Chapter 12

Storm Water Design

Storm water drainage system provides means of conveying rain water from road, building, open area etc in to a public storm water drainage network.

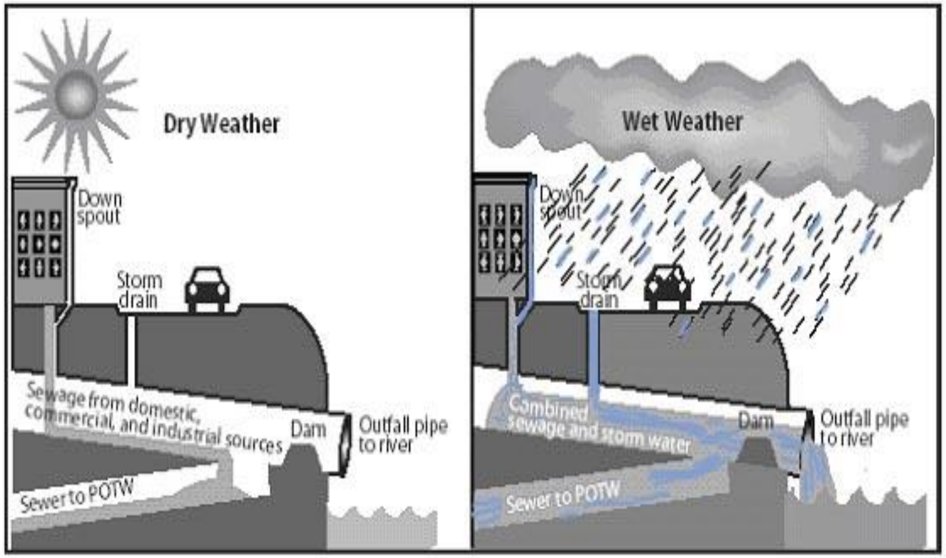
The code regulates the design, construction, installation, and quality of materials for drainage systems in order to protect public health.

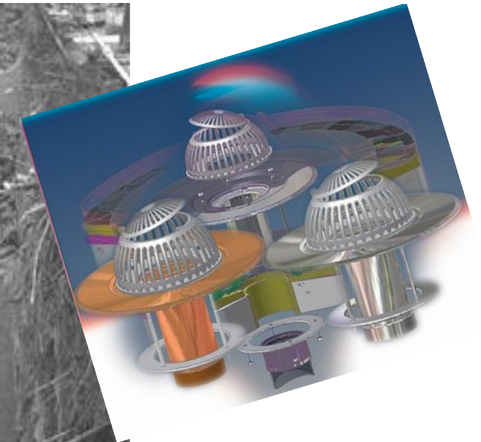
Materials for storm water drainage piping used in India is predominantly RCC Hume pipe and trenches in RCC, concrete or Masonry. Very few projects use HDPE ,DWC or Rigid PVC pipes for external storm water drainage.

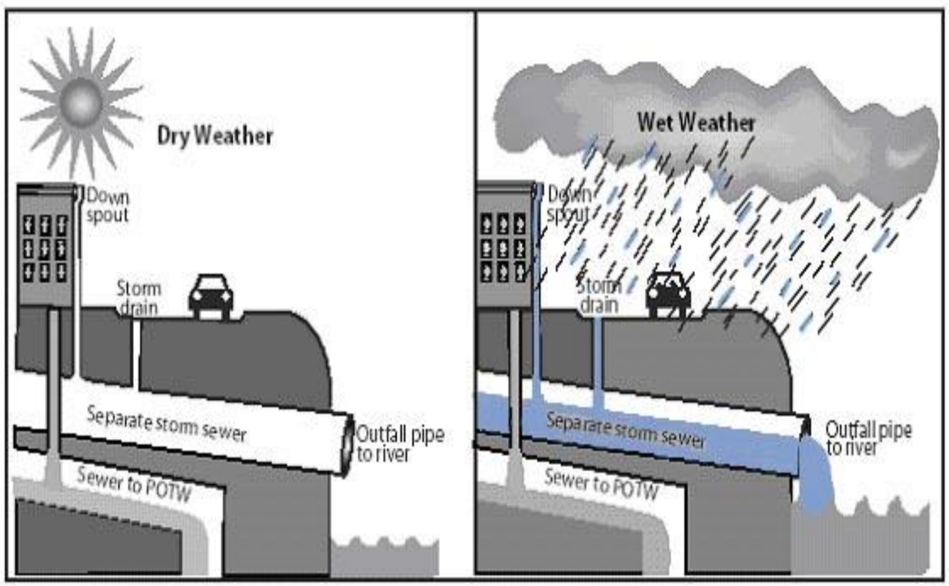
This topic provides the guidelines to collect/capture the storm water and discharge it in a safe and efficient manner. Source material for this course is UIPC-I -2017 Code

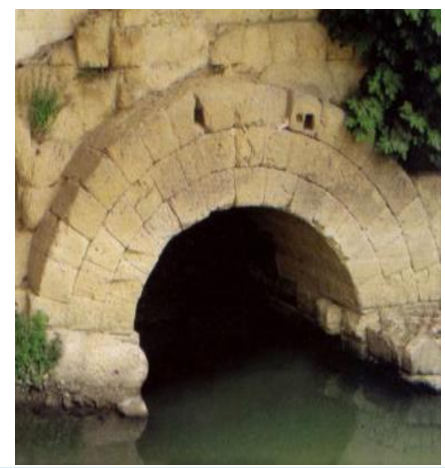
Subject Matter includes:

✓Storm drain required, prohibited connections, subsoil drains, sub-drains, sizing of gutters/channels/scuppers, window areaway drains, roof drains, strainers, leaders, conductors and connections, siphonic drains, underground drains, materials, traps required.


