Single-ply Roofing Systems for Commercial Applications

When it comes to the design of commercial buildings, more and more architects are opting for low-sloped roofs. Low-sloped roofs cost less to build, reduce the total volume of conditioned air in the building, and conveniently provide an out-of-the-way location for heating, cooling and fire suppression equipment. Specifying a roofing material for low-sloped roofs traditionally meant built-up roofing (BUR) and using asphalt or coal tar. Recently though, variations on single-ply roofing membranes have dominated the market. With so many options, styles, and technologies available, it is more important than ever that architects understand the differences between single-ply roof membrane systems and where best to specify these.

Learning Objectives

After reading this article, you should be able to:

1. Explain the different material types, properties and characteristics of TPO, PVC and EPDM roofing membranes.
2. Describe the different system applications and performance characteristics.
3. Identify the flashing and seam-sealing methods for the different roof assemblies available.
4. Explore how to match system and installation methods when considering which system best fits your design criteria.

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The main goal of any roofing project is to avoid water penetration. Mitigating damage from a leaky roof is expensive and time consuming. Low-slope roofs are not perfectly flat but have a slight pitch to keep water from pooling. If a roofing membrane develops a hole or if the seams are not sealed adequately, water can cause damage to a roof and eventually find its way into a structure. If a roof pools or leaks, it can cause sagging or deterioration, damage or weakening the roof membrane, and inevitably causing water damage in the structure. Water runoff from rain or snow on a properly designed, constructed and maintained low-slope roof poses few problems. A roof exposed to extreme weather or sudden weather changes, or a roof that is accessed frequently, can have a shorter lifespan. When planning the type of roof for a structure, you want to seek a roof that will perform, but that also is aesthetically pleasing and fits into a budget.

A Walk Through of Roofing Options

Before diving in the world of modern single-ply low-slope roofing options, it's helpful to have a historical perspective on traditional materials and systems. Though still in use, the last 15 years have shown a significant trend away from built-up roofing and similar systems and the industry has moved rapidly towards single-ply materials.

The "Old Reliable" asphalt roof

BUR is time-tested, and still enjoys some ardent followers today. BUR is installed by imbedding roofing felts in modified hot asphalt. This process is done multiple times, common selections are 3, 4 or 5-layer systems, and then covered with coarse gravel. An updated twist on the BUR is to use a granular cap sheet, or field applied reflective coatings to provide additional thermal and UV protection. Because there are multiple layers involved in installing BUR systems, this choice tends to be robust and durable, but also has a few drawbacks. The binding agent for a successful installation is the asphalt which can be labor intensive to install. Also, the process invariably means that the area in and around the building will have to tolerate the distinct odor of melted asphalt during the installation process. In some situations where high customer traffic must be maintained, the strong fumes can be off-putting and reason enough for building owners to move onto another roofing material option.

Styrene Butadiene Styrene (SBS)

SBS roofing systems are bituminous based systems that have been modified with rubber that enables the material to remain flexible for a wider range of temperatures. This is especially beneficial in colder climates. SBS has been around since the mid-1970's and has four primary installation options including torch, hot asphalt, cold applied and even self-adhering rolls. Because of the multiple installation options, SBS can be installed year-round regardless of ambient air temperatures, a handy option when construction dates shift to cooler months. These rolls are reinforced with usually polyester or fiberglass which makes the material very durable, while also allowing for customizations to satisfy specific design needs. On the down side, SBS does not weather well if constantly exposed to a high level of oil or hydrocarbon-based chemicals. Also, installation costs can require a longer return on investment window, meaning short-term owners looking to "flip" a property may not want to shoulder the initial cost. Another consideration with SBS is that it is important that an experienced (and certified) contractor be selected for the installation process.

Atactic Polypropylene (APP)

APP is designed to have a higher softening temperature, and is ideal for installation in hotter climates. The basic chemistry is similar to SBS, but can be more brittle at colder temperatures. The bituminous material has been modified with a crystalline plastic which allows it to remain stiff in high temperature situations, and ideal attribute for areas that experience both extreme heat and strong wind events. The resistance to heat means that there are only two viable installation methods, cold adhesive or torch application. Most APP systems include polyester reinforced backing and fiberglass reinforced which gives the material a higher tear strength. While APP systems perform well in high temperature regions, they are not recommended for cold climates, and due to the technical nature of the installation process, fewer qualified contractors are available for projects.

