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Overview of Roofing Materials for Forest Service Facilities

Dick Karsky, Project Leader; and Jasen Neese, Mechanical Engineering Technician

This Tech Tip provides general information about roofing systems to help facilities managers who are beginning a roofing project. It also provides information on some commonly used residential and light commercial roofing products and lists resources that can help managers determine the materials that would be needed for a roofing project. With reduced agency staffing, experts may not be available for this work.

Figure 1—Residence roofed with asphalt shingles.

Sloped Roof Applications

Roofing Materials

Asphalt Roofing—Asphalt shingles (Figure 1) are the most common roofing material for residential buildings. They come in two categories: organic base and fiberglass. Organic shingles have a cellulose mat. Fiberglass shingles have a fiberglass mat. These mats are saturated with asphalt and covered with mineral granules. Organic shingles are more flexible in cold weather than fiberglass shingles, but fiberglass shingles have a better fire rating than organic shingles.

The most common types of shingles are the three-tab and the architectural shingle. The three-tab shingle is a rectangular mat with two slots cut from its front edge. The slots provide stress relief as the shingle expands and contracts. An architectural shingle has a heavy base mat with other mats or sections added to it. Besides being

For additional Information contact: *Dick Karsky, Program Leader; Missoula Technology & Development Center; 5785 Hwy. 10 West; Missoula, MT 59808-9361. Phone: (406) 329-3921; Fax: (406) 329-3719; OpenMail: dkarsky/wo,mtdc; E-mail: dkarsky/wo_mtdc@fs.fed.us; Lotus Notes: Richard J Karsky/WO/USDAFS*

heavier and more durable, the architectural shingle gives the roof shadow lines and character, much like that of a tile or wood roof.

Cementitious Roofing— Cementitous roof tiles offer traditional looks with the benefits of modern materials. These tiles are made from steam-cured cellulose fiber reinforced with Portland cement. These tiles are durable. Because they are a masonry material, they resist weathering, insects, fire, and fungus. Their weight helps them resist being lifted by the wind.

Clay Roofing Tiles—Clay roofing tiles (Figure 2) are among the oldest and most durable roofing materials. The tiles are made out of kiln-fired clay and are weather resistant, fireproof, and insect proof. They can be barrel shaped or flat and may have a glossy finish. They are available in different colors. Tiles are fastened to the roof deck with a variety of clips, fasteners, or a tie-wire system that suspends the tiles from the ridge of the building.

Figure 2—Entry veranda covered with clay tiles.

Metal Roofing—Metal roofing is available in a wide range of materials and configurations. It is fastened in a variety of ways and may be unpainted or finished with various coating systems at the factory.

The most common types of metal roofing are steel panels with exposed fasteners, steel panels with hidden fasteners, and rust-resistant aluminum panels that look like shakes, shingles, or tiles. Copper and coated stainless steel are less common types of metal roofing. Some steel panels have stone granules resin bonded to the panel surface.

A coating of zinc (galvanized) or a mixture of zinc and aluminum (known as galvalume or galfan) provide corrosion and rust resistance to steel roofing materials. Top-quality steel roofing materials have a coating of zinc or a factory-applied coating.

Steel panels attached with exposed fasteners (Figure 3) are most common on agricultural and utility buildings, but are becoming more common on houses in areas of high snowfall. Panels with no exposed fasteners are known as standing-seam types (Figure 4). The panels are joined with crimped or snap-together seams that extend vertically from the roof.