Dry Weather
Down spout
Storm drain
Sewage from domestic, commercial, and industrial sources
Dam
Outfall pipe to river
Sewer to POTW
Wet Weather
Down spout
Storm drain
Combined sewage and storm water
Dam
Outfall pipe to river
Sewer to POTW




Dry Weather
Down spout
Storm drain
Separate storm sewer
Outfall pipe to river
Sewer to POTW
Wet Weather
Down spout
Storm drain
Separate storm sewer
Outfall pipe to river
Sewer to POTW



Building Drain (Storm)
A building drain which conveys storm water or other drainage but no sewage

Conductor
A pipe inside the building which conveys storm water from the roof to a storm or combined building drain or sewer

Scupper

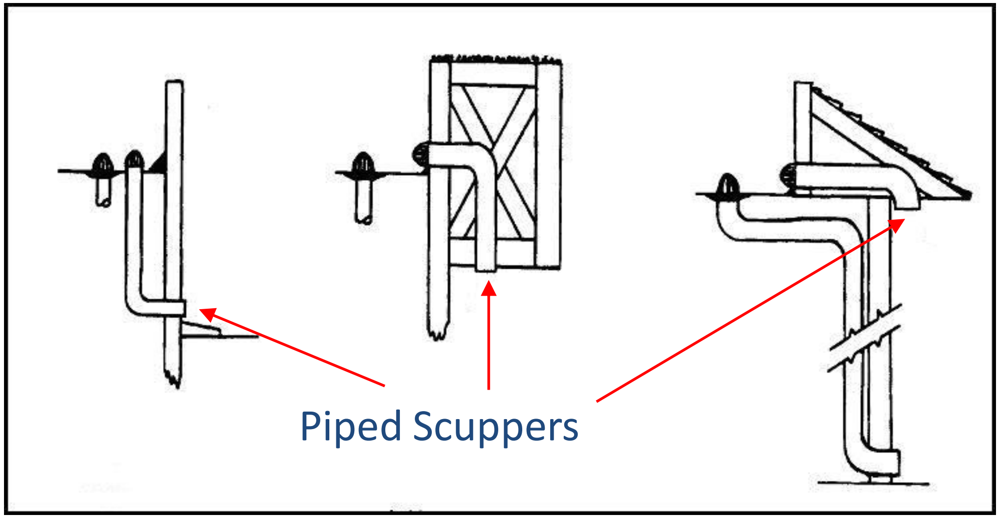
Overflow either thru wall as a cutout or piped

Downspout –

The vertical portion of a rainwater pipe outside of the building

Leader –

An exterior drainage pipe for conveying storm water from roof or gutter drains. A pipe to convey rainwater from the roof to the means of disposal


Piped Scuppers

Building Code requires roof drainage water not be permitted to flow over public property, side walks and walkways

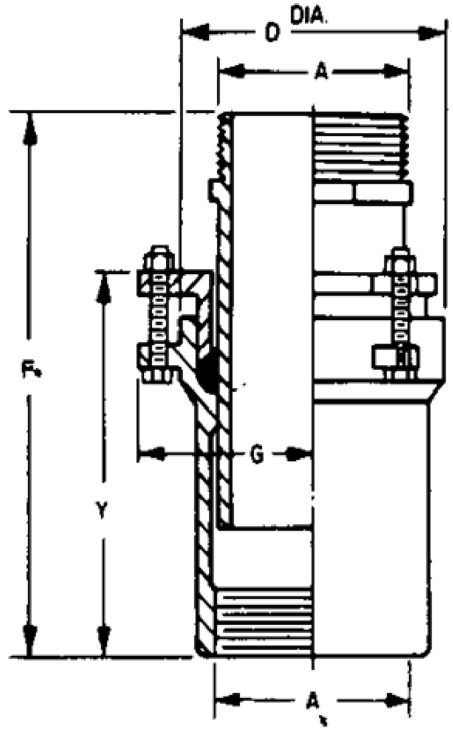
Roof drainage is also required for all buildings to prevent roof collapse

Where a plugged drain could allow rainwater buildup on the roof a separate emergency overflow shall be provided

In 1 & 2 family dwellings it may discharge on flat areas to drain away from the building and adjoining property and shall not create a nuisance.

Storm water shall not be drained into sewers intended for sanitary drainage only

All roofs, paved areas, yards, courts, and courtyards shall be drained into a separate storm sewer system, or into a combined sewer system, or to other designated place of disposal.



Expansion joints are Required where warranted by temperature variations or physical conditions

Offsets should be used where possible to allow for movement

Particular consideration should be taken for plastic piping and their large expansion rates

