country represent the greatest potential for growth in utilizing wood waste. Because of strong prices and a limited supply of virgin material, construction and demolition wood waste sources are becoming increasingly attractive as mills struggle to meet long-term fiber needs. Additionally, secondary wood fiber can have longer and stronger fibers than some of the virgin pulp on the market, which is an additional plus for the industry. The limitations, however, are that pulp and paper end uses require very clean material. Recyclers must be able to limit the number of contaminants in the wood waste, and this may be impossible to accomplish with salvaged wood siding.

3.3.2.3 Mulch and Animal Bedding

Clean, ground wood is also an excellent bulking agent and moisture regulator for compost and can be used for mulch or animal bedding. Several companies recycle waste wood that would otherwise go to landfills. Most of the wood is untreated pine, fir, spruce, or another softwood. The wood products are ground or shredded into mulch, and nails and other metals are removed.

Wood siding, as well as wood roofing material, generally can be recycled. Wood waste from cedar shake and shingle is often sold for landscaping bark or used to make pet beds that are essentially sacks full of cedar chippings. Shake and shingle roofing material is separated from its felt paper and ground to the desired size. Particular situations and factors such as geographic location will affect each end use's value.

3.3.2.4 Fuel

The current market, however, is dominated by fuel applications. Most wood siding waste ends up being used as boiler fuel if the wood can neither be reused nor recycled. Wood waste from construction and demolition activities is attractive as a fuel because of its low moisture content. Biomass-to-energy producers may be interested in the use of waste wood as a fuel to produce steam or electricity.

Bio-fuel has historically been, and continues to be, the largest market for recovered wood wastes. However, with industrial conversion to lower cost fuels such as natural gas and the increased stringency of air quality control requirements, the demand for bio-fuel material will continue to decrease. As this market declines, other markets will have to be found for low-grade wood.

3.3.3 New Construction

Solid wood siding constitutes about 12 percent of the total market for exterior siding. Wood siding is often the most desired and the most expensive. While wood siding is aesthetically pleasing and works with many building types, it is not always the most practical choice when remodeling. It requires the most maintenance, and solid wood siding must be painted or stained, adding several thousand dollars to the cost of the job and to maintenance expenses in the future. Solid wood siding is also susceptible to rotting, splitting, mold, mildew, and insect damage.

One of the benefits of wood siding is that, when properly cared for, it can essentially last forever. Among all the exterior building materials available in the United States, only wood products come from a renewable resource, and wood is the only material that is 100 percent reusable, recyclable, and biodegradable. Consider the fact that, compared with other products mentioned, wood is incredibly strong, extremely durable, and the most energy conserving. It takes less energy to produce wood siding than other building materials such as aluminum, vinyl, and wood composites.

3.4 BRICK

Brick may be salvaged from a particular building because of its historical significance and reused because of its appearance and low initial cost. Salvaged brick is about $30 to $70 less expensive per 500 bricks than new bricks. However, much more is gained from salvaging brick than the approximate $85 to $100 paid per pallet (Figure 10). The main advantage to salvaging brick is the reduced volume and weight when hauling the debris to a landfill.

Removing bricks in mortar can be easy or difficult, depending on how hard the mortar is. Not every pile of rubble with brick is going to be worth salvaging. Typically, bricks must be at least 50 years old or the mortar will be too difficult to remove and reuse.

Figure 10. Pallets of salvaged bricks.

3.4.1 Brick Salvage and Marketing

Before reusing bricks, they must be properly cleaned. If the old mortar is not completely removed from the brick surfaces, the bond can be negatively impacted. The only current method of cleaning that enables salvaged bricks to be made suitable for reuse in their original form involves removing old mortar by hand. Unbroken bricks are cleaned using a small blunt hand axe to chip away the mortar from the bricks. Bricks that are cleaned in this manner still tend to have small amounts of mortar remaining on them. When bricks are initially placed in contact with mortar, they absorb some particles of the cementitious materials, and it is virtually impossible to use the hand axe to completely clean these absorbed particles from the surfaces of the brick units. The pores of the bricks, therefore, may be filled with old mortar, lime particles, dirt, or other deleterious materials and, even with careful cleaning, the bond of new mortar to these units will be reduced.