The Rise of Single-ply

BUR systems require multiple layers of roofing material and asphalt in order to create a waterproof and durable surface. Likewise, SBS and APP systems utilize multiple layers including a base ply, and an adhesive layer under the SBS or APP cap ply to finish the installation.

By contrast, single-ply roofing materials can be installed directly on the approved roofing substrate. This can drastically reduce installation time, material costs and also allow for easier installation. The performance, cost and installation advantages of single-ply materials compared to traditional multi-layered systems has greatly increased their acceptance in the market. However, to fully appreciate the advantages of single-ply roofing materials, it is important to understand the variations in single-ply products and how they are produced.

There are three popular types of single-ply low-slope roof projects: EPDM, PVC and TPO.

EPDM - Cured Ethylene Propylene Diene Monomer

The development of EPDM, or rubber roofing, offered a system that is typically easier and more efficient to install than asphalt or coal tar BUR. The first EPDM roof membrane was created in 1965, two years after EPDM rubber production began. EPDM, as a roofing material, is traditionally black and has the same feel as the rubber used in tire inner tubes. In the early 1980s, white EPDM became available as a color choice, and butyl-based adhesives replaced the neoprene-based adhesives. Several years later, reinforced EPDM entered the United States market. In 1992, reinforced fastening strips and seam tape replaced seam adhesives.

Raw materials used to create EPDM include equal parts polymer and carbon black (for UV resistance), comprising about 50-60 percent of the formula. The rest is of the materials generally are used for processing, fire resistance and stability.

During manufacturing, the thermoset EPDM is created through the chemical cross linking of polymers, or molecular chains. A distinguishing characteristic is that EPDM can only be bonded to itself during installation by use of an adhesive or tape because, once cured, new molecular linkages cannot be formed. The material can be extruded or calendered into sheet form and can be reinforced with a polyester scrim for higher tear strength performance. It is important to note that extruded sheets have fewer pockmarks and air inclusions than calendered sheets.

EPDM performs well because it is highly UV stable due to the carbon black and has relatively high installation efficiency and consistency. The installation of thermoset and thermoplastic materials will be discussed in depth later in this article.

Polyvinyl Chloride (PVC)

Also called vinyl, PVC is composed of ethylene and chlorine. In its compounding process, vinyl resin is blended with biocides, color pigments, heat stabilizers, ultraviolet light inhibitors and plasticizers. PVC is recyclable and fire-resistant, and it uses fewer petrochemicals than other roofing systems.

A PVC roof consists of a single-ply membrane composed of two layers of PVC material covering a reinforcement scrim. The top layer is UV-resistant and flexible and can take on color through pigmentation. The bottom ply is often grey or black PVC and contains more plasticizers for flexibility and weldability. The reinforcements for PVC are typically polyester or fiberglass (when not mechanically fastened) and are added to provide increased strength, longevity and dimensional stability performance enabling the material to be a long-term, proven roofing solution with multiple installation options.

After a century of fine tuning and technological improvements to the workable flexibility by the inclusion of plasticizers, in 1985 PVC became the first single-ply roofing system to earn a standard from what is now ASTM International—ASTM D4434. At present, all commercial PVC roofing membranes are reinforced.

Thermoplastic Polyolefin (TPO)

TPO was introduced in the 1980s. TPO includes polymers as delineated in ASTM D5538.

In the polymer manufacturing process, polypropylene with ethylene-propylene rubber are polymerized; the polypropylene improves weldability and the ethylene-propylene enhances durability. This polymer is then used with other key ingredients like fire retardants, UV stabilizers, antioxidants, and pigments to produce TPO roofing membranes. Typical TPO incorporates both a cap and core membrane with a polyester reinforcing scrim encapsulated between these layers. The cap is up to 75 percent TPO polymer with 25-35 percent fire retardants, as well as small amounts of pigment and UV stabilizers. The core membrane is similarly composed but includes up to 15 percent recycled TPO and it doesn't need UV protection.