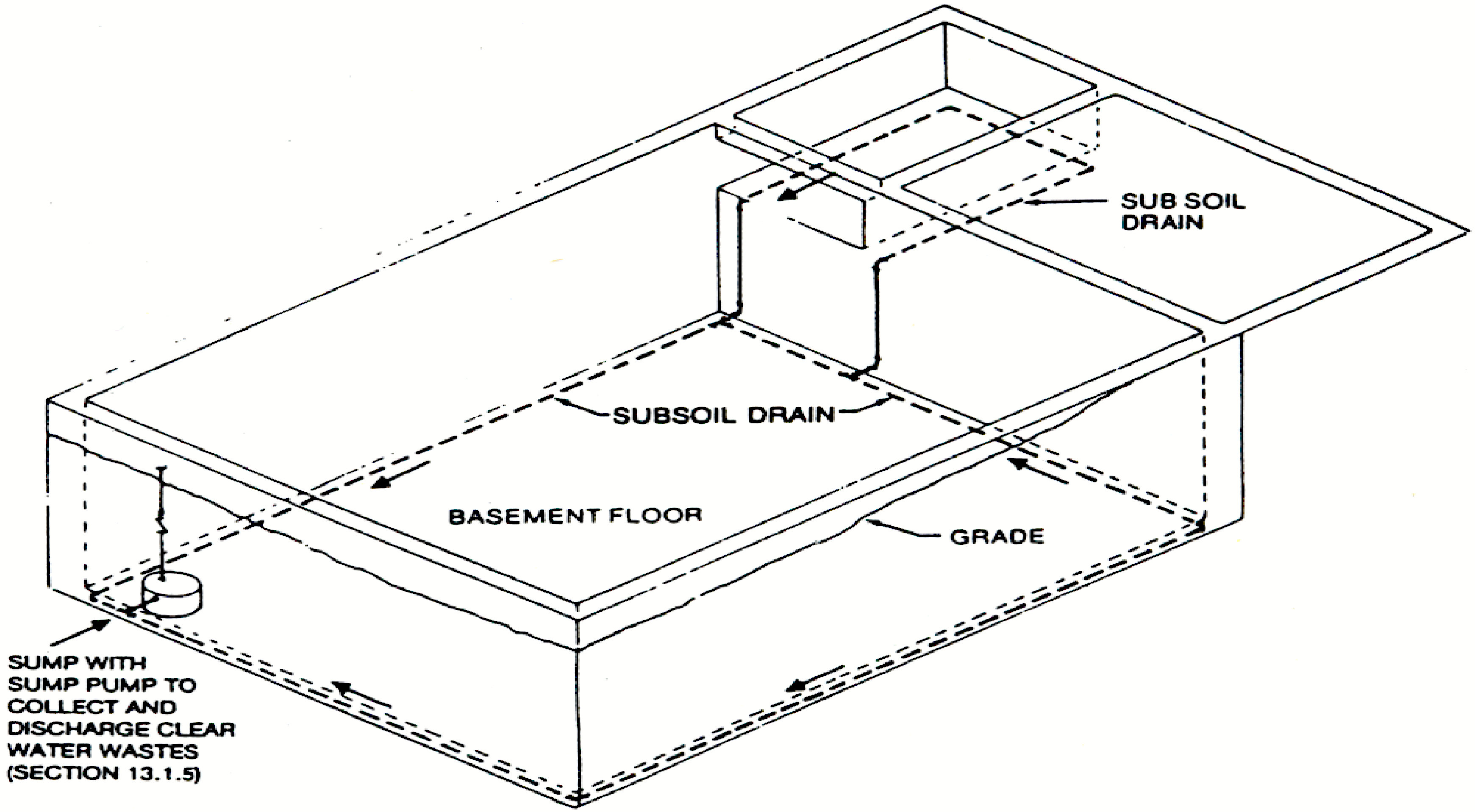
Subsoil Drains

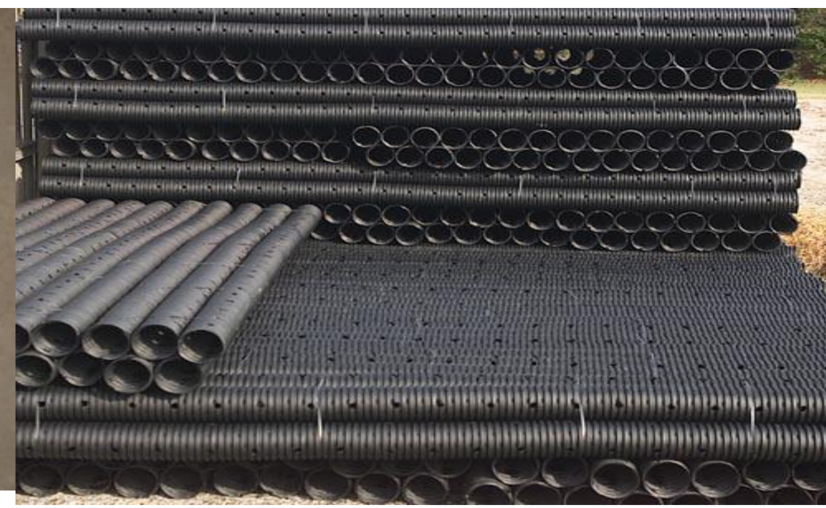
Shall be provided around perimeter of buildings having basements, cellars, crawlspaces or floors below grade

Shall be of perforated, open-jointed drain tile or pipe 6" min. diameter wrapped with geotextile membrane

Laid in gravel or crushed rock 18 mm with a min. of 300 mm surrounding pipe, with 200 mm sand layer for proper ingress of water in to the pipe

Shall discharge as other storm piping either by pumping or by gravity discharge based on the invert level of the public storm water drain.

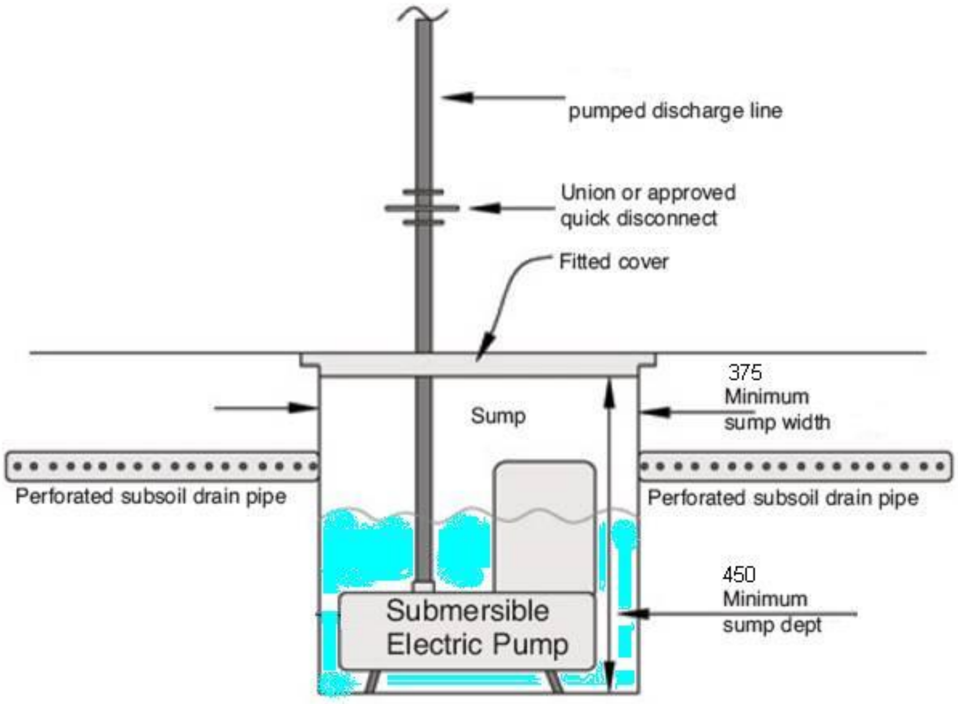

SUB SOIL
DRAIN
SUBSOIL DRAIN
BASEMENT FLOOR
GRADE
SUMP WITH
SUMP PUMP TO
COLLECT AND
DISCHARGE CLEAR
WATER WASTES
(SECTION 13.1.5)



Sump shall be sized as per the flow from subsoil water

Pumps shall be 1 w +1SB

Solid handling cap shall be 20mm min.



