For a leak-free BUR, choose materials that are appropriate to the climate and slope and pay careful attention to flashings, penetrations, and terminations

BUILT-UP Hot-Mop Roofing

by David Lopez

During my 30 years in the roofing business, I've installed many types of roofing and seen a number of products come and go. But one system that never goes out of style is the traditional built-up hot-mop roof. I learned how to do built-up roofing (BUR) during my early years in the trade, and my company continues to do it to this day.

It's not that we have anything against other types of roofing: We also install wood shingles, asphalt shingles, tile, and slate. But if a roof's pitch is shallower than 4 in 12, we're limited to using BUR or some kind of single-ply membrane, and my preference is the built-up roof.

BUR vs. Newer Systems

I've installed various kinds of single-ply membranes for previous employers, and until recently my company also did some modified bitumen torch-down roofing. While single-plies typically cost more than BUR, the installed cost

Figure 1. BUR is applied over wood, concrete, steel, or foam insulation. The original part of this house has one-by board sheathing, but the addition has plywood. Either substrate is fine, as long as it's structurally sound and solidly fastened.

Figure 2. Fiberglass felts will not take tight bends, so the crew installs cant strips at inside corners.

Figure 3. The base sheet goes over rosin paper and has 2-inch laps.

for torch-down is about the same. Torch-down became popular with roofers and GCs several years ago because it's flexible, takes less labor to install than BUR, and doesn't require the use of liquid asphalt (see "Torch-Down Roofing Basics," 8/01). The problem was that so many house fires were started with the torch, insurers have made torch-down too expensive for many roofers to install.

Fortunately, we never stopped doing conventional hot-mop roofs. The method has been around for more than 150 years and has a great track record. Depending on the design, a properly installed hot-mop roof will last 15 to 25 years. It's one of the least expensive low-slope systems out there, so it has a low life-cycle cost.

I like BUR because, unlike single-ply membranes, it has a built-in redundancy, thanks to the multiple layers and substantial laps.

As a GC, it's unlikely you'll ever install BUR yourself, but if you are advising the client or supervising the job, it helps to understand how the system works and what it takes to lay up a durable roof.

Components of BUR

My partner, Barry Wilkes, uses the analogy of a layer cake to describe BUR to customers. The base sheet and felts are the cake, and the hot asphalt is the icing that gets spread between the layers and over the top. The aggregate is like the sprinkles that get scattered

across everything.

The asphalt fuses the felts together, forming a waterproof membrane. The felts reinforce the asphalt and prevent it from cracking. The aggregate protects the surface of the membrane from fire and mechanical damage — and, even more important, it prevents the asphalt from being degraded by the sun's ultraviolet rays.

A typical built-up roof has a base sheet, two or three layers of felt, and three or four layers of asphalt. It's about 1/2 inch thick without the aggregate and about 3/4 inch thick with the crushed stone. A full tar-and-gravel system weighs about 450 pounds per square. If, instead of gravel, you use a cap sheet (an asphalt-impregnated felt covered with a thin coat of aggregate), the roof covering will weigh about 220 pounds per square.

Substrates. We do most of our residential work on existing homes and additions. The process of installing a built-up roof is the same for both, with one difference: On an existing structure, the old roofing has to be removed and the substrate may need to be repaired. BUR can be installed over wood, concrete, steel, or foam insulation — but in residential, it's nearly always wood.

In newer construction, the roof will be sheathed with plywood or OSB. Houses built before 1950 may have wood board sheathing (see Figure 1, facing page). The 1/4-inch gaps between boards are not a problem, but if the surface is excessively lumpy it has to be skinned with 1/2-inch plywood or a layer of perlite insulation board.

BUR can be installed on slopes of up to 4 in 12. It can also be installed on dead-flat surfaces, though it's better to have at least some slope, so the roof will drain. A flat roof can be sloped by covering it with a layer of tapered insulation, but most customers are unwilling to spend the $150 per square it takes to buy and install this material. Sloping a built-up roof does not prevent leaks, but it does reduce the amount of water that gets through if a leak occurs.

Figure 4. A roofer beds a scupper flashing in roofing cement (left) before fastening it over the base sheet (right).

Figure 5. Flashings are primed to make the hot asphalt stick better. Note the caps under the nails that hold the base sheet to the roof.

Figure 6. Different types of asphalt have different softening points. The type 3 material shown here softens at about 200°F but is applied at over 400°F.

Asphalt should not be applied to damp surfaces, because trapped moisture can cause blistering.

