ROOF DRAINAGE SYSTEMS

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Different roof types demand different drainage strategies.

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LEARNING OBJECTIVES

After reading this article, you should be able to:

+ **DISTINGUISH among various types of low- and steep-slope drainage assemblies and identify design considerations for each system.**
+ **IDENTIFY the components of Protected Roof Membrane Assemblies (PRMA), vegetative roofs, and traditional roofs.**
+ **RECOGNIZE signs of distress or potential problems and trace the issue to the primary design or installation shortcoming.**
+ **PREPARE a schedule of routine maintenance and repair that can proactively identify emerging problems.**

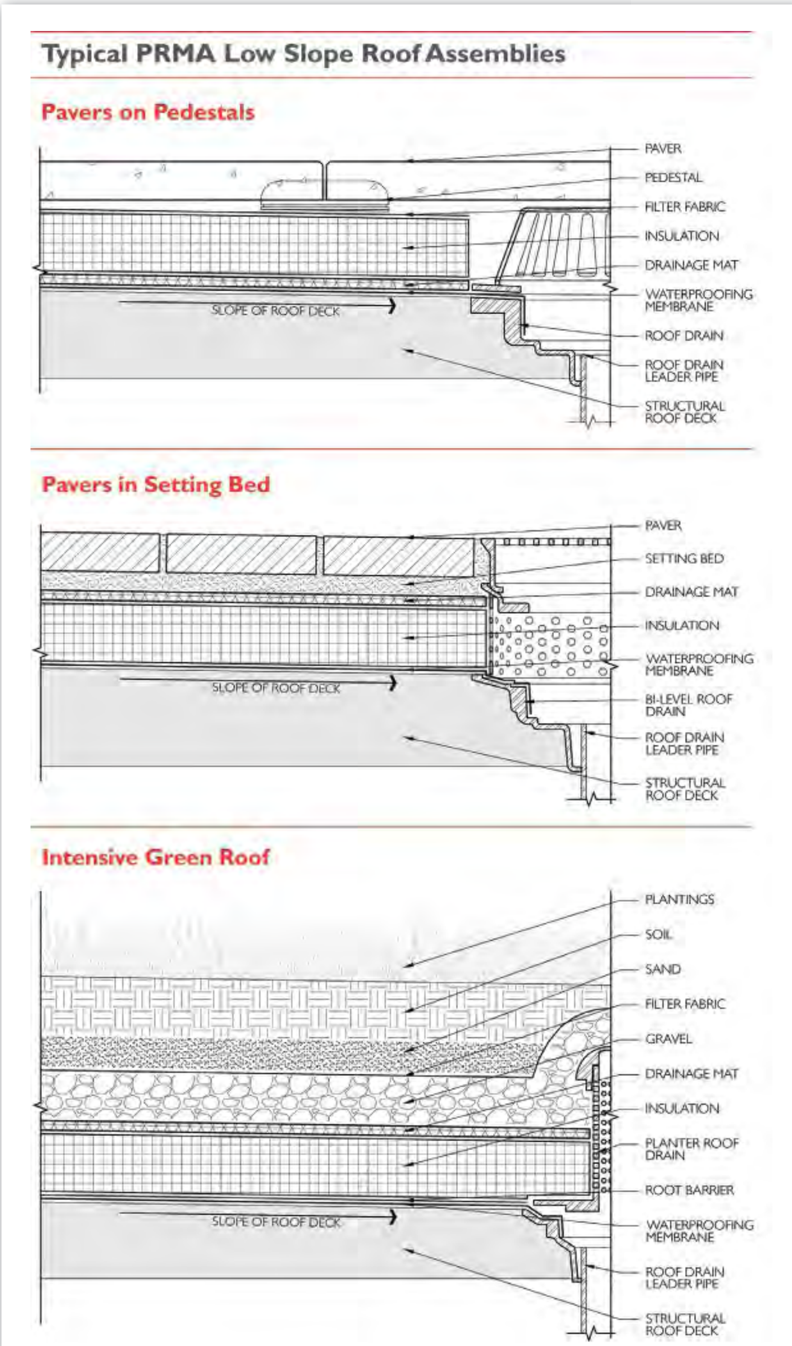
Among the most fundamental of architectural elements is the roof. Its principal purpose is to shelter a building's occupants, contents, and structure from the elements, most critically from precipitation.

While the various layers of the roof assembly play a key role in keeping moisture from infiltrating into the interior, adequate weather protection also depends on the roof's ability to drain moisture away from the building. If rainwater, snow, and ice accumulate, the moisture can degrade and permeate the roofing assembly. Not only does standing water negatively impact the performance, integrity, and longevity of the building enclosure, but it also can deteriorate the structural and interior elements the building enclosure is meant to protect.