Plinth protection

Subsoil drain or RWP can discharge on splash block

Required to protect the ground beneath the block from erosion.

min length 600 mm

Discharge 100 mm above block with flow parallel with block

For separate dwellings only

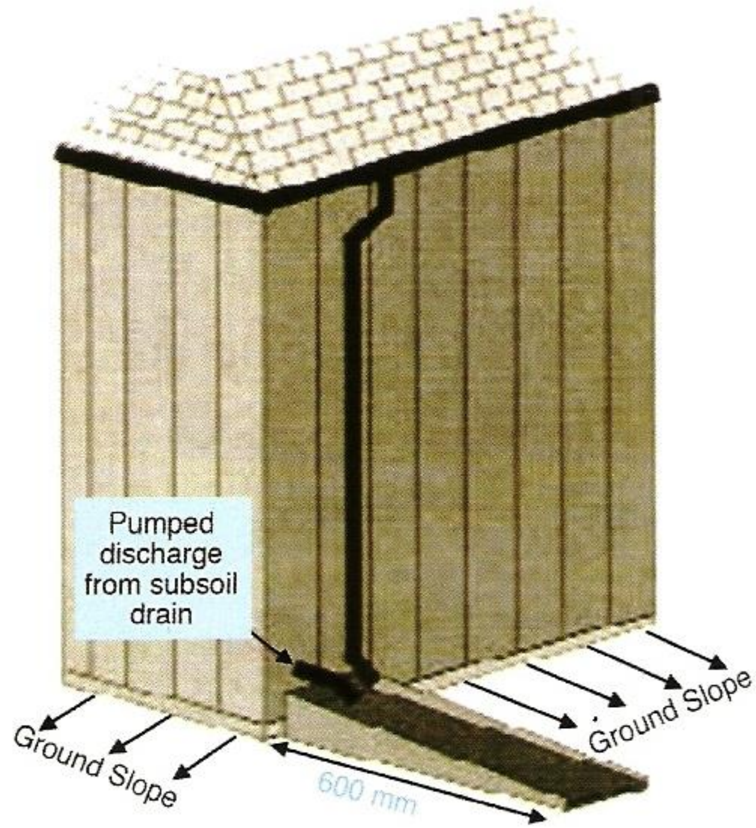
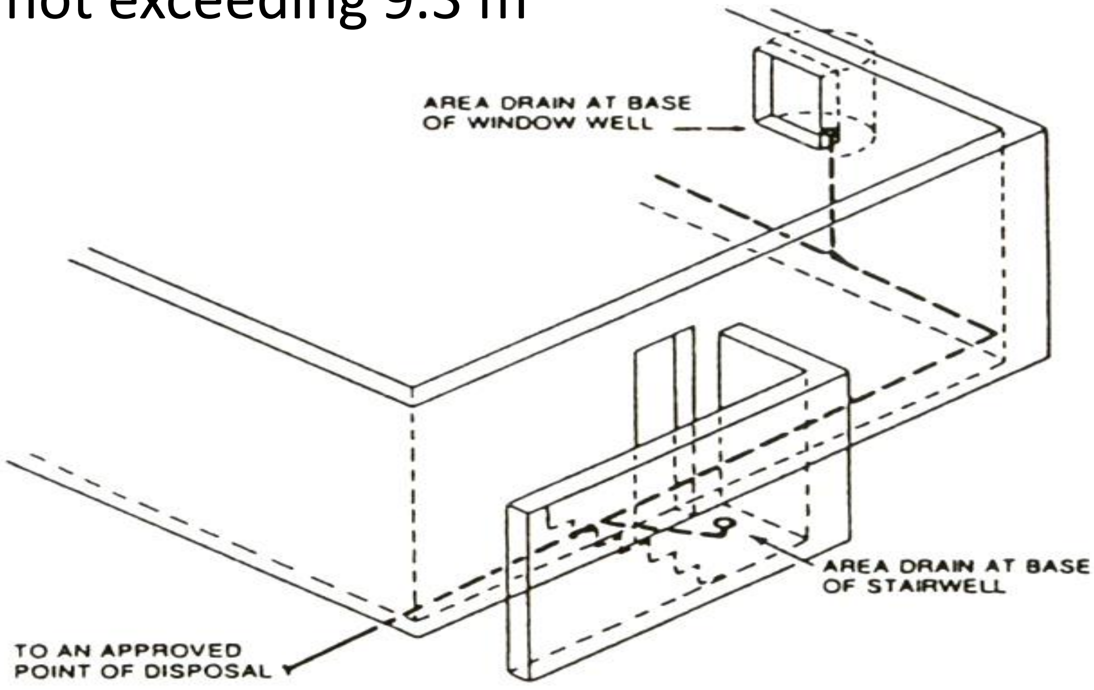


Figure 11-8
Splash Block

Areaway Drains

All open subsurface space serving as an entrance to a basement or cellar shall be provided with a drain The drain shall be 100 mm min diameter for area not exceeding 9.3 m^2



Primary Roof Drains

Gravity rainwater systems rely on the intensity of rain of water and area of the roof on which it is falling. It tries to reach the lowest level possible and tries to spread out evenly over whatever surface is supporting it.

This is exactly what happens when rainwater falls onto a roof and flows into a gutter. The depth of water accumulating in the gutter is the driving force which causes the rainwater to flow towards the roof outlet.

Primary and Secondary Roof Drains
Strainer 100 mm above the Roof
Secondary Drain Weir 50 mm above Primary

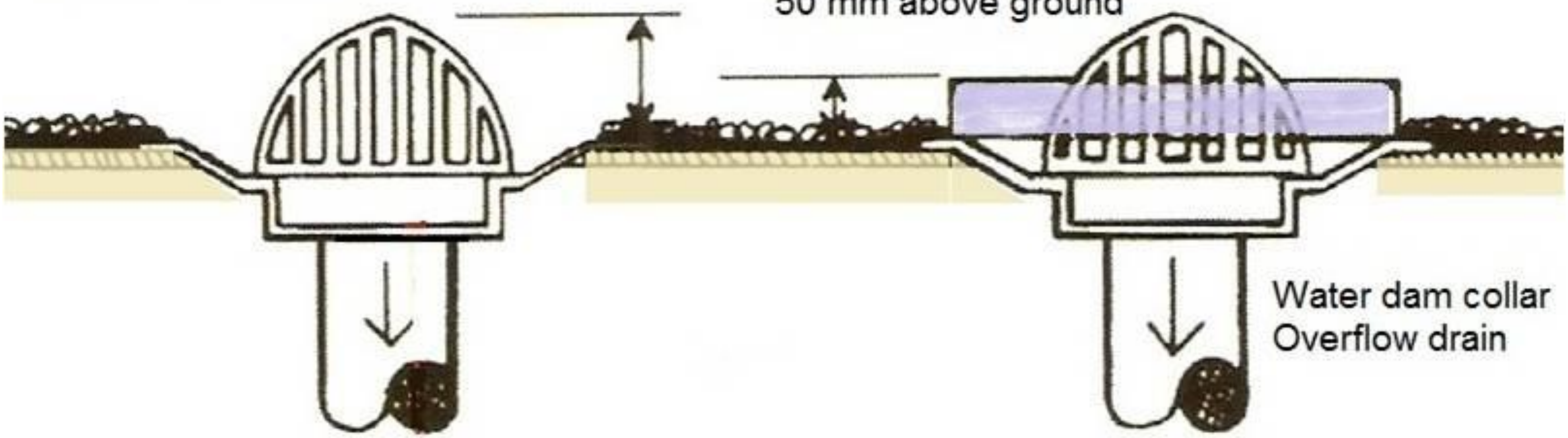


Figure 11-11

Primary and Secondary Roof Drains

Primary and Secondary Roof Drains –

Secondary With 50 mm Weir

Secondary Roof Drainage - Emergency Overflows

Required for roofs that may trap water when primary drains are plugged.