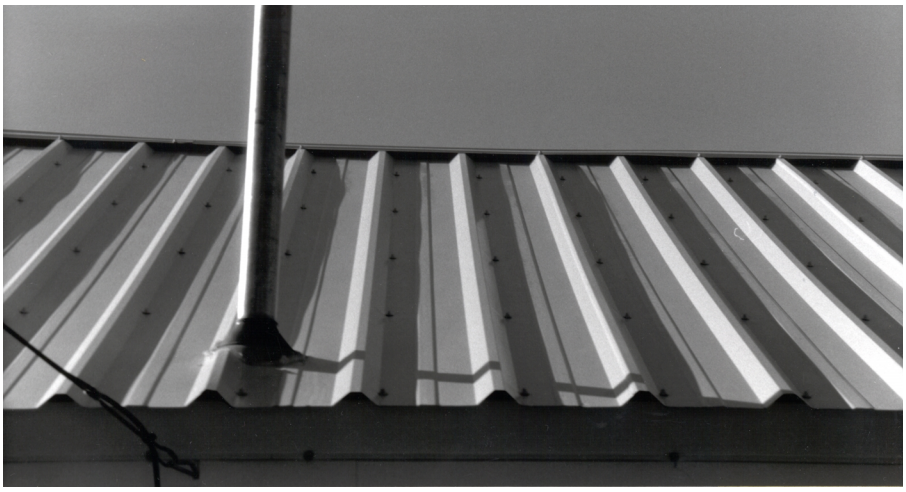

Figure 3—Metal roof with exposed fasteners.

Figure 4—Metal roofing with a standing seam. The fasteners are under the seam.

Wooden Roofing—Originally, wooden roofing came from the tree with little refinement. Today wood shingles and shakes are more sophisticated. Cedar roofing can be factory treated with chemicals to boost its fire rating from unrated to Class A, B, or C. Southern pine shakes are pressure treated to help them resist rot and decay. Although these shakes have been on the market only for 10 years, their manufacturers expect the products to have a 30-year life span. The same holds true for composite wood shingles.

A shingle is smooth, uniformly shaped, and is about $^1/_2$ inch thick at the thick end. Shakes (Figure 5) have a rough and uneven texture, and can be $^1/_2$ to $^3/_4$ inch thick at the thick end.

To get the maximum durability out of a cedar roof, roofing contractors recommend cleaning the roof with a pressure washer once or twice a year to remove debris. Debris holds moisture that can cause rot. Preservatives should be applied to help the cedar resist the sun and weather.

Slate Roofing—Slate roofing comes in two types: premium clear pieces and ribbon slate. Ribbon slate is not as durable as the premium clear product. The ribbons of light color that run across its surface distinguish it. The ribbons are areas of high carbon content. They are an impurity in the slate and are weaker than the dark areas.

Slate may be gray, purple, green, or red. Properly installed, it has incredible durability. Old slate roofs may require repairs such as fixing an occasional cracked piece of slate.

Rough Costs

The information above and the costs in Table 1 were taken from an

Figure 5—A wooden shake roof.

October 1994 *Popular Science* article. These costs were verified by a Missoula contractor who thought the estimate that would still apply in the Northern Region (R1) in 1998. Estimated costs include the complete cost of installation and premium grades of roofing material in each category (Table 1). The estimates do not include the cost of any roof repairs or of removing old roofing materials.

Table 1—Estimated cost of roofing systems for sloped roofs.

Description	Comments	Installed Cost (Per 100 square feet)
Asphalt, 3-tab organic shingle	Lifespan of 10 to 15 years depending on climate.	$110
Asphalt 3-tab fiberglass shingle	Lifespan of 15 to 25 years. Lifespan may be shorter in cold climates.	$110 to $180
Architectural asphalt shingle	A heavy, laminated shingle with a 20- to 30-year lifespan.	$150 to $200
Aluminum shingle panels	Lifespan of 30 to 40 years. Panels look like tiles or wood shakes.	$350 to $450
Galvanized utility steel	In relatively mild climates, these roofs have 20- to 25-year lifespans. Expect fewer years in coastal climates.	$200 to $250
Standing seam steel, painted	Factory-applied coatings extend the lifespan of these roofs to 30 to 50 years.	$600 to $700
Concrete tile	Very long-lasting roofs with a lifespan of 40 to 50 years.	$500 to $600
Fiber-cement tile	Lifespan expected to be 30 to 50 years. Some types cannot be used in cold climates.	$400 to $600
Slate	The best grades of clear slate make a nearly permanent roof with a minimum expected lifespan of 50 years.	$600 to $1000
Cedar shake	With maintenance, the roof can last up to 30 years.	$215 to $255
Cedar shingle	With maintenance, the roof can last up to 30 years.	$225 to $265
Fire-retardant cedar shingle	With maintenance, the roof can last 30 years.	$335 to $375
Southern yellow pine shake	Pressure treatment reduces maintenance. The roof's expected lifespan ranges from 20 to 30 years.	$330 to $350
Wood composite shingle	A relatively new product that has only been on the market for 20 years. Its lifespan is not known.	$150 to $160
Glazed clay tile	Very long-lasting roof with a vitreous surface. Its expected lifespan is at least 50 years.	$700 to $800

Flat or Slightly Sloped Roofs

Single-Ply Systems

EPDM Single-Ply Systems— EPDM roofing uses large sheets of synthetic rubber that are unrolled on the roof. Seams are sealed in place using adhesives and special tapes. The roof is complete in a single layer. Ethylene Propylene Diene Monomer (EPDM) rubber is used to make the large sheets. It is a highly weather-resistant, synthetic polymer designed for thermal stability. It is blended with carbon black, oils, and other additives.