Thermoset and Thermoplastic: All About Heat

Plastics are polymers that can be divided into two classes—thermoplastics and thermosets. The main defining difference is based on their behavior in the presence of heat. The material difference between the two is that thermoplastics have a lower melting point and can be heated and melted again, while thermoset plastics can withstand higher temperature without deformation and remain in a permanent solid state.

Single-ply roofing materials are either thermoset, or thermoplastic. EPDM is a thermoset while PVC and TPO are thermoplastics. There are advantages and disadvantages to each type. Thermosetting plastic can be very resistant to high temperatures, allow for flexible design options, and can be cost effective. On the down side, it cannot be recycled, remolded or reshaped after installation.

Thermoplastics have the advantage of being highly recyclable, are impact- and chemical-resistant, and can be reshaped. The main disadvantage is cost since they can be slightly more expensive than thermosets.

Thermoplastic roof membranes, both PVC and TPO, can be produced in three ways: calendering, spread coating, or extruding. The extrusion process, which was developed from and improves on calendaring, is most common. In extrusion, the formulation is heated then forced through an extruder die onto the reinforcing fabric. From there the sheet continues through some calender rolls and the second layer is then applied in the same fashion as the first. The reinforcement is now encapsulated in the thermoplastic membrane between cap and core and can be processed into a finished roll good. There are generally two formulations of PVC membranes. One contains only PVC. The second involves a product developed by DuPont called Elvaloy KEE. Mixed with PVC, Elvaloy is a soft, high-molecular-weight polymer plasticizer.

Understanding Single-ply Roofing Applications and Performance Characteristics

Designers have many choices when specifying a roof system. It is important to identify the characteristics you need in the roof system before making a selection.

To ensure a single-ply roof system will perform for years to come, it is crucial to hire a knowledgeable, experienced roofing contractor. Consult your manufacturer and specific publication guides, as well.

Now let's take a look at the applications, performance characteristics, and general attributes of the thermoset and thermoplastic single-ply roofing membranes.

Thermoset—EPDM

EPDM has been a reliable material in the low-slope commercial roofing industry for decades, and its sustainable and durable nature make it a good choice for many applications. It's ideal for low-slope roofing. It can also be used for terraces and balconies, garden roofs, outbuilding and garage roofs, foundations, tunnels, through-wall flashings and flat roof extensions. It can either be mechanically fastened to a substrate or installed by adhesion, or with a ballast system where natural stone or pavers are used to hold the material in place, depending upon the type of EPDM being installed. EPDM withstands temperature extremes and does not absorb moisture.

EPDM membranes come in many sizes and are available as either reinforced or non-reinforced sheeting from 10 to 50 feet wide and up to 200 feet long. Depending on the roof design the larger sheets can be more economical to install. They come in varying thicknesses from .045 to .09 inches thick. Fleece can be added to the underside for alternate application methods.

Well-constructed, thoughtfully installed, and consistently maintained EPDM roof systems are very resilient. EPDM systems are known for their longevity, lasting 30 years or more. They have been shown to withstand extreme weather patterns. EPDM is resistant to the ozone, as well as scuffing, abrasion and impacts from hail. The roofs are durable, even against thermal shock, and also resistant to heat and fire. EPDM's resistance to strong winds is an attractive attribute. An EPDM roof system can attain wind uplift criteria of FM Class 1-60, 1-90 and 1-120 or more.

EPDM sheets are available in black or white; both options are smooth and have reflective surfaces that can lower energy costs. White sheets may not be as UV

resistant as black EPDM sheets. Still in any climate, EPDM roof membranes function well. Seaming technology has improved reliability with tape-applied installation methods.

EPDM can be susceptible to swelling if exposed to solvents or oils, so it is important to protect affected areas. Most sheets are non-reinforced, as reinforced sheets can delaminate if water penetrates, so typically only consider reinforced sheeting for mechanically attached applications. Reinforced sheets, however, may offer more resistance to punctures and tearing.

EPDM is known for its low installation cost and lifetime economic value, and it can also be a component of "green" building envelopes. The material is relatively easy to repair and modify as needed, and it provides excellent resistance to ozone, abrasion and weather, along with superior resistance to extreme heat and fire. Finally, reclaimed EPDM membrane can be ground down and reused.