Historically, roof drainage was accomplished by simply

Protected Roof Membrane Assemblies are one of the most efficient waterproofing systems for low-slope roofs. They consist of a waterproofing membrane adhered directly to the structural deck, atop which sit drainage mat, insulation, filter fabric, and ballast.

ILLUSTRATION BY STEFFANY MALARK



sloping the roof downward. Water could then pour off overhanging roof eaves onto the ground below, or, in more sophisticated assemblies, flow toward the perimeter and into a clay, wood, or metal gutter system, or through a drainage outlet in the exterior walls.

Responding to the local climate of different regions, modern roof systems evolved to include not just steep-slope assemblies, but also low-slope roofs, often (mistakenly) referred to as "flat roofs."

Originally found in arid locations with little annual rainfall, low-slope roofs have a subtle pitch, allowing the roof assembly to be hidden behind a parapet wall, or portion of the façade that extends above the roof plane.

In regions with substantial precipitation, steep-slope roofs were more common. The pitch can be quite prominent and play a significant role in the building's overall design. Steep pitches are achieved by a variety of roof shapes, but gable, hipped, and mansard roofs are among the most prevalent.

As mechanical and plumbing system technologies and programmatic requirements evolved with the modern world, roof types began to respond less to climactic conditions, and more to interior layout and contemporary styles. Low-slope roofs are now commonly used for high-rise and long-span commercial and industrial buildings, as well as urban residential buildings. Steep-slope roofs are more typically found on suburban and rural residential buildings, as well as many cultural, civic, and institutional buildings of diverse scales and locations.

To promote the efficient function of roof drainage assemblies in these different roof types, it is important to recognize typical deficiencies and apply preventive maintenance strategies that keep the system working effectively. In some cases, persistent problems cannot be addressed through maintenance alone, and a design professional should evaluate the capacity, configuration, and detailing of drainage assemblies to determine whether they are adequate for the climate and roof area. Appropriate slope to drains, as well as flashing details and drain outlets, should also be considered as part of a thorough investigation.

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Often an afterthought in a reroofing or new construction project, roof drainage systems tend to be given little attention—until they fail. Considering the damage water can do when allowed to pond on roofs and overflow from gutters, it is clear that ignoring roof drainage issues can lead to urgent problems. Better to design appropriate drainage assemblies and address incipient concerns now, than to chase after water damage later.

LOW-SLOPE ROOFS AREN'T ACTUALLY FLAT

Low-slope roofs are not actually flat, as they may appear, but instead have a subtle pitch (slope) of between one-quarter inch per foot (2%) and two inches per foot (17%). The pitch of the roof is created by varying the height of building columns to slope the structural roof deck, by installing tapered insulation, or a combination of both.

Positive Drainage Achieving expeditious drainage is critical to maximizing the lifespan of a roof. The goal is to direct all water toward roof drains and create *positive roof drainage*: "the drainage condition in which consideration has been made for all loading deflections of the roof deck, and additional slope has been provided to ensure drainage of the roof within 48 hours of precipitation" (Chapter 2, 2015 *International Building Code*).

The number and location of primary interior roof drains is determined by structural requirements limiting deflection, and by plumbing requirements, based on vertical drain leader diameter, roof slope, roof area per drain, and rainfall rate. Typically, a low-slope roof is designed with one primary roof drain and one secondary roof drain—or overflow *scupper* (drainage outlet) at the perimeter of the building—per structural bay.

Clogged Drains Standing water can cause myriad problems, and, if left unaddressed, can damage the waterproofing membrane, void the waterproofing warranty, and cause dirt and debris to collect, resulting in unwanted vegetation. Eventually,