EPDM membranes are anchored to the building using one of three techniques. The ballasted membrane is the most common. It uses stone or concrete pavers (1-inch-thick rectangular blocks) to hold the roof down. The membrane is laid over insulation boards that are not anchored. The seams of the membrane are sealed and covered with a minimum of 10 pounds per square foot of nominal $1^1/_2$-inch rounded river bottom stone.

Mechanically attached systems use rows of fasteners to hold the membrane to the roof deck. Wind and thermal forces are transferred from the membrane to the fastener and, ultimately, to the deck. These systems vary greatly from manufacturer to manufacturer.

The last anchoring technique uses either a contact adhesive, sprayed foam, or asphalt to bond the rubber to the top of an insulation layer. The adhesives contain solvents. Any nearby air intakes should be closed to reduce the amount of solvent fumes entering the building.

EPDM is best suited for roofs with large open areas where the large panel size allows fast installation.

Cuts, tears, and seams are a major concern with rubber roofs. Ballasted roofs, with their thick stone cover, are hard to inspect. Leaks can be difficult to detect. Walkways should be provided to allow easier movement across the roof.

Thermoplastic—Edges of thermoplastic sheets are placed together and heat welded with hot air to form a continuous roof layer. These sheets are manufactured from thermoplastic resins, the most common being PVC and TPO. The sheets are reinforced with either a fiberglass or polyester scrim.

Thermoplastic systems (Figure 6) are often mechanically attached to the deck through the lap area. This lets them take maximum advantage of their light color and scrim reinforcement. When the seams are properly fused, they are as strong as the sheet itself.

Thermoplastic roofing works well on roof decks that will take a fastener, where good fire resistance is needed, and where concerns about seams are an issue. These systems are also puncture resistant and are highly resistant to certain chemicals.

These materials are very slippery when wet. On sloped roofs, walking on a wet roof can be dangerous. Some of the earlier products suffered premature failures, but today's products have overcome these problems.

Metal—The two basic types of metal roofing are architectural and structural. The architectural systems require that the metal be supported on a continuous deck. The structural systems can be placed directly on metal supports. Structural systems are generally watertight systems and can be used at slopes as low as $^1/_4$ inch of rise to 12 inches of run. Architectural systems generally require quick drainage to function. For architectural systems, the slope should be at least 2 inches of rise to 12 inches of run.

Galvalume-coated steel is the most popular metal for structural applications. Steel that is painted to complement the building design is the most popular metal for architectural applications. Other metals for architectural applications include aluminum, zinc, and copper.

Metal roofs (Figure 7) are used on buildings where the roof is visible. The roof should be less than 200 feet wide for architectural systems. Structural systems are well suited for buildings where some slope needs to be added to the roof.

Metal systems generally have a higher initial cost than other systems. The amount depends on the choice of materials used and on the system. For reroofing where slope needs to be added, the additional cost for a metal roof may not be that much higher than for an asphalt shingle roof.

Foam—Foam roofs combine an insulating foam that is sprayed in place and a protective layer. The protective layer is commonly a liquid coating applied over the foam. Although the foam is not the roof, it needs protection afforded by a coating or gravel because the foam is susceptible to damage from ultraviolet light.

