Rainwater Roof Drainage Systems

By S. Jerry McDanal, FASPE, CET, CPD

Don't take them for granted!

Many articles have been written over the years concerning storm/rainwater disposal systems. Although a small of the overall scope of a project, these systems are vitally important. I have been employed in the plumbing/drainage industry for many years, and it is apparent to me that some designers are comfortable with the basics and have taken some things for granted. Roof drainage and stormwater systems are often designed for the very minimum when, for various reasons, based on recent developments and conditions, it would have been prudent to exceed the minimum.

Beware when the weather bureau warns of flash flooding. Flash flooding can be very serious. The potential for flooding in the residential area of my hometown was regarded as remote, if not impossible. Flooding was considered only in relation to the river, which is quite a distance from my home. On May 7, 2009, my hometown experienced the most severe rainstorm in its recorded history. It rained relentlessly for four continuous hours without letting up and deposited 14.25 inches of rain on the east and north sides of the city. This exceeded NOAA's 100-year existing record of 10.26 inches for this area. Flooding was prevalent everywhere in the city. More than 800 structures (including homes) and 1,200 automobiles were flooded. There were numerous road washouts, bridge damage and associated secondary flooding damage and problems.

Flash flooding can cause havoc with the roof drainage system and structure. Witnessing this record rainfall confirmed my personal concerns regarding design parameters and the ability to look beyond the minimum. This rainstorm was just one of many that occur not only in the Southeast but also throughout the entire United States. It does seem as though rainstorms are continuing to increase in strength, intensity and duration. If an area is prone to frequent flash flooding, then do not hesitate to design drainage systems for greater protection that goes beyond the minimum.

Codes and standards establish a minimum acceptable standard for the design and installation of storm/rainwater systems. There are two major codes that most municipalities adopt, with local amendments that relate to conditions in their particular area. The information pertaining to storm/rainwater shown in the codes must be used as the primary source for accepted methods and sizing. All designs must meet or exceed the local requirements. Your sizing should be based on recent developments and changes in your area's climatic conditions.

The local code should be consulted to determine the rainfall rate that is applicable for the project location. A minimum design should be no less than 10-year/5-minute for the building roof and site unless other factors require designing for greater protection. For example, if the local code requires that the design be based on a minimum 10-year/5-minute storm but recent changes in the area's climatic conditions have consistently produced storms that have changed in frequency and intensity (even if temporary), then it is prudent to take this into consideration. Exercise good engineering judgment and use a greater severe storm frequency and duration to design beyond the minimum.

Many considerations should be weighed in the design of any storm/rainwater system. These include rainfall rate, snow depth, potential wind conditions, probable freeze conditions, building construction, type of roof, pattern of drainage slope, vertical wall heights, parapet heights, parapet scuppers (sizes, quantities and locations), emergency (secondary) overflow drain requirements and locations, ceiling space allocation, wall and chase space locations, etc.

Roof drains are subjected to stoppage, hence, the requirement for the dome. Free area ratios are 1.5 to 1. (See the following chart.) The dome (strainer) is required not to extend less than 4 inches above the roof per the applicable codes.

Roof drain manufacturers construct their drains in accordance with the applicable standards and codes. The

Outlet Size	Outlet Free Area (Sq. In.)	Minimum Sq. In. Required (1.5 to 1) For Domes
2 in.	03.14	04.71
3 in.	07.065	10.575
4 in.	12.56	18.84
6 in.	28.26	42.39
8 in.	50.25	75.375
10 in.	78.5	117.75

codes provide charts with sizing criteria based on roof area in square feet, corresponding to the drain outlet/leader size and the rainfall rate/hour. A 4,600-sq.-

Continued on page 50

Continued from page 48

ft. roof area subjected to 4"/hr. requires a four-inch roof drain outlet and vertical leader. Once you turn horizontal, the piping must be sized using one of the horizontal rainwater sizing charts which are 1/8 inch, ¼ inch and ½ inch per foot slopes. In most cases the horizontal leader will increase in size, particularly when the roof areas to be drained are much larger.