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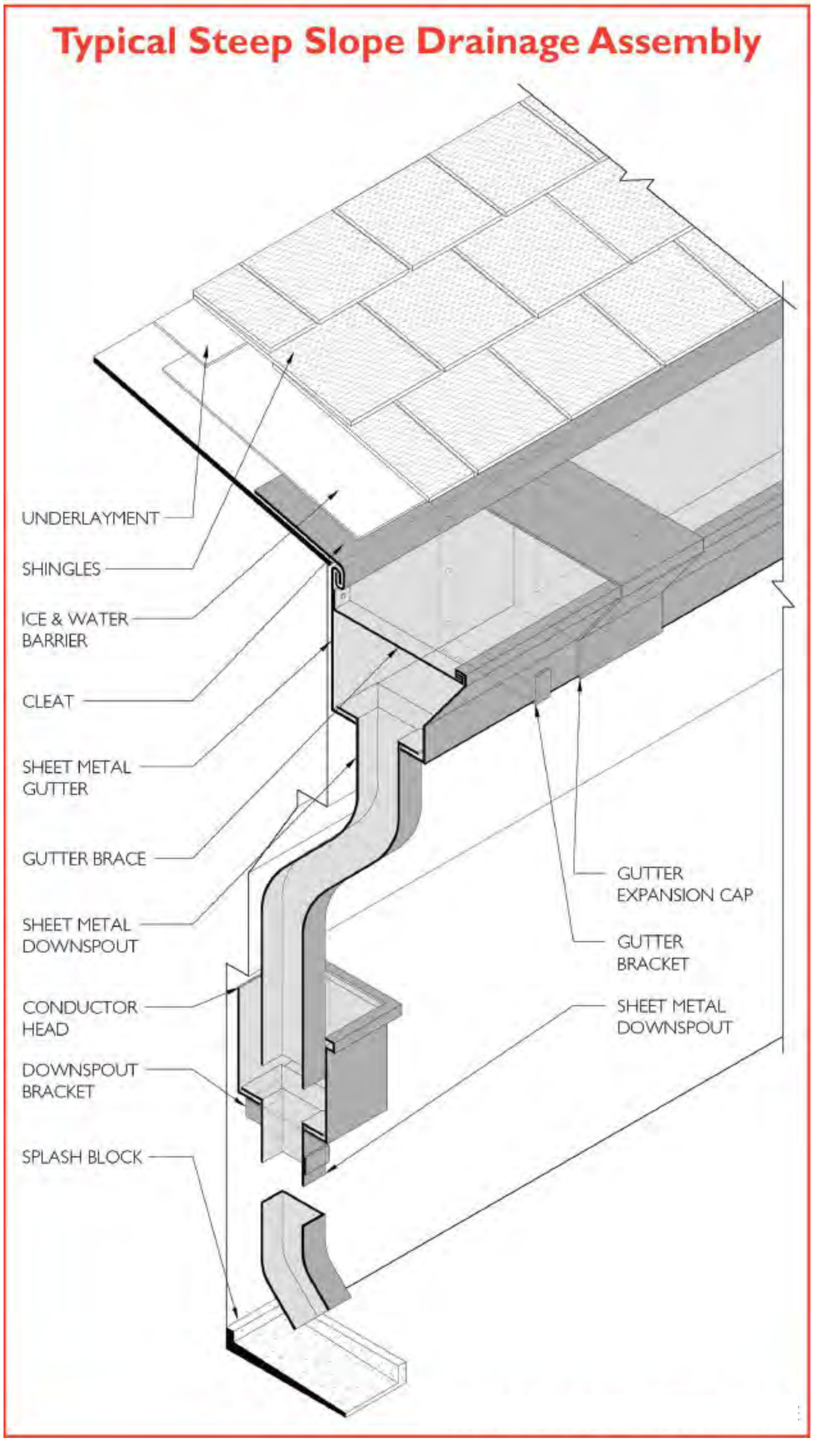
In this vegetative roof above a parking garage, insufficient drainage caused ponded water (right). The new assembly (left) incorporates waterproofing membrane, drainage mat, and gravel.

ILLUSTRATION BY RICHARD OFF / ARI LEVINE



The two most vital steps in achieving a functioning drainage system for steep-slope roofs is to 1) maintain a minimum roof slope and 2) create a continuous and controlled path for water to drain.

long-term water accumulation could cause detrimental structural deflection. Any sign of ponding water should be promptly addressed.

One common cause of standing water, which can be quickly remedied, is clogged drains. It is recommended that roof drains be cleaned out regularly, and drain bodies replaced as part of roof replacement projects.

Inadequate Number of Drains Drainage problems may also be attributed to an insufficient quantity of drains for the size of the roof area or for the amount of precipitation. The 2015 *International Plumbing Code* requires that emergency overflow roof drains or scuppers be provided wherever the roof perimeter construction could entrap water if the primary drains fail.

It is common to add such *secondary drains* during a roof replacement project. Secondary/emergency overflow roof drains look similar to primary drains, but a standpipe or dam blocks water from entering the drain until it reaches a certain depth. Overflow scuppers can also act as secondary drains at the perimeter of the roof. Scuppers are typically easier to install during a roof replacement project when additional secondary drains are required; however, the visibility of the scuppers may be undesirable.

Roof Assembly Design Deficiencies Other causes of standing water that require more extensive work to diagnose and fix are related to the roofing assembly.