Cant strip. The fiberglass felts we use have a memory, meaning they'll break or try to flatten back out if you bend them into the 90-degree inside corners at parapets, chimneys, and curbs. If the felts lift, this defect, called a fish mouth, weakens the membrane and creates paths for water to get into the building.

To avoid this problem, we install 45-degree cant strips at inside corners. The strips, made from a composition material containing perlite, are nailed 12 inches on-center (Figure 2).

Base Sheet

After the cant strips are installed, we cover the sheathing with a layer of red rosin paper, which functions as a slip sheet for the base sheet to follow. The base sheet is an asphalt-coated "fabric" mat. Years ago, these mats contained asbestos. Manufacturers later switched to organic fibers, which tend to absorb moisture and rot. The mats are now made with synthetic materials like fiberglass.

We normally use a Johns Manville base sheet called PermaPly 28. It's a heavier version of the felt used to reinforce the hot asphalt. The base sheet needs to be heavy because it's nailed to

the deck and you don't want fasteners pulling through. It also has to span small gaps in the sheathing.

The base sheets are applied shingle-style up the roof with approximately 2 inches of overlap at the joints (Figure 3, page 2). On wood substrates, the base sheet is typically fastened with 6d nails with 1-inch caps spaced 6 to 9 inches on-center at the edges and 12 inches apart in the field. The base sheet runs to the top of the cant strip and is cut or notched to fit around plumbing vents and other penetrations.

Flashings

After the base sheet is down, we install flashings. The project pictured in this article was a reroof, so we had to replace the flashings around vent pipes and at the scuppers. If there hadn't been a parapet, we would have installed gravel stop flashings at the edge. Flashings come in aluminum or galvanized steel; either type works on a hot-mop roof.

We bed the flashings in plastic roof cement, nail them to the sheathing, and prime them with a spray-on or brush-on asphalt primer (Figure 4, page 3). With torch-down, it's standard procedure to lay up the entire roof, then patch in around scuppers and plumbing vents. It's possible to do this with hot-mop, too, but installing the flashings before the asphalt and felts are applied leaves fewer seams (Figure 5, page 3).

Asphalt

There are two kinds of asphalt used in residential BUR: standard and modified. Both are made from bitumen, but the modified materials contain additives that increase flexibility and lessen susceptibility to fatigue.

There are also different types of standard asphalt. Some are designed to produce fewer fumes when melted, but the main difference between types has to do with softening points.

Standard asphalt is available in types 1, 2, 3, and 4 (Figure 6, previous page). The lower the number, the lower the softening point, measured in degrees Fahrenheit. Asphalts with low softening points weather particularly well because they remain more flexible in cold weather. However, high outdoor temperatures can soften asphalt, and if the pitch is steep enough it may begin to slide down the roof.

To prevent that from happening, choose a type of asphalt based on local weather conditions and the slope of the roof. Type 1 works for dead-flat roofs and types 2, 3, and 4 suit re-

CAUTION

The fumes from molten asphalt are a suspected carcinogen and, with repeated heavy exposure, can produce a number of negative health effects. This is primarily an issue only for roofers and people who manufacture roofing products. However, in some jurisdictions there are rules about when, where, and if you can use hot asphalt. In some cases, you can comply by using a low-fuming product or a kettle that's equipped with a filtration device. In other cases, you may need to switch to a cold-applied bitumen or use a different roofing system. — *D.L.*

Figure 7. A roofer carefully slips another chunk of asphalt into the kettle. Splashed asphalt can cause serious burns, which is why he is wearing gloves, long sleeves, and face protection.

Figure 8. On small jobs, the hot asphalt is carried to the roof in buckets. This job was large enough that it made sense to pump the asphalt up in temporary pipes before transferring it to buckets or wheeled carts.

spectively steeper pitches.

Where we work, the weather is moderate; temperatures rarely go below freezing or above 85°F. But if we were to do a job 20 miles farther inland, the roof would have to withstand summer temperatures that frequently exceed 100°F. The roof in the photos was made with type 3 asphalt; farther inland, we would have used type 4.

Melting. Most contractors have never been up on the roof while BUR was being installed, but everyone has seen the kettle on the ground, which is built onto a trailer and uses propane to melt the asphalt (Figure 7, previous page). My kettle holds up to 350 gallons and is equipped with a pump that moves asphalt to the roof through steel pipes (Figure 8, facing page). The asphalt we use comes in 100-pound cylindrical plugs; we break the plugs into smaller pieces with an axe and put them in the kettle to melt.

