RAIN LOADS ON BUILDINGS

INTRODUCTION

Rainwater ponding has lead to the collapses of many buildings due to lack of, inadequate, or plugged roof drainage systems. One inch (25.5 mm) of water collecting over a 1 ft^2 (0.09 m^2) area of a roof, weighs 5.2 lb (25.4 kg). A 20 ft x 20 ft (6.1 m x 6.1 m) roof area with 1 in. (25.5 mm) of water would have over a ton (908 kg) of additional roof loading.

Depending on the shape of the roof, rain water will be diverted either to the edge of the roof or into a drainage system. The gutters and downspouts on the edge of the roof keep the water outside the building. If the roof has a parapet at the edge, scuppers, small openings in the wall at the roof, are provided to allow the rain water to drain off the roof. Roof drainage systems consist of roof drains, down pipes, and a collection pipe. There are two types of roof drain systems, gravity and siphonic. The gravity drainage system (see Figure 1) typically uses large down pipes for each roof drain. The down pipes are then connected to a collection pipe typically under the floor. The siphonic systems (see Figure 2) typically use smaller pipes and connect several roof drains to a down pipe.

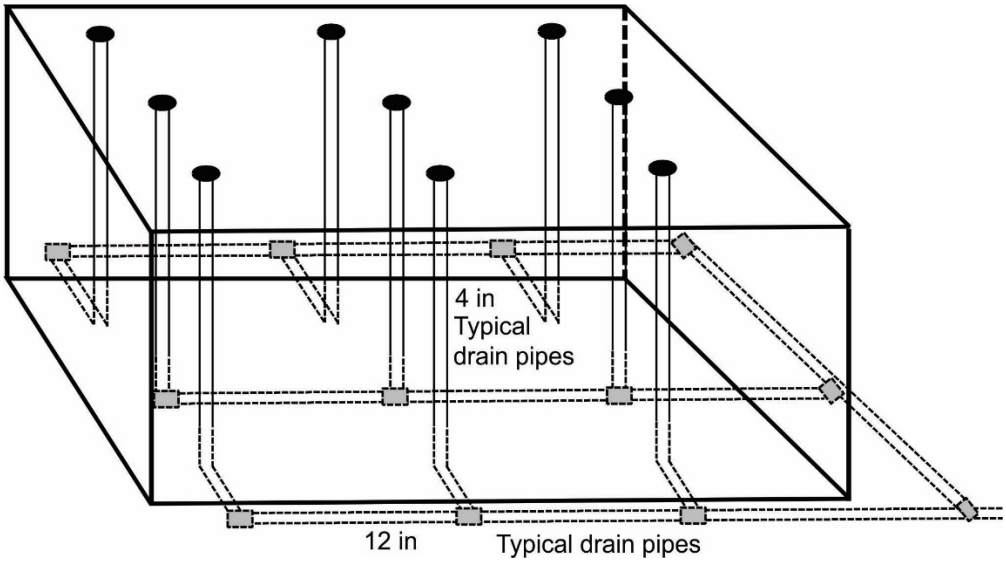

Figure 1: Typical Gravity Roof Drain System

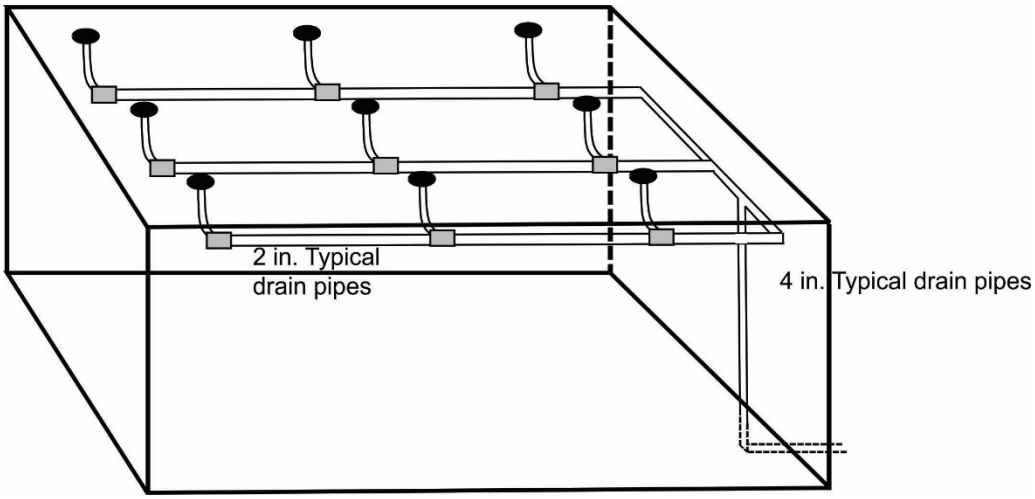

Figure 2: Typical Siphonic Roof Drain System

POSITION

Design all new flat roof buildings, low sloped roof buildings, and buildings with parapeted exterior walls, with a roof drainage system to withstand the anticipated rainfall intensity.

Evaluate existing drainage systems to ensure they can handle the anticipated rainfall intensity.