Protected Roof Membrane Assemblies (PRMA) are one of the most common and efficient waterproofing systems for low-slope roofs. Originally referred to as an Insulated Roof Membrane Assembly (IRMA), this type of roof system consists of a waterproofing membrane adhered directly to the structural deck, atop which sit drainage mat, insulation, filter fabric, and some type of ballast. Water flows through open joints in the ballast, down to the drainage mat layer, where the slope of the structural deck directs the water into drains.

Drainage mat is typically composed of a polystyrene core with an array of raised buttons that provide space for water to move. On the top side, woven filter fabric allows water to pass through, while trapping soil particles that could impede the flow of water. This is an essential layer in the PRMA. It is important for the ballast to allow water to seep down to the drainage mat layer. Large river gravel was the typical choice, but some areas, such as New York City, restrict use of stone ballast, and instead pavers on pedestals are standard. The pedestals elevate the pavers and allow water to flow through the joints and beneath pavers.

Another form of PRMA sets pavers in a sand or mortar setting bed, rather than on pedestals. Below the setting bed are drainage mat, insulation, and a waterproofing membrane adhered directly to the structural deck. In this type of assembly, most of the water does not flow down through the paving surface; rather, it flows along the top of the pavers. Some water will inevitably penetrate the sand or mortar joints, so it is important to include *bi-level roof drains*, which receive water through a grate at the paving surface level, as well as through a perforated screen at the roof membrane level, for water that seeps below the paving surface. This type of assembly is especially susceptible to unwanted plant growth, as water soaks through the joints and is not able to freely flow through the setting bed to the roof drains. Trapped water can also cause the pavers to spall, crack or develop efflorescence.

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Undersized gutters led to façade deterioration at eaves and downspouts (right). Clogged with debris, these inadequate gutters are filled with standing water (left).

Vegetative roofs, commonly referred to as "green roofs," are another form of PRMA. Vegetated roofs typically consist of either a roof assembly and additional landscape material components, or pre-vegetated trays assembled on top of a roof covering.

In addition to elevated green roofs atop buildings, vegetative roofs at grade, consisting of lawn areas and plazas, may conceal underground parking garages or other usable space. Such green roof assemblies usually include gravel and sand in addition to the drainage mat. These additional layers of drainage media help prevent plantings from becoming too saturated for proper growth. When undertaking green roof replacement projects on an underground structure, it is important to consider the area of existing pervious (permeable) surfaces. If the area of impervious surfaces is increased beyond the capacity of the existing storm water management system, a new system must be designed and installed to accommodate the increased volume of water shed by the expanded impermeable area.

Traditional roofing assemblies consist of rigid insulation adhesively or mechanically attached to the structural deck, with waterproofing membrane installed on top. In this assembly, all water flows along the waterproofing membrane and is directed into roof drains. When an existing structural roof deck does not provide the minimum required slope, or other components of the roof, such as skylights or curbs, disrupt the slope of the structural deck, *tapered insulation*, as part of a traditional roofing assembly, can be utilized to establish an appropriate pitch.

The two most common layouts for tapered insulation are the two-way and four-way systems. Two-way tapered insulation functions by splitting the roof drain catchment area into two parts and creating a primary slope at each part, forming a V-shaped linear valley that directs water toward the center of the roof. Another layer of tapered insulation, referred to as a *saddle*, is then used to divert water into the appropriate roof drain.

A four-way system functions by creating square roof drain catchment areas with tapered insulation panels sloped equally in four different directions with the high point at the perimeter of the roof and the low point at the roof drain. The intersection of the panels creates mitered valleys that direct water into the roof drain.

Crickets are additional layers of tapered insulation installed on the high side of large penetrations to direct water around the obstacle. Crickets and saddles are typically twice the slope of the adjacent roof.

LOW-SLOPE ROOF SOLUTIONS

Standing water due to clogged or inadequate drains, or because of insufficient slope to drains, is, unfortunately, commonplace for low-slope roof assemblies. The first step to address persistent ponding is to determine the cause of poor drainage, which may involve investigative probes into the roof assembly, as well as evaluation of existing drainage components. In addition to regular maintenance to prevent clogged drains, the roof assembly may need modification to improve water flow to drains and to provide sufficient drainage capacity during heavy rainfall. Providing a clear path for water movement across the roof assembly, as well as adequate roof slope and flow around penetrations, can improve the longevity of the roof and deliver reliable water management for the life of the system.

Editor's note: *Additional reading is required for this course. Visit BDCnetwork.com/RoofDrainage to complete the reading and take the exam.*

+EDITOR'S NOTE

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