Thermoplastic—PVC and TPO

Thermoplastic membranes—PVC and TPO—are similar to thermoset or EPDM membranes in application and usage, but their structure includes no chemical-crosslinking. Thermoplastic sheets can run from 5 to 12 feet in width. Factory-welded larger sheets are available from some manufacturers.

The lap seams are heat-welded on site, to form an equally strong layer to avoid leaks and keep maintenance to a minimum. Thermoplastic roofs always include a layer of reinforcement. Thermoplastic roofing membranes can be fully-adhered to an approved substrate or mechanically fastened to the building structure.

Both PVC and TPO are suitable for low-slope and commercial roofing applications. A fleece-backed thermoplastic membrane may be ideal for applications that cover abrasive surfaces. One of the oldest single-ply roofing types still in use today, PVC membranes and PVC blends have been verified as highly stable and durable. PVC roofing materials are the most resistant to oils and grease and thus a wise selection for roofs with exposed to exhausts (kitchens, manufacturing facilities, etc.).

Introduced in the 1980s, TPO membranes are the newest membrane on the market. They are typically white, and they differ from PVC in that they do not use added plasticizers for flexibility. The National Roofing Contractors Association specifies the use of TPO membranes that are at least 60 millimeters thick. Like PVC, TPO also comes in rolls, and it can be fastened mechanically to insulation boards or installed with adhesive.

Thermoplastic single-ply roofing such as PVC and TPO is an increasingly popular choice for commercial roofs, and for good reason. The aesthetics of the roof are clean and pleasing. The material is not difficult to maintain and is usually repairable after encountering unexpected damage from a severe storm. It is possible to reduce weather damage by following a few guidelines (see sidebar above).

Installing thermoplastic materials is reported to be a satisfying process with several installation options to consider depending on a location's climate and the contractor's experience and preference.

Flashing and Seams

Flashing, seams and other accessories are designed to ensure and support the excellent functionality of single-ply roofing systems. T-joints, lap splicing, tapes, pre-molded accessories, seam welders and mechanical fasteners are important components that help ensure all parts of the roofing system are intact and work together to protect the building from water intrusion.

Lap splicing and tapes

Lap splicing of EPDM has improved significantly. The seal strength used to be 3-5 pounds per-inch with three steps that employed cement to seaming laps: splice cleaning, lap cement and lap caulk. Now the butyl tapes used provides 10-12 pounds per-inch seam strength. This toughens the seams, increases lap consistency and streamlines installation. Some manufacturers offer pre-taped seams; pre-taping enhances efficiency and consistency of installation. Prepare all membraned for lap splicing by first removing the factory parting agent for best seam performance.

T-joints

When three layers of single-ply membrane overlap, it forms what commonly referred to as a T-joint. Look out for any voids along the middle layer edge of a T-joint, as these could allow water to become trapped in the roof system.

T-joint patches are now standard requirements for all manufacturers with single-ply systems. T-joints need to be protected by a patch that covers at least 3 inches beyond the seam edges. For EPDM, after you clean and prime the membrane sheet, pull the release paper, and lay and press the patch over the joint. Use a wide roller to apply pressure for secure adhesion. T-joint patches are fully welded for TPO and PVC membranes.

Pre-molded Accessories

Manufacturers offer pre-molded accessories to help protect single-ply roof systems, reduce installation labor and increase flashing consistency. Flashing accessories are easy to install and offer protection from roof edges to parapets, from penetrations to walls and corners. Drain boots, exhaust boots, clad edges, wraps, curb and corner wraps, vents and many other accessories are available to protect corners that are fluted or inside. They may be heat molded to the membranes of PVC or TPO roofs. They can be installed by tape and primer or other specialty sealants per manufacturer recommendation.

The Roof as a System

Like any building system, there are many elements that must be carefully considered in order to produce a successful roof installation that performs well over its lifetime. The consequences of a failed roof system can be severe for occupants and building owners, so attention to detail is critical. For a roofing system there are four key areas to pay attention to:

1) Design. The roof must be well-designed by competent and thoughtful architects, engineers and consultants.