Shall discharge by separate system or combined system which is visible at ground level forimmediate identification.

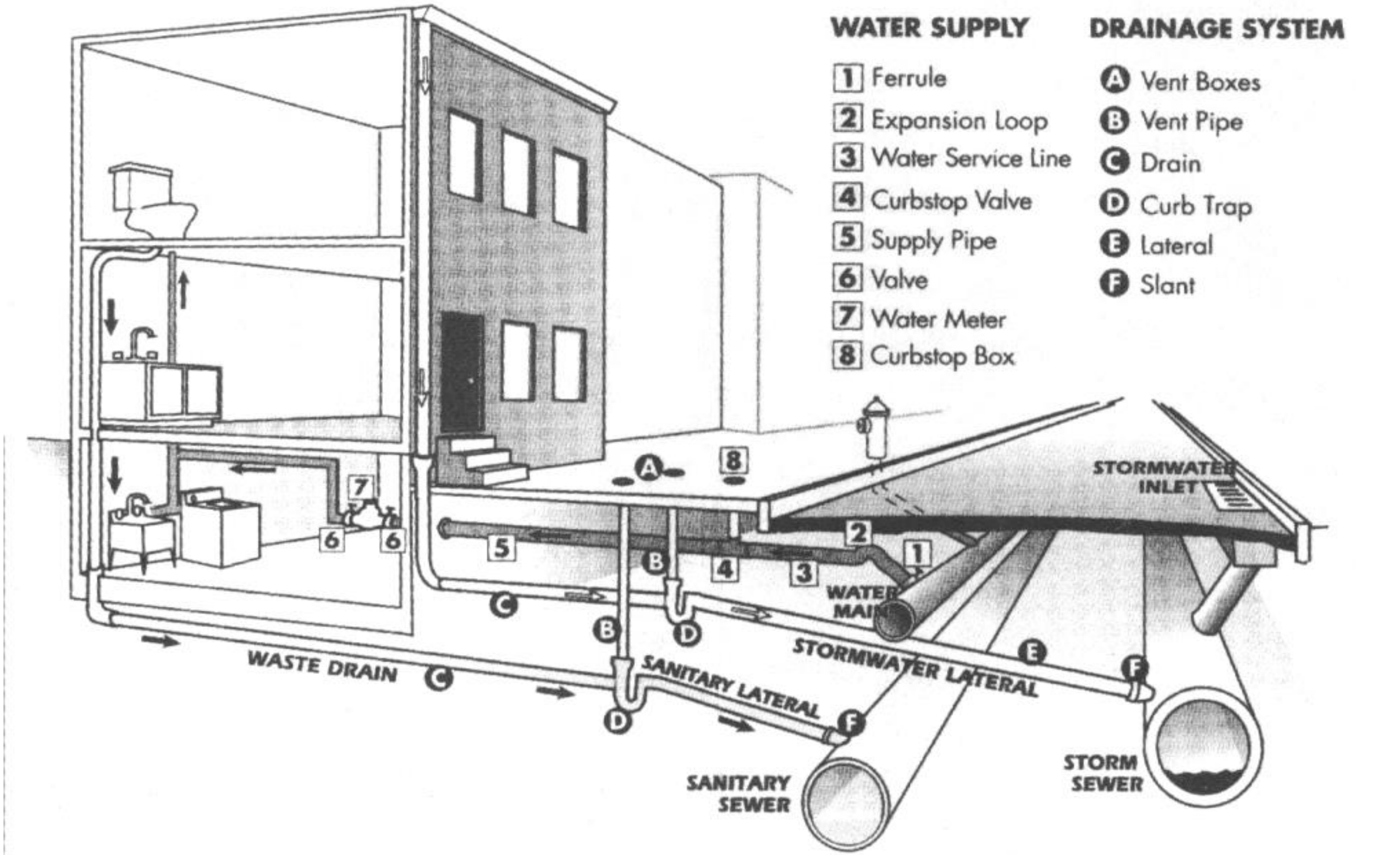
The roof must be designed for the weight of standing water

The secondary roof drainage system shall be a separate system of piping, independent of the primary roof drainage system.

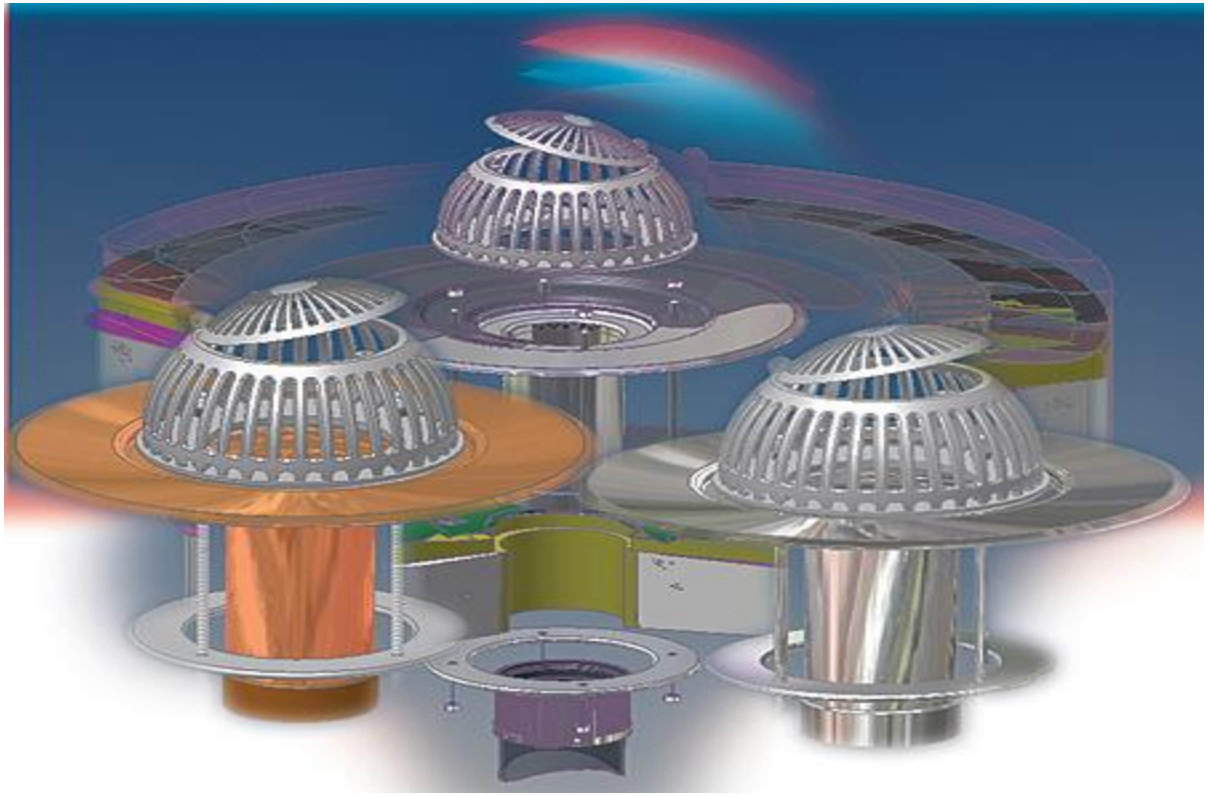
The discharge shall be above grade, in a location observable by the building occupants or maintenance personnel.