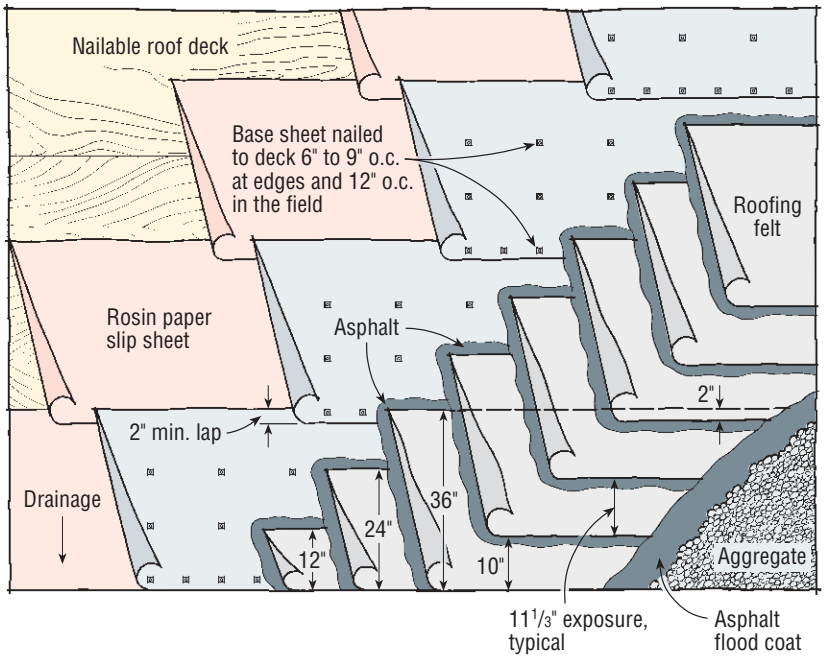
It's important to maintain the proper temperature when melting and applying asphalt. If the kettle is too hot, the asphalt could catch fire or be degraded by overheating. If that happens, it won't perform properly.

We frequently use Trumbull's type 3 asphalt, which is designed to be applied to the roof at 410°F, plus or minus 25°F. At this temperature, it has the correct viscosity to properly bond the felts. If the asphalt is too hot, it goes on too thin. If it's too cool, it will go on too thick and will not fully bond the felts, producing a membrane prone to cracking. Of course, the kettle must be hotter than the application temperature because the asphalt will cool on its way to the roof.

Once the hot asphalt gets to the roof, we transfer it to buckets or wheeled carts and haul it to the area where we're working. Hot asphalt can give you a really nasty burn, so whenever we move it we yell "Hot!" to alert everyone around to be on guard. It's a bad idea to work below a hot-mop roofing crew: If a bucket is tipped, hot asphalt could slosh over a skylight curb or pour off the edge of the roof.

Built-Up Roof Layout

Four-Ply Roof



Five-Ply Roof

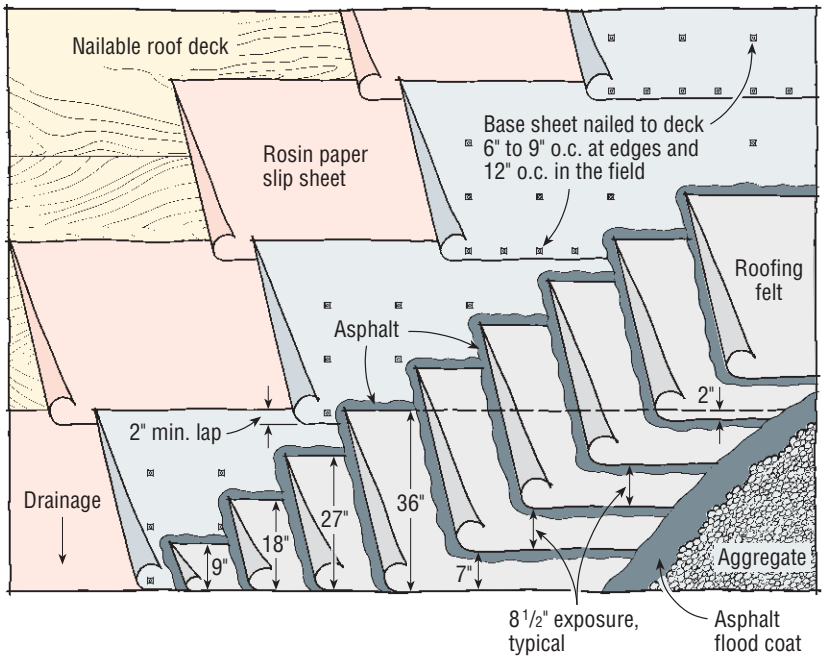


Figure 9. The same materials can be laid up different ways. Most residences have framed wood roofs, so the first waterproofing layer is a nailed-on base sheet. Successive layers of felt are bedded in hot asphalt and covered with a cap sheet, an emulsion coating, or, as is shown here, a flood coat of asphalt and loose aggregate. Because the base sheet qualifies as a layer, a base sheet plus three layers of mopped-in felt constitutes a four-ply roof.