To estimate drainage requirements for a roof, determine the rainfall intensity based on a 1 hour rainfall with a 1% chance of exceedance (100-yr) period and 5 min. rainfall with a 10% chance of exceedance (10-yr) period. Table 1 shows the area of a roof effectively drained by one downspout (of size selected) for the particular rainfall intensity chosen.

TABLE 1
Maximum Roof Area In Ft² Per Drain Pipe Size

Vertical Leader (in.)	Rainfall Rate (inches per hour)									
	1	2	3	4	5	6	7	8	9	10
2	2,880	1,440	960	720	575	500	410	360	320	290
3	8,800	4,400	2,930	2,200	1,800	1,500	1,200	1,100	980	880
4	18,400	9,200	6,130	4,600	3,700	3,100	2,600	2,300	2,000	1,800
5	34,600	17,300	11,530	8,650	7,000	5,700	4,900	4,300	3,800	3,400
6	54,000	27,000	18,000	13,500	11,000	9,000	7,700	6,700	6,00	5,400
8	116,000	58,000	38,660	29,000	23,000	19,000	16,500	14,500	12,800	11,600

*Rainfall intensity is the number of in. per hr for a 1 hr duration.
SI Units: 1 ft^2 = 0.0929 m^2; 1 in. = 2.54 cm

To obtain the number of drains required for a specific roof area divide the total roof area by the area served per drain from the table. Normally there should be at least one drain per 10,000 ft^2 (930 m^2). Space and locate drains to serve equal areas of roof. Multiple small drains are preferred to one large drain.

Provide means for secondary runoff in case roof drains become plugged. Provide peripheral scuppers in the parapets enclosing the roof. Position and size these scuppers so that any water buildup in excess of a 1 in. (25 mm) depth will overflow to safe ground level discharge away from the building.

Perform daily inspections as needed during winter, spring and fall. Ensure that drains are not obstructed and that snow and ice buildup is not excessive. Regular inspections are even more important in regions where torrential rains and heavy snowfalls are common.

DISCUSSION

The effectiveness of roof drain system depends on many factors including pitch of the roof, design of the drain hardware, and design load of the roof system. Most roofs, particularly large flat roofs, require a drain system to carry melting snow and rainwater from the roof and away from the building foundation. Without a proper drain system, water would quickly add enough weight to exceed the roof design and cause collapse.

For the large flat roofs, two type of roof drain can be used, the gravity drain or the siphonic drain system. The major difference between the two is the way they get the water off the roof.

- The gravity drain system uses open drain vents, typically one large down drop pipe for every vent, or if multiple vents on the drain pipe, that pipe is pitched, the pipes can have air in it, a larger drain pipe under the building connected to the main drain pipe. The water flows down the pipes along with the air.
- The siphonic drain system siphons the water off the roof. The roof vents have an air baffle to prevent air from entering the drain pipes enabling the siphon process. As the water enters the drain system, it is sucked through the piping therefore the piping is not required to be pitched. The siphoning process allows the use of smaller piping to achieve the same results. The only issue with the siphonic system is that more water on the roof and the rain load needs to be considered when designing the roof.

Any drain system can become obstructed. A roof can fail even with a properly designed drainage system. Accumulating ice can clog the drainage system even if the drains are well designed. Good design practice requires a secondary drain or runoff system, such as appropriately located scuppers to drain excessive water. Most large flat roofs have drain systems, but if a drain system is allowed to freeze or clog with debris, it can become overloaded and lead to collapse.

Long roof spans tend to sag. When they do, water will accumulate where there is no drainage. This is called ponding. The greater the sag, the larger the pond. One sign of ponding is a water stain that develops as ponded water evaporates. Ponding can result in roof collapse unless the affected roof section or drainage area is modified.

CHECK LIST FOR SIPHONIC ROOF DRAIN SYSTEMS

☐	Have a full set of design plans and calculations for the system been prepared for review.
☐	Have calculations been completed using hydraulic software approved for siphonic drain systems.
☐	Has the system been designed by an engineer who is experienced and qualified in the design of siphonic roof drain systems.
☐	Is the design in accordance with the relevant local plumbing or drainage system code such as ASPE 45.
☐	Does the design meet needs of the 100 year rainfall (or 500 year rainfall if in monsoon affected areas)
☐	Has the roof structure been designed for maximum anticipated water accumulation.
☐	Are drainage system pipes and fittings in accordance with the code in terms of materials and minimum pressure rating.
☐	Are roof drains points properly spaced and marked, and include a baffle.
☐	Does piping meet the minimum sized required by the code. e.g. 1½ in (38 mm)
☐	Are there any pipe size reductions in the direction of the flow.
☐	Does the length of the vertical section tail piece meet the codes minimum requirement –e.g. 18 in. (450 mm).
☐	Are concentric not used.
☐	Are eccentric reducers properly installed per the code.
☐	Are elbows properly installed per the code.
☐	Is the siphonic to gravity transition location in accordance with this code.
☐	Is the transition sized for the correct velocity and also properly vented.
☐	Has pipe freezing been dealt with in the siphonic to gravity transition.
☐	For plastic pipes and fittings, has expansion been taken into account.
☐	Has a secondary drainage system been provided to deal with siphonic system blockage or inadequacy.
☐	Have any drains or downpipes been moved or added in comparison to the design on which calculations were based.
☐	Has piping been properly supported to the building structure