Secondary roof drain systems shall be sized in accordance with code based on the rainfall rate for which the primary system is sized.

Separate Sanitary and Storm Drainage Systems



Roof drains shall be of cast-iron, aluminum, stainless steel, PE, copper or copper alloy or plastic



Side outlet drains

CI Roof Drain with 100 mm Dome Strainer

CI Flat Deck Roof Drain

Under Deck Clamping Ring

Test by water or air and prove watertight

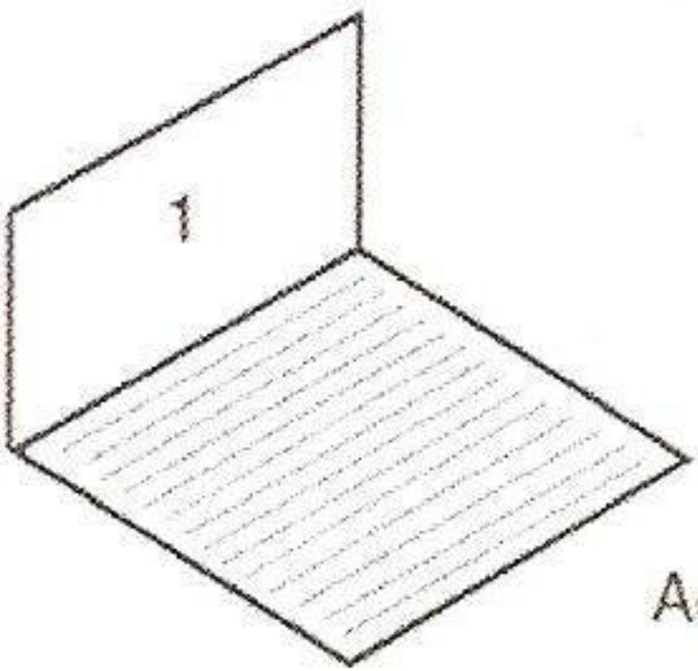
Water: Entire system at once, fill to highest level. If in sections, each section with 3 m head
Test duration, 15 minutes

Air: 34.5 Kpcal for 15 minutes

Side Walls Draining Onto Roof
Rain falling against an adjacent wall or parapet drains onto the roof and contributes to the area to be drained. Drains must be sized to include this contribution.

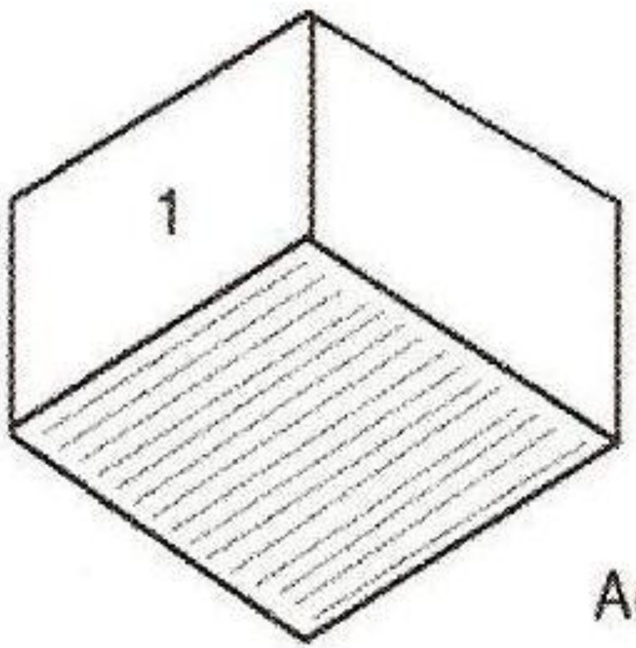
Example (1)

50% Tributary Area

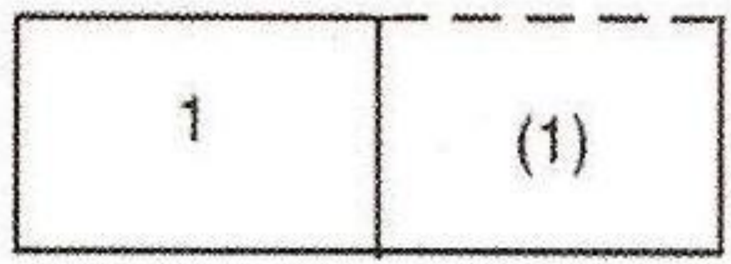


Add to 100% of roof area.