Bricks that were laid in lime mortar over half a century ago can be easily reclaimed. The use of lime mortar, at least in large buildings, was discontinued in the 1920s. Most of the salvaged brick is obtained from demolished buildings that were built over 50 years ago because it is next to impossible to salvage brick from modern structures that use Portland cement mortars to set brick. There has been investigation into a new technology that involves using pressure waves to break the bond between the mortar and the bricks. At this time, any mortar containing Portland cement is usually too strong and too difficult to remove without damaging the bricks.

Reclaimed brick with the mortar carefully removed are an asset. They are often used for aesthetic reasons in new construction. Common brick from the Chicago area is salvaged from demolition projects, cleaned and palletized onsite, and shipped to the South for use in exclusive homes. Salvaged bricks can also be used for interior walls and fireplaces within a home. Rarely do they present trouble because they are out of the elements and normal agents of their decay.

Salvaged bricks used for outside walls and chimneys, where they are exposed to weathering, have a much greater risk of unsatisfactory performance. Some problems commonly experienced in walls built of reclaimed brick include decay, spalling, efflorescence, and rain penetration. When reclaimed bricks are used externally, careful attention must be paid to the design of the wall to afford it as much protection as possible from the rain and other moisture.

Bricks that are difficult to clean are alternatively taken to the landfill or crushed for aggregate. Crushed brick rubble may be used as an aggregate for lightweight concrete, reducing the requirement for virgin aggregate. Recycled brick aggregate concrete could be used in road sub-bases and certain types of foundations where low strength concrete is required. Crushed masonry aggregate in some regions of the United States is popular as a landscaping rock. Crushed brick has also been used experimentally as aggregate for grouting new concrete masonry walls (ECC 1999).

3.4.2 Reusing Salvaged Brick

For repairs in small areas, using salvaged bricks should not present a problem. In many cases, however, walls made from salvaged brick will not be durable because of the questionable bond of the new mortar to the salvaged bricks and the quality of the bricks themselves. Generally, salvaged brick is fine for interior use, but it should be avoided if possible in exterior construction. Salvaged brick should not be used for chimneys, paving, or in other high-exposure areas, because it just will not endure.

A lime mortar instead of a Portland cement mortar is recommended for laying reclaimed brick. Lime mortar is composed of lime and sand and is generally low in salt content that can cause efflorescence on the brickwork. Such mortar is also highly plastic and is thus more likely to achieve a good bond with the porous bricks (Ritchie 1971). Mortar made of lime is also relatively weak compared to cement and its shrinkage. A high stress will not be imposed on the bricks; however, walls made from salvaged brick are less durable than walls constructed of new brick masonry units.

3.4.3. Choice in New Construction

Products made from renewable materials such as wood, or plentiful materials such as brick, are preferable to products made from scarce, nonrenewable materials. Brick continues to be one of the most popular exterior claddings in America. Using locally produced materials will reduce burdens on transportation systems. As one of the most durable building materials, brick requires very little maintenance and will last throughout the life of the building.

4 SUSTAINABLE CONCEPTS FOR NEW CONSTRUCTION

4.1 COMPREHENSIVE PROCUREMENT GUIDELINES

The Comprehensive Procurement Guideline (CPG) program is part of the U.S. EPA's ongoing effort to promote the use of materials recovered from the solid waste stream. The site <http://www.epa.gov/cpg> describes EPA’s effort to facilitate the procurement of products containing recovered materials. CPG requirements apply to all Federal agencies.

The CPG program offers purchasing guidelines to Federal agencies and their contractors by recommending recycled-content materials. The CPG recommends high-performance construction products, including building insulation, carpet, cement and concrete, consolidated and reprocessed latex paint, floor tiles, shower and restroom dividers/partitions, laminated paperboard, structural fiberboard, and roofing.