Roofs that are most suited for spray foam include those that have a slope allowing them to drain, those that are still sound, and those that have unusual configurations. These roofs are manufactured by the operator as the foam is sprayed. This technique makes it easy to conform these

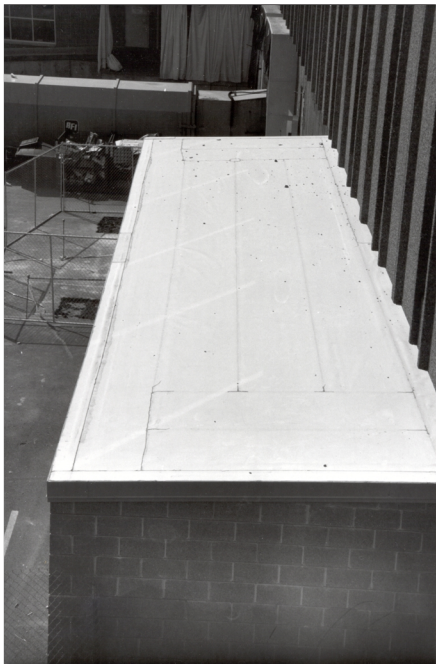

Figure 6—A low-sloped utility addition covered with a thermoplastic-resin roofing system.

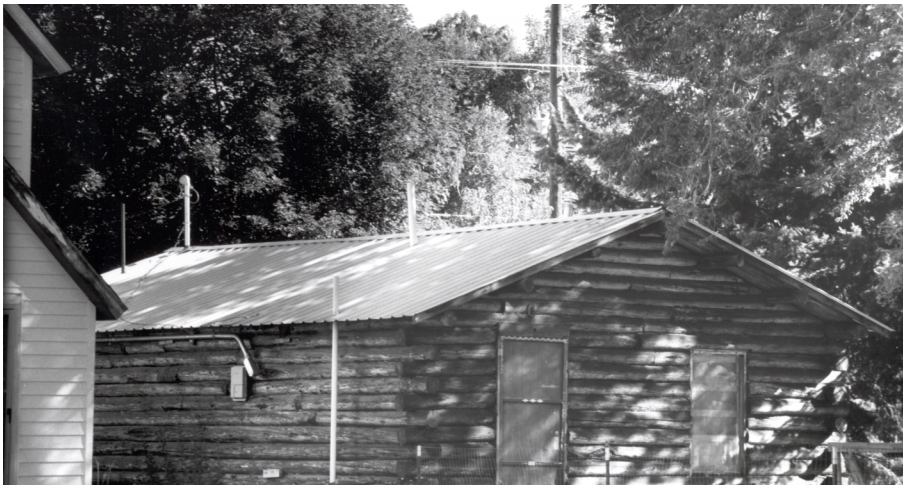

Figure 7—A log home with steel roofing.

roofs to unusual roof configurations.

These systems are more susceptible to roof traffic. Birds have been known to damage foam roofs. Adding roofing granules to the wet coating as it is being applied may deter birds. You may use foam systems known not to have the problem. Protection from ultraviolet (UV) light must be maintained for the foam to work. If a coating provides UV protection, the coating must be repaired when it is damaged.

Multiple-Ply Systems

Built-Up Roofing (BUR)— Typically, built-up roofing is the most common type of low-sloped roofing. These systems are "built up" from alternating layers of roofing felt and asphalt or tar. In the past, reinforcing felts were made from recycled rags, paper, and asbestos. Today the majority of roofs use fiberglass as the reinforcing felt. The roof functions by having the felt reinforce the thin uniform layers of waterproof bitumen.

Built-up roofing commonly is described by the layers of roofing felt that are overlapped (three ply, four ply). The waterproofing factor is determined by the bitumen layers and not the felt. Therefore, if you have three plies of felt (the minimum number of plies), you have two or more waterproofing layers, depending on the attachment of the membrane to the substrate and the top coating used. The felt provides the strength to resist thermal and other rooftop stresses. The system is adhered to the top of an insulation layer, or to a base sheet that is fastened to the roof deck.

Owner-maintained facilities usually use built-up roofing. With some training in-house staff can maintain these roofs. Repair materials are readily available and repair techniques are not difficult to master. Built-up roofs are reasonably resistant to abuse and are difficult to vandalize.

During installation, the smell can be very disruptive. Today's fume-control kettles greatly reduce the fumes and odor. Close supervision of installers is recommended because installation shortcuts are difficult to detect once the roof is installed.

Modified Bitumen—The waterproofing abilities of asphalt and coal tar can be compromised when they are made into moppable roofing grades. Polymers are used to modify the properties of asphalt so it will be stable over the wide range of rooftop temperatures. This modified bitumen is put onto a reinforcing carrier, cooled, and rolled up, creating a waterproof, weatherproof sheet. These sheets are assembled into the final roofing product.