Example (2)



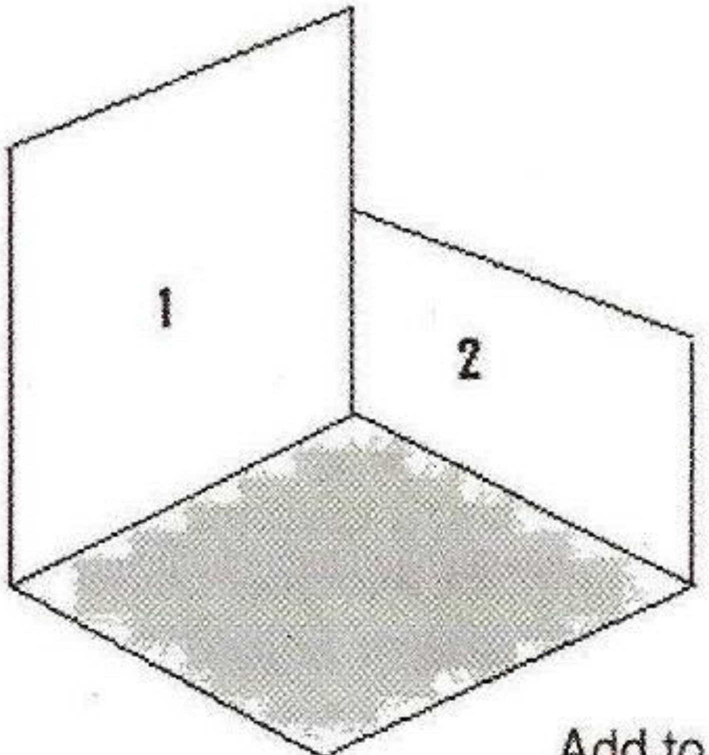
Tributary Areas



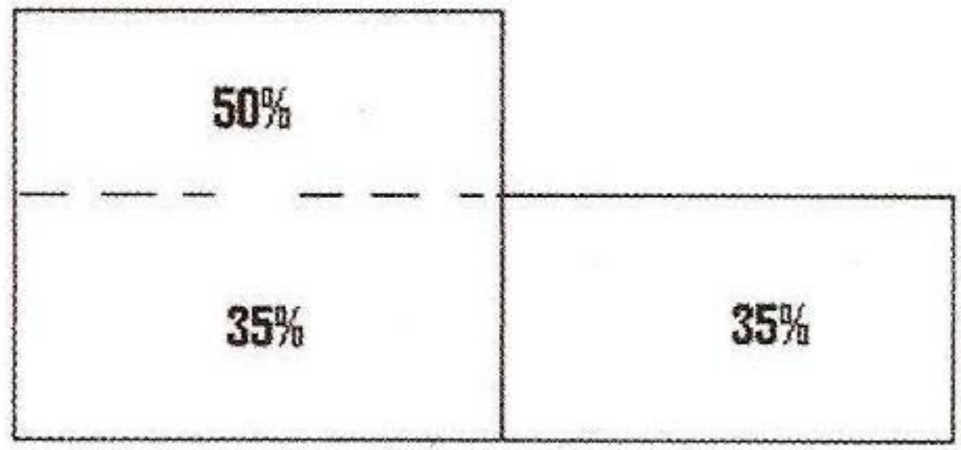
35%

Add to 100% of roof area.

Example (3)

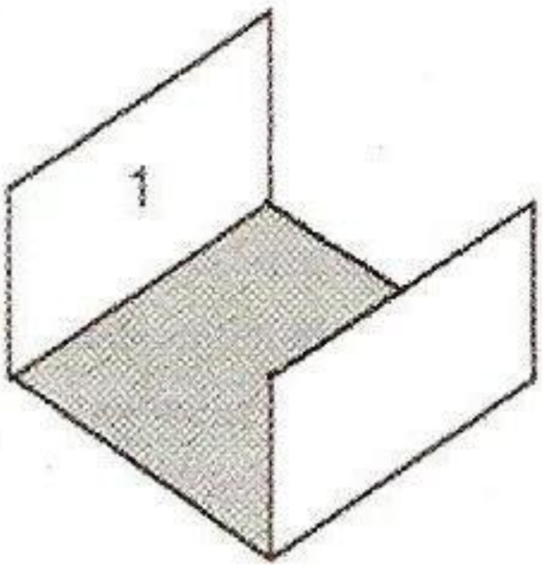


Tributary Areas



Add to 100% of roof area.

Example (4)



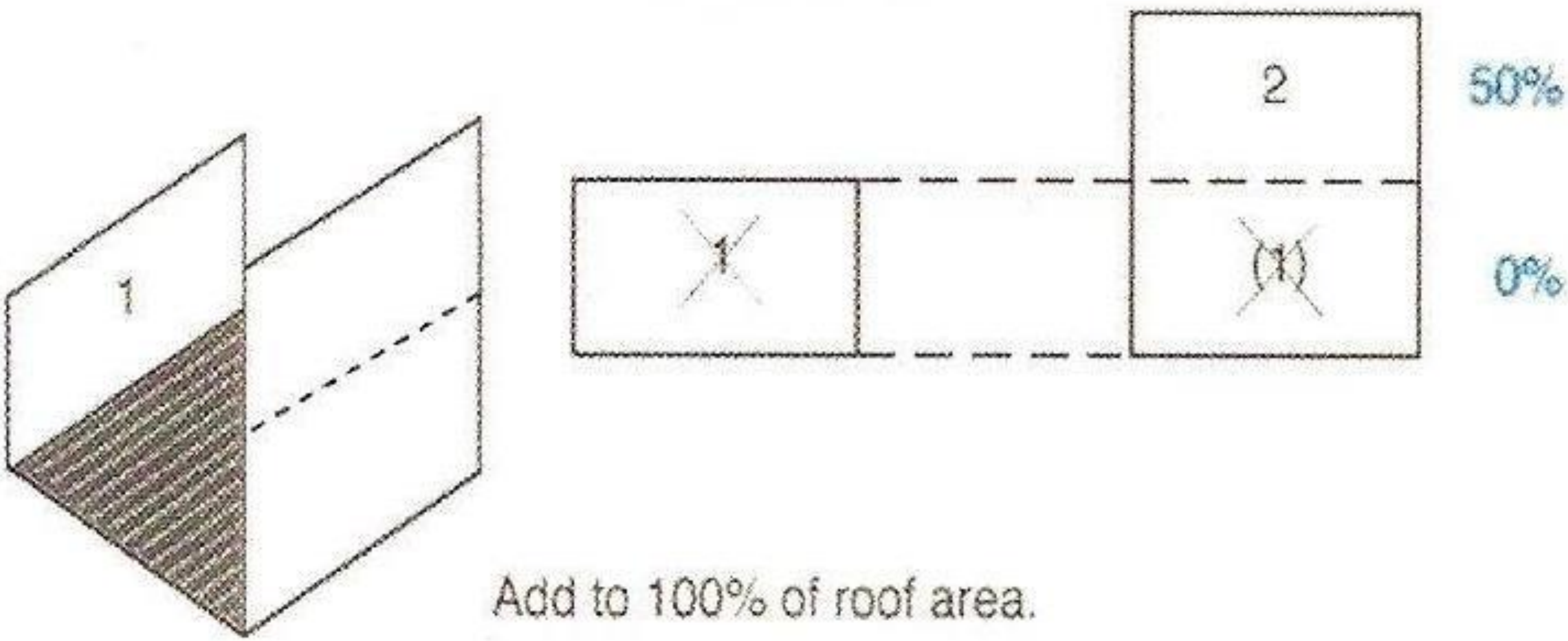
Tributary Areas

0%

Add to 100% of roof area.