To make it easier to buy recycled, the EPA updates the CPG every 2 years. The EPA issued a final rule on 30 April 2004 amending its CPG by designating seven new items that are or can be made with recovered materials. Roofing materials are included as one of the seven newly designated items.

This designation specifically covers roofing materials containing steel, aluminum, fiber, rubber, plastic or plastic composites, and cement. Table 6 shows the recommended recycled-content levels for purchasing roofing materials.

A procuring agency is not precluded from purchasing roofing materials manufactured from another material. This designation, however, requires that a procuring agency, when purchasing steel, aluminum, fiber, rubber, plastic, wood, or cement roofing materials, purchase these items made with recovered materials when these items meet applicable specifications and performance requirements.

To help expand markets for recyclable materials, it is important to buy building supplies that contain recycled materials. Some of these materials have been used for years by the construction industry, but they have not been advertised as recycled. Information about the products available and how to purchase them can be obtained by consulting some of the publications or offices listed in Appendix B.

Table 6. Recovered materials content recommendations for roofing materials.

MATERIAL	POST-CONSUMER CONTENT (%)	TOTAL RECOVERED MATERIALS CONTENT (%)
Steel (Basic Oxygen Furnace Process)	16	25-30
Steel (Electric Arc Furnace Process)	67	100
Aluminum	20-95	20-95
Fiber (felt) for Fiber Composite	50-100	50-100
Rubber	12-100	100
Plastic or Plastic/Rubber Composite	100	100
Wood/Plastic Composite	--	100
Cement	Refer to cement and concrete recommendations in C-3 of the RMAN	
(www.epa.gov/cpg/products/roof.htm)		

4.2 DESIGN FOR RECYCLING

Manufacturers should plan for the eventual recycling of every product they develop so that all products can be efficiently and safely recycled. Despite the economic and environmental advantages derived from recycling exterior building materials, scrap processors are finding it increasingly challenging to handle many items because they are manufactured with hazardous components that make recycling either extremely difficult or, in some instances, even impossible. To ensure the growth rather than the demise of recycling, the end-of-life management of building products should be considered from the very start (ISIR).

Manufacturers in the carpet industry, for example, are beginning to make products that can be remade into the same products at the end of their useful lives. Buildings can also be made more panelized (e.g., raised flooring) to make them easier to take apart and reuse.

Materials carefully salvaged from existing buildings during remodeling or demolition can often be reused in another building. One of the most environmentally responsible building materials is one that has already been used. This saves all the energy and resources that would be required to make a new product, and it also keeps used building products from becoming waste. Reused materials lend a project a special character, because they may be materials that you could not get, or could not afford, if you tried to buy new. Incorporating environmental guidelines into contracts and specifications encourages the use of recyclable assemblies and products that can be easily deconstructed at the end of their useful lives.

Much of the waste that is taken to a landfill is from discarded building materials due to their short service lives. Roofing and floor coverings make up the majority of this waste category. Specifying highly durable and weather-resistant cladding and roofing can substantially reduce long-term waste. Roofing and claddings made from metals or natural aggregate are the most weather-resistant, having a service life several times that of asphalt and vinyl materials. Durable materials initially cost more, but save the building owner and tenant over the long term.

4.3 LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED)

The U.S. Green Building Council (USGBC) created the LEED rating system to provide green building guidelines for organizations to follow in qualifying their buildings as environmentally sound. LEED includes standards on topics such as maximizing the salvage of existing structures, maximizing recycling and reuse during construction, and specifying recycled or reused building materials. Elements of the LEED standards can be incorporated into contract specifications without going through the entire LEED rating process.

Reusing existing building materials, incorporating recycled products, and recycling C&D waste may contribute to earning certification points under the LEED system. For example, a point may be earned for building reuse by maintaining existing walls, floors, and roof. Other points can be earned for construction waste management and recycled content. Complete information is available on the USGBC LEED web site at http://www.usgbc.org.