Asphalt is commonly modified with either Styrene Butadiene Styrene (SBS) or Atactic (amorphous) PolyPropylene (APP) on a reinforcing carrier. The material can be attached by mopping (asphalt with SBS), torching it in place (asphalt with APP or SBS), or by using cold adhesives designed for the specific system (asphalt with APP or SBS). Some self-adhering systems are available for asphalt modifed with SBS.

Modified bitumen roofs are very versatile. These roofs can go on most buildings that have good drainage. The roofs are tough. When they are damaged, they are not too difficult to repair using cold repairs such as built-up roofing or by torching. These systems are cost effective on most buildings, especially those with a lot of flashing.

Open torches on the rooftop create a fire risk. Installation crews need to be knowledgeable about the system they are installing.

Table 2 (page 7) gives some specifications of the roofing systems described in this Tech Tip. They are taken from the article, *Understanding Roofing Systems*, by Ted Michelsen (Roofing Industry Education Institute Information Letter, summer 1998).

Roof Management Costs

Table 3 provides estimates of the costs of managing common roofs. Periodic inspection can save money.

Table 3—Roof management costs (from Tremco Co. newsletter, November 1998).

Maintenance Measure	
Periodic inspection of a roof with no corrective action required	$0.05 to $0.10 per square foot
Roof repairs with some corrective action required to prevent more expensive repair	$0.25 to $0.50 per square foot
Roof restoration or overhaul maintenance to significantly extend roof life	$2.50 to $5 per square foot
Tear off and replace the existing roof	$6 to $9 per square foot

Table 2—Some specifications of roofing systems described in this Tech Tip.

Criteria	Multi-Ply Roofing Systems				Single-Ply Roofing Systems				
	Built-up (coal tar)	Built-up (asphalt)	Modified Bitumen (APP)	Modified Bitumen (SBS)	EPDM	Thermoplastic	Structural Metal	Architectural Metal	Foam
Typical weight lbs. per sq. ft. *Fully adhered*	6 to 7	2 to 7	1 to 3	1 to 3	1 to 2	1 to 2	1 to 2	1 to 2	1 to 5
Mechanically attached					1 to 2	1 to 2			
Ballasted					11 to 15	11 to 15			
Speed of installation	Medium	Medium	Medium	Medium	Medium/ fast	Medium/ fast	Slow	Slow	Fast
Initial cost	Moderate/ high	Moderate/ low	Moderate/ low	Moderate/ low	Moderate/ low	Moderate/ low	High	High	Moderate/ low
Expected life with maintenance (years)	20+	20	20	20	20	15	20+	20+	20+
Warranty (maximum years)	20	20	20	20	20	15	20	20	10
Building interruption	Low/ high*	Low/ moderate*	Low/ moderate	Low/ moderate*	Low/ moderate	Low/ moderate	Low/ moderate	Low/ moderate	Low/ moderate
Maintenance expense	Low	Low	Low	Low	Moderate	Moderate	Low	Low	Moderate
Special maintenance and materials	Coal tar mastics and reinforcing mesh	Asphalt mastics and reinforcing mesh	Torch or special mastics	Torch or special mastics	Specialty material with limited shelf life	Sheet material and welder	Special tools and materials	Special tools and materials	Special sealants and foam
Traffic tolerance	Good	Good	Good	Good	Fair	Fair	Good	Good	Good
Reinforcements typically used	Organic, fiberglass	Fiberglass, organic	Polyester, fiberglass	Polyester, fiberglass	Polyester (when reinforced)	Polyester, fiberglass	None	None	None
Color availability	Gravel	Gravel, black granules, or coating	Granules or coatings	Granules, foils, or coating	Gravel, black, or coatings	Many colors or gravel	Many colors	Many colors	Many colors or gravel
Ease of inspection	Hard	Hard (gravel) Easy (exposed)	Easy	Easy	Hard (gravel) Easy (exposed)	Hard (gravel) Easy (exposed)	Easy	Easy	Easy
Insulations	Nonmelting overlay	Nonmelting overlay	Non-flammable	Nonmelting overlay	Most	Most, but can be applied directly to polystryrene	Fiberglass batts	Most	None other than foam
Best application**	Very low slopes	Most	Small to medium-sized, also those with limited access	Most	Large open areas	Exposed light-colored roofs on steel and wooden decks	Roofs needing additional slope	Steep roofs with aesthetic needs	Roofs with unusual configur-ations

* Low with the use of fume-control kettles
** These guidelines indicate where a particular type of roofing system may work better than another.