Roof drains are designed for the architect, engineer and contractor for any application.

One of the most common design characteristics I have observed with large box roof areas is the preference to use fewer larger drains rather than additional smaller drains. The reasoning is simple; reducing the number of openings in the roof slab reduces the chances of the roof leaking. This adds stress to the roof structure, though, as it allows more rainwater to be ponded on the roof, waiting to be drained.

During severe conditions, rainwater may be pushed by the wind from one side of the roof to the other. This not only adds additional stress and weight but also overloads the drainage system. For example, a large box store located in southern Florida had two 10-inch roof drains for the entire roof. When Hurricane Andrew rambled through the area in the nineties, not only was it dumping severe, above average rainfall on the roof but the wind also blew all of the rainwater to the west side of the roof. This added so much additional stress, weight and rainwater to that side that a portion of the roof collapsed. In this case, several smaller drains may have been able to endure the storm.

One item of extreme importance is planning for emergency (or secondary) overflow drains. Yes, it was not that many years ago that they were not required. Presently, one major code requires an overflow drain to be piped and discharged separately while the other allows it to be connected back into the primary system, dependent upon appropriate increased sizing of the primary system.

Providing a separate system and discharging it separately, usually to a location that will be seen by pedestrians is the best application. If it is observed discharging, then someone is going to report it. It is good engineering practice to have a 1-to-1 ratio for primary to emergency overflow roof drains. In the event of an extreme storm, the emergency roof drains can assist in draining the roof if the primary system is overloaded. This is another reason to keep the emergency system separate from the primary system.

The horizontal section of the pipe and the roof drain body should be insulated with a vapor barrier to control condensation. Low-temperature liquid flow in the piping causes condensation to form on the outside of the piping, potentially causing stain damage to ceilings and drip marks on floors, along with other problems.

Piping layouts must be coordinated with all the trades that may be affected, such as the architect for furring-in the proper columns for vertical leaders, the structural engineer for pipe support and footing depths, the electrical engineer for conduits, etc., and the HVAC engineer for ductwork and piping.

Locating the roof drains should be a coordinated and cooperative effort among the architect, structural engineer and plumbing engineer. The architect is familiar with the building construction, parapets, walls and chase locations, available headroom for horizontal pipe runs, roof construction and waterproofing membrane. The structural engineer is familiar with the structural support layout, roof slopes, column orientation, footing sizes and depths and maximum allowable roof loading. The plumbing engineer can provide information concerning the maximum roof areas per drain, wall and col-

REMEMBER THESE FACTS:

• The characteristics of rainwater will vary, sometimes it is more sensitive than other times, according to temperature, pressure, composition (density), head, intensity, specific gravity and so forth all contributing to its mechanical behavior.

• A relatively large hydraulic head of rainwater is required to increase the flow through the drain and to achieve peak flow.

• A considerable amount of air is entrained with the rainwater as it enters the drain. This prevents the leader piping from flowing full. In a vertical installation the rainwater will actually swirl around the inside diameter of the piping. In a horizontal installation, the air will occupy the upper half of the leader piping. Consideration should be given for partially full piping during peak flow.

• For each primary roof drain, there should be the same size secondary (overflow) roof drain. A 1-1 ratio is desired.

umn furring-out requirements, ceiling space requirements, elevations of horizontal piping in ceiling space and inverts of horizontal piping once underground.

The plumbing engineer also should ensure that the drains are located in the low points of the roof to limit deflection which may cause ponding and shifting of the low roof point and to minimize the horizontal runs. The plumbing engineer should determine the potential weight of ponded water and provide the structural engineer with such data. The roof structure must be able to support the weight of ponded water by design or by nature. It is always best to determine the worst possible situation in calculating the potential rainwater load in pounds of weight.