2) Materials. The roof will only perform as well as the materials used. For a long-lasting installation, high-performing, tested and verified materials should be specified (ideally with active support from the manufacturer to assist in the process.)

3) Quality installation and inspection. Highly trained, professional contractors should be selected who are familiar with both the materials and systems specified. Going cheap on labor can result in missed steps or unsealed seams later on. Hand in hand with installation is the inspection of the process. Making sure that materials specified were used and installed per manufacturer's instructions is key.

4) Maintenance. After installation roofs are often "out of sight, out of mind," however, maintenance is critical to ensure a durable, sustainable roofing system. Annual inspections of drains, roofs are cleaned, (especially on highly reflective surfaces) and that debris has been removed is important.

Seam welders

Hot air welds are quick, durable and reliable. Seam welders make permanent and waterproof seams by fusing thermoplastic membrane sheets together without

adhesive or glue. Seam welding can take place in many different conditions, even cold weather. A hand-held hot air welder is a convenient choice when welding membrane sections at corners or vertically. Hand-held hot air seam welders are also used to weld membrane sections together and to weld membrane to thermoplastic-coated metal.

New technologies are making seam welders capable of dual direction, and they are fast and simple to use. There are hot air hand tools for quicker warm-up times and improved adhesion at membranes. Consult your seam welder's manufacturer for specific guidance on use and maintenance.

Mechanical fasteners

Today there are mechanical fasteners designed specifically for single-ply roofing systems, such as coated steel plates and fasteners. Mechanical fasteners come in different load strengths to suit a project, such as high load or extra high load or super heavy duty for wider membranes. Plate designs also have improved with the use of barbs and other fasteners.

More than 50 years ago, mechanical fasteners were designed to replace asphalt mopping. It took time for the fastening design of mechanical fasteners to evolve into deeper and finer threads with stronger holds and more resistance to pulling out, but today there are many such options available.

Thermoplastic Installation Options

This section will discuss the three main installation options for single-ply thermoplastic roofing systems: mechanically attached, induction welded and fully-adhered. There are advantages to each type of installation that must be weighed depending on locale and contractor experience. While it may be tempting to assume a certain type of system doesn't hold up as well, the reality is that factors such as unpredictable weather, contractor error and poor maintenance will affect any type of installation. Each of the main options are discussed and evaluated for ease of installation, cost, structural advantages, and general warnings or concerns that must be addressed during installation for PVC and TPO roofing materials.

Mechanical attachment

Mechanically attached roofs are the most common of the thermoplastic roofing installation options. Mechanical attachment offers a fast, simple and low cost way of applying a single-ply system any time of year. Mechanically attached roofs can be installed more quickly than fully adhering the material, and the membrane

comes in large roll sizes that save time and labor. Mechanically attached roofs are relatively easy to inspect and validate, as well.

The membrane is laid out and screws fasten through a layer of insulation into the nailable deck along the seams. The screws are covered with the next membrane sheet and sealed into the roof system. Finally, welding a watertight seal will close any gaps in seams to fuse the system into a single layer.

It's important to prepare the roof deck before any type of installation by ensuring it is clean, dry and flat. Cut insulation for a close fit and taper to drains. Install wood nailers and preformed metal flashing at the perimeter as recommended. Roof substrates such as vapor retarders should be sealed off at edges and penetrations to prevent moisture from inside or out passing up into the roof system or down into the building. Incorporate air barriers onto structures with high internal pressure such as airport hangars warehouses.

Set the base and wall flashing and gravel stops as specified by the manufacturer. Immediately replace any materials that happen to get penetrated by water during installation. Occasionally, wind gusts can cause the installed membranes to flutter, possibly compromising the system and even causing noise and air leakage inside the building. For this reason it is crucial to know the wind uplift requirements in your area so you can adequately adjust spacing of the fasteners.

Induction welded

Induction welding enables a thermoplastic roof to be mechanical attached without penetrating the roof membrane. This can save labor costs by allowing for wider sheets to be installed and reducing the number of seams on the roof. Induction welding requires a hand-held machine welder. It is relatively straightforward to use and, when manufacturer guidelines are followed, limit the possibility of user error. The thermoplastic roof membrane is bonded to fastening plates that are factory coated with the either TPO or PVC compatible adhesives. Working from above with an induction welding tool, the welder bonds the membrane to each of the specially coated plates.