Figure 10. Hot asphalt is mopped onto the base sheet and felt in preparation for the next layer of material (left). These roofers are applying the first full-width piece of felt. There's already a 12-inch and a 24-inch strip below (right).

Figure 11. The roofers apply successive layers of felt over hot asphalt. On this roof, full sheets lap 2/3 onto the sheets below, which means there will be at least three layers of felt plus one layer of base sheet at any given point.

Mopping in the Felts

The roof is laid up from low to high, a section at a time. We apply the asphalt with a large fabric mop. The first coat goes on the base sheet and is immediately followed by a layer of felt, which must go on while the asphalt is hot. We then lay successive layers of felt onto freshly applied asphalt. The roofing stiffens and solidifies as the asphalt cools.

The roof shown in this article has four layers — a base sheet plus three layers of felt (Figure 9, previous page). Built-up roofs typically have three, four, or five layers. A roof with three layers should last about 15 years. Each additional layer adds another five years.

Laps. The number of layers determines how the felts should lap. The felt we use comes in 36-inch-wide rolls, so if there are to be three layers, we install a 12-inch strip along the edge of the roof, lap it with a 24-inch strip, and then lap them both with a full 36-inch piece (Figure 10). That gives us three layers of felt at the edge of the roof — four layers if you include the base sheet below. Each felt is mopped with hot asphalt before the next layer is applied.

Once the joint offset is established, the remaining felt layers are applied

Figure 14. Loose aggregate will not stick to vertical surfaces, so the crew covers parapets with cap-sheet material. The roofers mopped hot asphalt onto the back of the sheet and are flipping it into position.

Figure 12. It's possible to flash penetrations after the bulk of the roof is done, but this roofer is laying the roof over the flashings, an approach that creates fewer seams.

Figure 13. Most leaks happen at flashings and penetrations. To keep water from entering, crew members seal terminations with roofing cement (above). They then coat the cement with aluminum paint to protect it from UV rays (right).

full-width, lapping 24 inches onto the sheets below (Figure 11, above).

Terminations

We take special care at edges and around penetrations like vents and scuppers: If a roof ever leaks, it's likely to be at a penetration or termination point (Figure 12, next page).

To seal the joint between a plumbing vent and the flashing that surrounds it, for example, we apply a coat of plastic roofing cement, embed a strip of fiberglass mesh, and then give the joint another coat of roofing cement. The cement extends down far enough to cover the joint between the felts and flashing, and we slope it so it sheds water (Figure 13, next page).

Because UV rays will eventually break down exposed roofing cement, we paint it with an aluminum roof coating.

Parapets. We waterproof parapets with a two-ply finish that consists of a base sheet and a cap sheet with hot asphalt between. The sheets start at the top outside edge of the wall and lap onto the cant strip. It would be messy and dangerous to mop hot asphalt onto the parapet wall, so instead we mop the back of the cap sheet before lifting it into place (Figure 14, next page).

There are a number of ways to tie into the exterior wall finish. In some cases, three-coat stucco wraps over the wall and terminates at a weep screed on the inside face of the parapet. You might think the stucco would leak on top of the parapet, but it's installed over BUR, building paper, and a layer of self-healing peel-and-stick membrane. If any water gets through, it should drain to a weep (Figure 15, page 8).

Metal termination strips are available that allow you to replace the roof without damaging existing stucco. Or you can remove the stucco from the inside of the parapet, run the BUR over the top, and cover the top with a finish metal cap that laps both sides of the wall.

Aggregate Surface

The asphalt in a built-up roof will deteriorate if it's not protected from UV rays. One way to provide that protection is to cover it with a stone aggregate. Crushed granite is the standard covering in my area, but pea gravel is sometimes used on commercial jobs.

After the felts are installed and we've coated all the flashings with plastic cement, the roof is given a final extra-thick mopping of asphalt. After that, we spread the aggregate over the asphalt. Some of it sinks in, so we keep adding it until no asphalt shows through (Figure 16, next page).