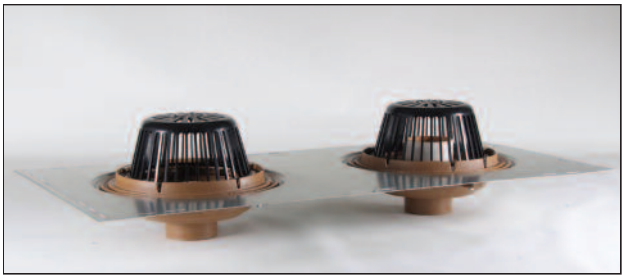
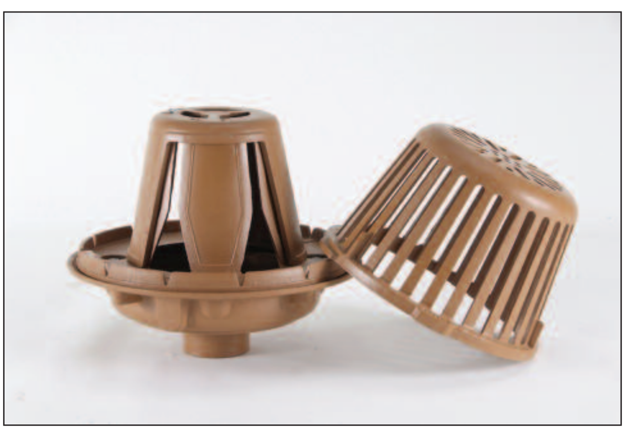


Image 2: Roof drain and secondary overflow deck with deck plate.

The building roof transfers the combined weight of live and dead loads to the supporting structure. Live loads include snow, rain, wind and water on the roof. Dead loads include all mechanical equipment, electrical equipment, other equipment and the roof deck. The importance of involving the structural engineer cannot be emphasized enough. The design of the roof structure is critical, and the structural engineer must have complete information to make the correct decisions. Always design for the worst scenario. Determine the potential maximum volume of water (convert to pounds) that could pond on the roof if all roof (primary and emergency) drains were non-functional and no other means existed for draining the water.



Raintrol roof drains from Jay R. Smith feature an adjustable flow rate control.

Most roof drain manufacturers provide charts in their roof drainage technical sections. These charts are all taken from one of the various plumbing codes or other technical manuals. The sizing procedure is simple. A 4"/hour rainfall rate and a 4" roof drain outlet/vertical leader size intersects at a maximum of 4,600 square feet of roof area per drain or, depending on which code is being referenced, it could be slightly greater or less than 4,600 sq. ft. This does seem simple, but roof drainage is a major liability and must be carefully designed, sized and coordinated. Some designers fail to look past the simplicity of sizing the system to the results of a poor or inadequate design.

In defense of these charts, many thousands of roofs have been designed successfully based on the criteria they contained. There is, however, a small percentage of roof drainage systems that fail, usually because of a weather phenomenon and not because of the design or capacity of the system. This could happen after years of successful service with no problems, so why all of a sudden is the roof drain to blame? Other reasons have to be investigated, such as overloading, structure inadequacies, incorrect locations of drains, depressed roof areas causing ponding, drain or leader stoppage and lack of sufficient secondary overflow drainage.

In some cases, a designer may elect to use larger outlet roof drains to reduce the number of openings through the roof structure. This is normally acceptable, except when a weather phenomenon occurs. A hurricane, for example, will definitely overload a roof. Unless the structure is engineered to support this extraordinary load, the roof is likely to collapse. In the last several years, there have been an abundance of extreme storms causing flash flooding, having the same end effect as a hurricane.

Logic and good engineering practice must prevail when designing roof drainage systems. Some charts list allowable flow in gallons per minute (gpm). For example, one chart indicates a 4" vertical leader will flow 192 gpm. Okay, but at what head of water over the roof drain? Until the rainfall intensity and head of water builds up to a certain level, the drain will not flow 192 gpm. Some plumbing designers fail to realize that a specific volume of flow does not occur until a certain head of rainwater is achieved over the drain. Even an undersized roof drain will eventually drain the roof of the rainwater, but will the roof's structure hold up during this drain down period? For the flow of rainwater through the roof drain to increase the hydraulic head of rainwater over the drain must be heightened. ■

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