Induction welding involves no membrane penetration. Membranes can even be hot air welded in cold weather but may require preheating and a slower speed.

TPO and PVC weld differently, with PVC generally requiring a higher temperature than TPO membranes.

A hand-held hot air welder eases the work at corners or on vertical surfaces and can be adjusted for the appropriate temperature, but it is a skill perfected with experience. Machine hot air welding, on the other hand, allows for consistent high-speed welding at the seams. The speed is determined by the heat setting based on ambient air temperature. Overheating, for example, prevents a decent weld and requires patching.

Need to Know Terms:

BUR - Built-up roofing often consisting of asphalt or coal tar with gravel over the top.

SBS - Styrene Butadiene Styrene is a bituminous material modified with a type of synthetic rubber that can retain its shape after being stretched.

APP - Atactic Polypropylene, sometimes called plastic asphalt, is similar to SBS but is less flexible in cold temperature conditions.

EPDM - Cured (vulcanized) synthetic rubber sheet with cross-linking polymers that cure to create a permanent chemical bond.

PVC or KEE - Composed of ethylene and chlorine and is often called “vinyl.”

TPO - Thermoplastic polyolefins in the thermoplastic elastomer family.

With either method, it is important to test weld seams for integrity and continuity, and to complete a series of test welds at the start of each work period. As soon as seams cool, run a blunted tool along the seam while applying firm pressure but without scoring. Voids are indicated by any penetration and must be patched. If weather conditions change or the automatic hot air welder is shut off for any reason, follow up with a testing cycle.

Fully-adhered

A fully-adhered roof is not fastened mechanically but glued with an adhesive. While a fully-adhered roof typically costs more and takes longer to install, certain locations—in particular, windy and coastal regions—call for this method. Fully adhering the membranes prevents sheet flutter. When air gets pulled up under a fluttering membrane, energy is lost and condensation can occur within the roof following cold temperatures. The correct layering and type of insulation can help minimize the effects of wind uplift, but with a fully-adhered roof, the membranes are glued like a sticker onto the insulation below. This method also requires

installer expertise on the correct application rate of the adhesive, as well as the right time and temperature windows. Too little can result in an incomplete seal but overcoating can lead to poor adhesion.

There are two types of membranes: smooth-backed and fleece-backed. Generally, after unrolling a membrane, let it relax. Position the membrane, then fold back along its length, and apply fully mixed adhesive with a saturated roller to both the substrate and/or the back of the smooth-backed membrane. One- and two-sided application methods is manufacturer and product specific. (Note to only apply glue to the substrate with fleece-backed membranes.) After the glue reaches the appropriate tack, a weighted roller carefully presses the membrane onto the glue to avoid any wrinkles, and then the seam is welded.

Note that adhesives generally have a temperature minimum for application of at least 40 degrees Fahrenheit, and installers should be well-versed in the listed application rate. Follow the manufacturer's directions for specific adhesive and membrane type. Be aware that manufacturers often offer multiple adhesive type options: water-based, solvent-based and low VOC solvent-based. Odors differ from one manufacturer to the next and do not always relate to the solvent content. Pay attention to local code requirements and installation conditions when deciding the type of adhesive to use.

Advantages of a smooth-backed membrane on a fully-adhered roof can include a smoother appearance, longer warranty, and reduced likelihood of condensation and thermal bridging through the assembly. Fleece-backed membranes can qualify for warranties up to 30 years, and they allow for additional adhesive options like hot asphalt and urethane foam adhesives. Additionally, there are self-adhering systems with pre-coated membranes covered by a release liner that help reduce labor, flash times and installation consistency.

A fully-adhered roof is leak resistant, but there is a risk of not knowing about a hole until water from rain or snowmelt has pooled and degraded the glue. Ponding or pooling of water on a roof can indicate a drainage problem and compromise a roof system. Care and maintenance—such as annual inspections and ensuring proper drainage—is required by most warranties, and also critical to keeping a roof system durable and effective for years to come.