4.4 LIFE-CYCLE COSTS

Life-cycle costing calculates the true cost over time to determine the best value for the money. It is a comparative analysis process that evaluates the direct and indirect environmental burdens associated with a product system throughout its life cycle. Too often projects and building systems are evaluated on initial cost, rather than life-cycle costs. While it is an important factor, initial cost is not the only factor. Roofing and siding decisions based on a complete life-cycle analysis must also include the expected life of the system and costs for scheduled maintenance, energy, and disposal.

Reliable, high-quality roofing and siding simply lasts longer and has lower maintenance expenses over their lifetime. Many so-called “bargains” last only a decade or so, and if a building needs to be re-roofed or re-sided every 10 years, then the cost over 30 years ends up being more than three times the initial price paid. Quality roofing and siding should last 25 years or more, so its cost would be much less than the cost of an inferior product, even if the initial installed cost is more (Spencer 1997).

Using life-cycle analysis as a measure for quality helps isolate factors that contribute to better roofs and siding and sorts out the best practices from many available options. It would be wonderful if life-cycle costs were considered as a matter of course in building design today, but they are not. Those in the building profession are forced to deal almost solely with first-cost in justifying projects.

5 CONCLUSION AND RECOMMENDATIONS

Today government legislation, increased public awareness, and the costs for landfill space have caused a move toward alternative demolition practices for the reuse and recycling of exterior building materials. Arguments can be made for having the owner, manufacturer, or both held responsible for making sure building products are recycled at the end of their useful life. Several jurisdictions are banning landfill disposal of some construction products, and, eventually, landfilling may be restricted to materials that cannot be disposed of in any other manner.

The growing concern for the environment has prompted recycling efforts in many directions. As consumer demand increases for environmentally friendly products, manufacturers are pursuing programs that reduce, reuse, and recycle raw materials. One area that is growing at a rapid rate is the recycling of exterior finish materials from building demolition debris.

In summary, options to consider for exterior building materials include:

1. Use exterior building materials with recycled content.

2. Select roofing and siding types appropriate for the application and based on life-cycle costs.

3. Develop a plan that sends old roofing or siding back to the manufacturer or local processor for recycling, rather than to landfills.

4. Use regular cleaning and other maintenance to maximize the useful life of exterior building materials.

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APPENDIX B: RESOURCES FOR RECYCLING OF ROOFING AND SIDING

The information here is accurate to the best of our knowledge. Inclusion in this listing does not represent an endorsement by the U.S. Army Corps of Engineers.

Asphalt Roofing Manufacturers Association (ARMA)
1156 – 15th Street NW, Suite 900
Washington, DC 20005
(202) 207-0917
www.asphaltroofing.org

Construction Materials Recycling Association (CMRA)
PO Box 644
Lisle, IL 60532-0644
Phone:(630)-585-7530 Fax:(630)-585-7593
www.cdrecycling.org

National Asphalt Pavement Association (NAPA)
5100 Forbes Blvd.
Lanham, MD 20706
Phone: 888-HOT-MIXX (468-6499)
www.hotmix.org

Asphalt Recycling and Reclaiming Association (ARRA)
#3 Church Circle, PMB 250
Annapolis, MD 21401
www.arra.org

National Roofing Contractors Association (NRCA)
10255 W. Higgins Road
Suite 600
Rosemont, IL 60018
Phone: (847) 299-9070 Fax: (847) 299-1183
NRCA’s InfoExpress (866) ASK-NRCA (275-6722)
www.nrca.net

National Association of Home Builders (NAHB)
400 Prince George’s Blvd.
Upper Marlboro, MD 20774
(301) 249-4000
www.nabrc.org

The Recycled Materials Resource Center
University of New Hampshire
220 Environmental Technology Building
Durham, NH 03824
Phone: 603.862.4704 Fax: 603.862.3957
www.rmrc.unh.edu

AASHTO
American Association of State Highway & Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, DC 20001
Phone: (202) 624-5800
Fax: (202) 624-5806
http://www.transportation.org

Sheet Metal and Air Conditioning Contractors' National Association
4201 Lafayette Center Drive Chantilly, Virginia 20151-1209
Tel (703) 803-2980 Fax (703) 803-3732
www.smacna.org