If the roof surface is visible from the street, the client may choose a decorative aggregate, such as 1/2-inch or 1-inch white dolomite. We've also used various landscaping rocks and a type of red lava rock that blends nicely with clay tile on steeper parts of the roof.

Alternative coverings. Loose aggregate cannot be used on pitches over 3 in 12 because it will slide. On steeper roofs, we can protect the BUR with a cap sheet, which contains felt, asphalt, and a thin coating of aggregate. Another method is to coat the roof with a clay emulsion coated with aluminum paint. The problem with this method is that you need 24 to 48 hours of completely dry weather to apply the clay and paint.

Maintenance and Repair

Built-up roofs last longer if they are maintained. We recommend inspecting the roof once every five years. Periodic maintenance involves

Figure 15. For houses with three-coat stucco finishes, the standard detail is to run the finish over the parapet and terminate it at a weep screed just above the roof. A cap sheet, building paper, and a layer of peel-and-stick membrane prevent the water that seeps through the stucco from getting at the framing. If the exterior finish is wood or masonry, the top of the parapet is covered with a large metal cap.

removing piled-up leaf debris, which can break down to form acids, and using roof cement to reseal around vent pipes and scuppers.

BUR is pretty simple to repair. First, we cut out the damaged area. Then we spud the gravel back from the edge of the cut about 12 inches.

We clean the area where the gravel was removed and prime it with an asphalt primer. Next, we patch the damaged section with layered felts and asphalt that lap and feather onto the area that was primed. Last, we re-cover the section with gravel (or a cap sheet or coating, depending on what had been there originally).

***David Lopez** has more than 30 years of experience in the roofing industry and has installed nearly every type of roofing system. He is the co-owner of Advanced Roofing Services, Inc., in Alameda, Calif.*

Roof-to-Parapet Detail

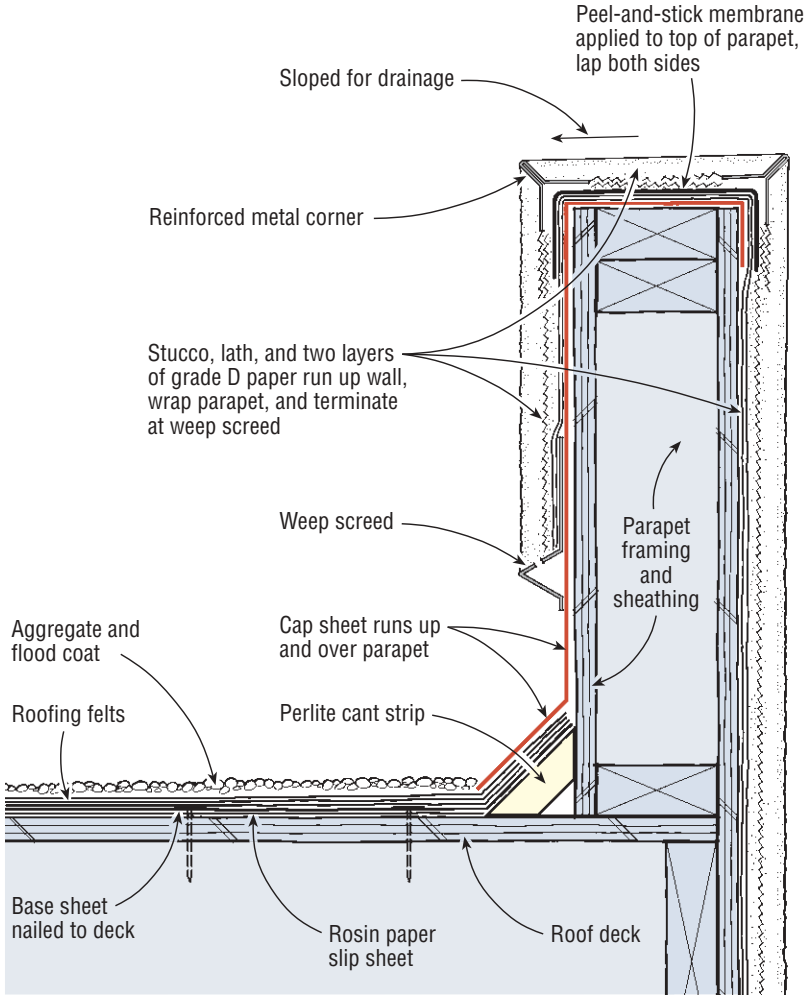


Figure 16. Here, one roofer lays down a thick flood coat of hot asphalt while another spreads crushed granite aggregate on top (left). Since the aggregate protects the roof from UV rays, no asphalt should be visible when the roof is done (above).