Common Roofing Problems

Sun

Heat and ultraviolet rays cause roofing materials to deteriorate over time. The deterioration can occur faster on sides facing west or south.

Rain

When water gets underneath the shingles, shakes, or roofing materials, it can work its way to the deck and rot the roof structure. The extra water can encourage mildew and rot elsewhere in the house, damaging walls, ceilings, insulation, and even electrical wiring.

Snow and Ice

Melting snow often refreezes at the roof's overhang (where the surface is cooler), forming an ice dam and blocking proper drainage into the drain or gutters. Water can back up under the roofing material and seep into the building's interior. In early stages of melting, gutters and downspouts can fill with ice and be damaged beyond repair or torn off the house.

Wind

High winds can lift edges of shingles or other roofing materials, forcing water and debris underneath them. Very high winds can do extensive damage and can lift the roofing material off the building.

Moss and Algae

Moss can grow on wooden shingles and shakes if they are kept moist by cloudy, wet weather or by bad drainage. Once moss grows, it keeps even more moisture on the surface, causing rot. The roots of moss work their way into the wood. Algae also grows in damp, shaded areas on wood- or asphalt-shingle roofs. Besides creating an ugly black-green stain, algae can retain moisture, causing rot and deterioration. Trees and shrubs should be trimmed away from the house to eliminate damp, shaded areas. Gutters should be kept clean to ensure good drainage.

Trees and Leaves

When tree branches touch the roof, they scratch and gouge roof material as they are blown back and forth by the wind. Falling branches from overhanging trees can damage or puncture shingles and other roofing materials. Leaves on the roof retain moisture and cause the roof to rot. Leaves in the gutters block drainage.

Condensation and Ventilation

Condensation can result from the buildup of relatively warm, moist air. Moisture in poorly ventilated attics promotes decay of the wooden roof sheathing and rafters, reduces insulation effectiveness, and can destroy the roof structure. To prevent these problems, attic ventilation can be increased by adding vents or installing larger vents to keep the attic temperature closer to the outside air temperature. Never block off sources of roof ventilation, such as louvers, ridge vents, or soffit vents. A rule of thumb recommended by the Federal Housing Administration is to provide 1 square foot of free vent area for each 150 square feet of attic floor if there is no vapor barrier under the insulation. If a vapor barrier is used, only half as much free vent area is needed.

Torn Shingles

The key to a roof's effectiveness is complete protection. When shingles are missing or torn off, the roof structure and the building's interior are vulnerable to water damage and rot. The problem is likely to spread if the roof is not repaired because nearby shingles are easily ripped off or blown away. Repair missing or torn shingles as soon as possible.

Shingle Deterioration

When shingles become old and worn out, they curl, split, and lose their waterproofing effectiveness (Figure 8). The weakened shingles are easily blown off, torn, or lifted by the wind. The result is structural rot and interior damage. A deteriorating roof only gets worse with time. It should be replaced as soon as possible.

Figure 8—These old shingles are rotten, allowing the elements access to the building's interior.

Flashing Deterioration

Many apparent roof leaks are really flashing leaks. Without good tight flashings around chimneys, vents, skylights, and wall/roof junctions, water can leak into buildings and damage walls, ceilings, insulation, and even the electrical system. Flashings should be checked twice a year when the roof is inspected and the gutters are cleaned.

Warranties, Materials, and Contractors

Different grades of materials can be used for roofing projects. The grade of material helps determine the expected life of the roof. Be sure you have the product you specify.

Check to see that the contractor is familiar with the product the contractor is installing and that the contractor is reputable. If you have a question about a contractor, you can check with the National Roofing Contractors Association for more information.

Some products have a warranty that covers the workmanship of the materials used. The contractor may specify a waranty for installation of the roofing system. Get this information before the job is started.

Additional Resources

Computer Programs
Roofer for Windows
This software was developed by the U.S. Army Corps of Engineers and is distributed by the Technical Assistance Center at the University of Illinois (217-333-2882). This database keeps an inventory of roofs that a manager is responsible for. A ROOFER GIS software package is also available. This package allows GPS information to be attached to notes so that a contractor can mark areas on large roofs that needs attention.