Wind Uplift and Single-ply Roofing

Roofing problems can occur anywhere geographically, but they are more prevalent and serious in coastal areas that are susceptible to higher wind speeds and torrential rains. According to the Federal Emergency Management Agency (FEMA),

damage to roof coverings is the leading cause of building problems during hurricanes and other coastal storms. A roof can be damaged by wind-born debris, or by uplift pressures caused by high winds. Once a roof is compromised, rainwater can then flood into the building envelope, and moisture trapped within a structure can harbor mold growth and degrade the building materials and structure.

Investigation teams from the Roofing Industry Committee on Weather Issues (RICOWI) visited the damaged areas following Hurricanes Charley, Ivan and Katrina. Most damage to single-ply roofing was related to perimeter problems, including inconsistent fastener placement or roofs installed without following manufacturer's directions. Generally, low-slope roof damage was "a result of the products not being applied according to code or prescribed manufacturer standards for perimeter and membrane attachment," according to the Hurricane Katrina Investigation report.

Low-slope roofs generally did well where installation and maintenance procedures were followed, leaving little or no damage post-hurricane. In one case, a PVC roof on a hospital wasn't secured to manufacturer's standards for the wind zone but still fared well, thanks to little or no air infiltration. Another PVC roof came through with only a few fasteners loose at the corners. At another investigation site, a TPO roof with heat-welded seams over insulation board mechanically attached to the deck virtually had no damage other than a tear, and it likely would been perfect but for sheet metal blowing across it.

Still, a mechanically fastened EPDM system on the roof of a freezer plant was the most extensively damaged low-slope roof observed. The membrane was blown off the 60,000-square-foot facility. Its fasteners weren't up to the job. "This proprietary system used a 'non-penetrating fastener' that was considered to play a major role in the blowoff," according to the report. "Although fastener screws remained well embedded in the steel deck, either fastener heads failed, allowing the membrane to blow away, or the membrane was torn at the fastener heads, resulting in release of the membrane. In addition, one minor section of steel decking blew out above an area that may have been pressurized from below."

The higher uplift forces in susceptible areas have been integrated into national building codes. It is reassuring that single-ply roofs that are properly installed according to current codes and standards generally perform well in a storm. Still, it's important to be aware of the following:

- Low-slope roof failures are usually due to the integrity of attachment of the composite system (mainly failed edge details)

- Perimeters and corners are the most vulnerable areas in a roof assembly; peeling on the edge of a low-slope roof can set off a chain reaction of damage
- Inadequate adhesive strength along the bond line and within insulation layers can lead to problems
- Insufficient or poorly installed mechanical fasteners weaken a roof
- Failure to account for higher negative wind pressures at eaves and corners (or pressurization via door or window failures) can weaken a roof system, rendering it susceptible to worse damage
- Keep the edges or perimeter solid and intact; there are low cost options to help prevent peeling on the edges. A simple peel stop in the form of curbs or pipes can be installed about 12 inches from the edge of the roof to prevent peeling.
- Sealing deck and wall prevents air infiltration

A takeaway theme for builders is to plan to prevent possible pressurization build up under a finished roof membrane. Make sure every part of the roof system, including deck, base sheet, layers of insulation, cap sheet and membrane, is adhered or fastened to resist any potential wind uplift. Such measures will mitigate wind uplift damage to a roof assembly. If a roof is designed to current codes and standards, it should hold up well in the event of a hurricane.

According to the report, “older roofs constructed with little concern for the magnitude of the wind pressures at eaves and corners, and roofs installed with poor practices that lead to progressive failure of the roof membrane, were consistently the ones with significant damage. Many roof designers do not seem to understand that winds produce uplift forces that affect not only the roofing system but the roof deck as well.”

Conclusion

TPO, PVC and EPDM are the most popular single-ply roofing materials used in low-slope roof applications today. While each choice has its pros and cons, all three can be used to ensure protection of the roof and structure from the elements. Understanding the physical properties of each of these materials, as well as flashing and installation options, should help you make the best choice for your next commercial project. In addition, you should be armed with information that will help you choose the most durable option for the specific application while still meeting the project’s budget and sustainability goals. BE

Complete the quiz and receive a certificate of completion!

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