AZoM.com (the A to Z of Materials)
139 Hudson Parade
Clareville, Sydney NSW 2107
Australia
Tel: +61 (0)2 9918 7375
www.azom.com

Vinyl Siding Institute (VSI)
Phone: 1-888-FOR-VSI-1
www.vinylsiding.org

American Plastics Council (APA)
Recycled Plastics Product Directory
1300 Wilson Blvd.
Arlington VA 22209
Phone: 1-800-2-HELP-90
www.plasticsresource.com

Associated General Contractors (AGC)
333 John Carlyle Street
Suite 200
Alexandria, VA 22314
Phone: 703-548-3118 Fax: 703-548-3119
www.agc.org

General Services Administration
Federal Supply Service
Centralized Mailing List Service
P.O. Box 6477
Mailing code RCPG-0001
Fort Worth, TX 76115
www.gsa.gov

The Official Recycled Products Guide
American Recycling Market, Inc
P.O. Box 577
Ogdensburg, NY 13669
(800) 267-0707
www.recyclingdata.com

Global Recycling Network
http://grn.com

Recycler’s World
RecycleNet Corporation
P.O. Box 1910
Richfield Springs, New York 13439
Help Line (519) 767-2913
www.recycle.net

Environmental Building News
RR 1, Box 161
Brattleboro, VT 05301
800-861-0954 x191
www.buildinggreen.com

The Vinyl Environmental Resource Center (VERCE)
1360 East 9th Street, 7th Floor
Cleveland, OH 44114
Phone: (800) 969-VINYL (8469)
www.vinylinfo.org

The Brick Industry Association,
11490 Commerce Park Drive,
Reston, VA 20191-1525
Phone: 703.620.0010 Fax: 703.620.3928.
www.bia.org

Cedar Shake & Shingle Bureau
P.O. Box 1178
Sumas, WA 98295-1178
Phone: 604-820-7700   Fax: 604-820-0266
www.cedarbureau.org

United States Green Building Council (USGBC)
U.S. Green Building Council
1015 18th Street, NW, Suite 508
Washington, DC 20036
Phone: (202) 82-USGBC or 828-7422 Fax: (202) 828-5110
www.usgbc.org

BuildingGreen
122 Birge Street, Suite 30
Brattleboro, VT 05301
802/257-7300 (phone); 802/257-7304 (fax)
www.BuildingGreen.com

Western Wood Products Association (WWPA)
522 SW Fifthe Avenue, Suite 500
Portland, OR 97204-2122
(503) 224-3930
www.wpa.org

Institute for Scrap Recycling Industries, Inc.
1325 G Street
Washington, DC 20005-3104
Phone: (202) 737-1770 Fax: (2029) 626-0900
www.isri.org

University of Florida
Powell Center for Construction and Environment
Rinker Hall Room 304 / P.O. Box 115703
Gainesville, FL 33711-5703
www.cce.ufl.edu

Used Building Materials Association (UBMA)
1702 Walnut
Boulder, CO 80302, USA
Fax: (303) 441-4367
www.ubma.org

Leadership in Energy and Environmental Design (LEED)
U.S. Green Building Council
1015 18th Street, NW, Suite 508
Washington, DC 20036
Phone: (202) 82-USGBC or 828-7422
www.usgbc.org/leed/

National Recycling Coalition (NRC)
1325 G Street NW
Suite 1025
Washington, DC 20005
Phone: (202) 347-0450 Fax: (202) 347-0449
www.nrc-recycle.org

Solid Waste Association of North America (SWANA)
1100 Wayne Ave.
Suite 700
Silver Spring, MD 20910
Phone: 1-800-GO-SWANA (467-9262) Fax:(301) 589-7068
www.swana.org

Unites States Environmental Protection Agency
Comprehensive Procurement Guidelines
www.epa.gov/cpg

Reuse Development Organization, Inc. (ReDO)
2523 Gwynns Falls Parkway
Baltimore, MD 21216
Phone: 410.669.7245 Fax: 410.728.3633
www.redo.org