Advisor Software
Impact Software Systems
600 Cleveland St., Suite 760
Clearwater, FL 33755
Phone: (813) 466-9220

Payback Estimating System
Crossroads Technical Group, Inc.
http://www.paybackestimating.com

This software package contains a good database and is easy to use. The cost starts at $3,000. The package has a database of many commercial designs, making information easy to obtain.

Internet Sites

Advanced Roofing Technology
http://www.advanced-roofing.com/productsservices/commercial_directory.htm
Information on commercial product types.

Single-Ply Roofing Institute
http://www.spri.org
Information on single-ply roofing products.

Sweets Group
http://www.sweets.com
An index of metal roofing and metal roofing manufacturers.

Architectural Engineering Construction
http://www.aecinfo.com/bpl/div07/index.html
Information on shingles, roofing tiles, and metal roofing.

National Roofing Contractors Association
http://www.nrca.net
Information on roofing contractors, items of interest to consumers, and technical reference books on roofing.

Books, Manuals, and Periodicals

Roofing, Construction, and Estimating, by Daniel Atcheson,
Craftsman Book Co.
6058 Corte del Cedro
P.O. Box 6500
Carlsbad, CA 92018

Roofers Handbook,
by W.E. Johnson
Craftsman Book Co.
6058 Corte del Cedro
P.O. Box 6500
Carlsbad, CA 92018

National Roofing Contractors Association (http://www.nrca.net) has many technical roofing articles and references for sale.

Professional Roofing magazine
National Roofing Contractors Association
10255 W. Higgins Road, Suite 600
Rosemont, IL 60018-5607

The Roofing Industry Educational Institute
14 Inverness Drive East,
Building H, Suite 110
Englewood, CO 80112

Buildings,
Stamats Communications, Inc.
427 Sixth Ave. SE
P.O. Box 1888
Cedar Rapids, IA 52406-1888
Phone: (319) 364-6167

The Handbook of Accepted Roofing Knowledge (HARK)
The National Roofing Contractors Association
10255 W. Higgins Road, Suite 600
Rosemont, IL 60018

The Manual of Low-Slope Roofing Systems
by C.W. Friffin and Richard Fricklas
McGraw-Hill
11 West 19th Street
New York, NY 10011

Roofing: Design Criteria, Options, Selection
by R.D. Herbert III
R.S. Means, Inc.
100 Construction Plaza
Kingston, MA 02364-0800

Architectural Sheet Metal Manual
Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
4201 Lafayette Center Drive
Chantilly, VA 20152-1209

Copper & Common Sense
Revere Copper Products, Inc.
P.O. Box 300
Rome, NY 13442-0300
http://www.reverecopper.com

Design and Application Manual for New Roof Construction
Cedar Shake and Shingle Bureau
515 116th Ave. NE #275
Bellevue, WA 98004-5294
http://www.cedarbureau.org

Magazine Articles and Brochures

Topping Off
by Roy Berendsohn, Popular Mechanics Magazine
October 1994.

Understanding the Roofing Systems
by Ted Michelsen
RIEI Information Letter (Roofing Industry Educational Institute), summer 1998.

Roofing, National Roofing Contractors Association
10255 W. Higgins Road, Suite 600
Rosemont, IL 60018

About the Author…

Dick Karsky has a bachelor's degree in agricultural engineering from North Dakota State University and a master's degree in agricultural engineering from the University of Minnesota. Dick is a registered Professional Engineer (PE). He worked for Allis-Chalmers Manufacturing Co. and White Farm Equipment Co. before coming to the Missoula Technology and Development Center in 1977.

Additional single copies of this document may be ordered from:

USDA Forest Service
Missoula Technology and Development Center
5785 Hwy. 10 West
Missoula, MT 59808-9361
Phone: (406) 329-3978
Fax: (406) 329-3719
IBM: pubs/wo,mtdc
E-mail: pubs/wo_mtdc@fs.fed.us

For additional technical information, contact Dick Karsky at the address above.

Phone: (406) 329-3921
Fax: (406) 329-3719
IBM: dkarsky/wo,mtdc
E-mail: dkarsky/wo_mtdc@fs.fed.us
Lotus Notes: Richard J Karsky/WO/USDAFS

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