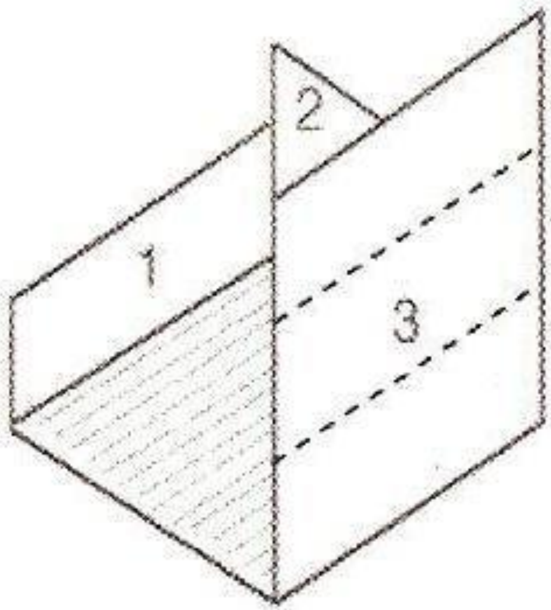
Example (5)

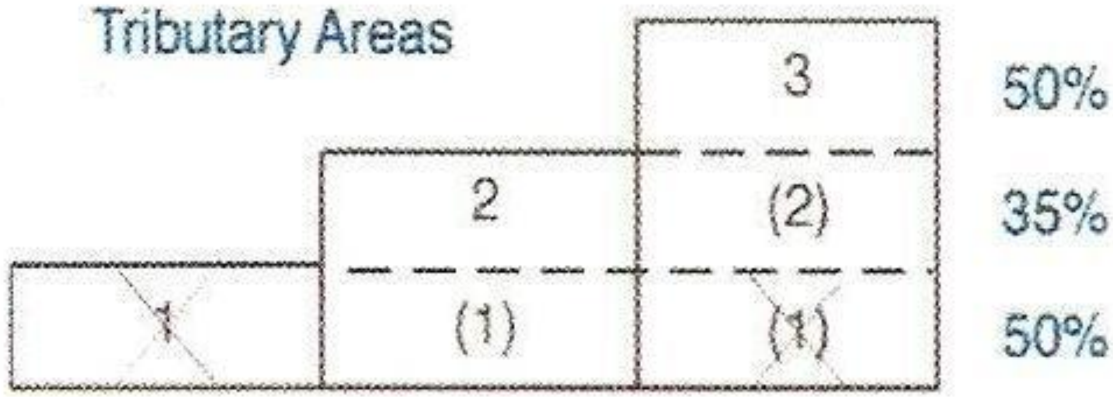
Tributary Areas



Add to 100% of roof area.

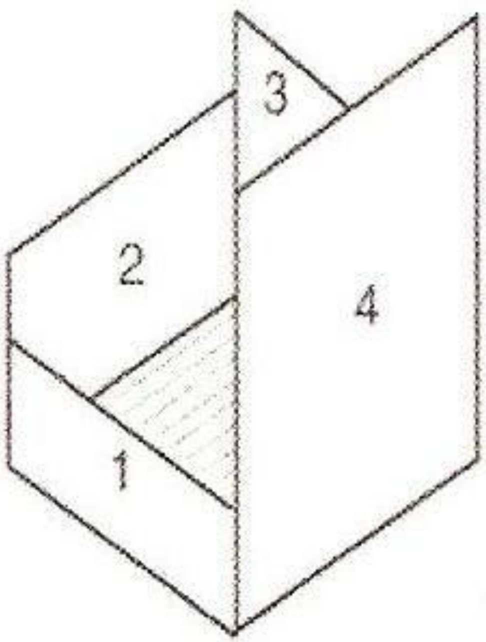
Example (6)



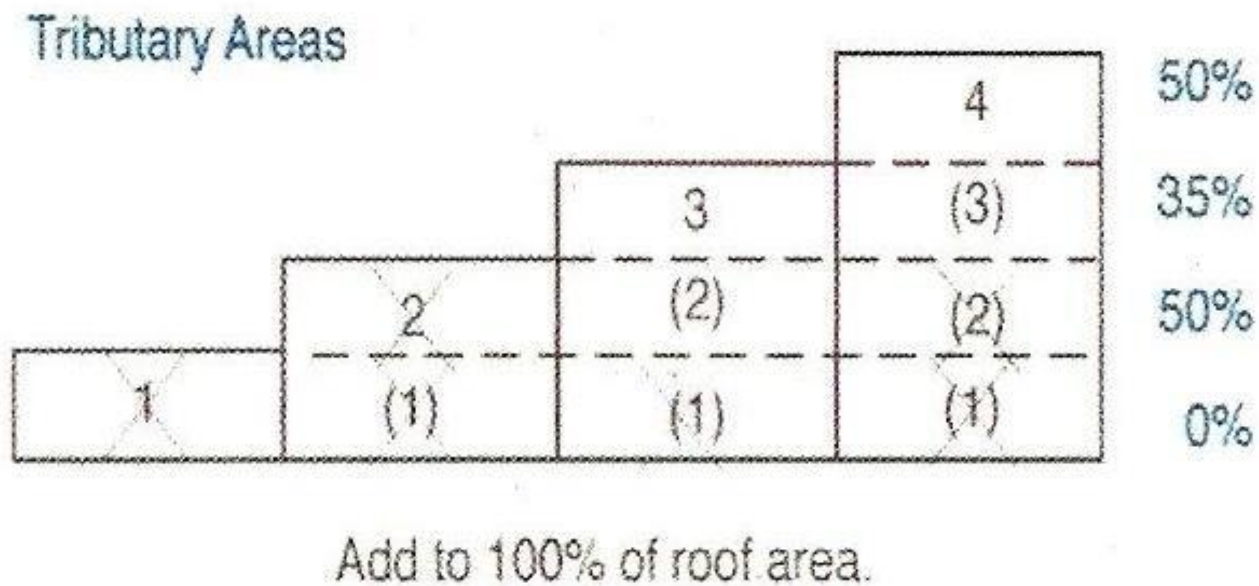


Add to 100% of roof area.

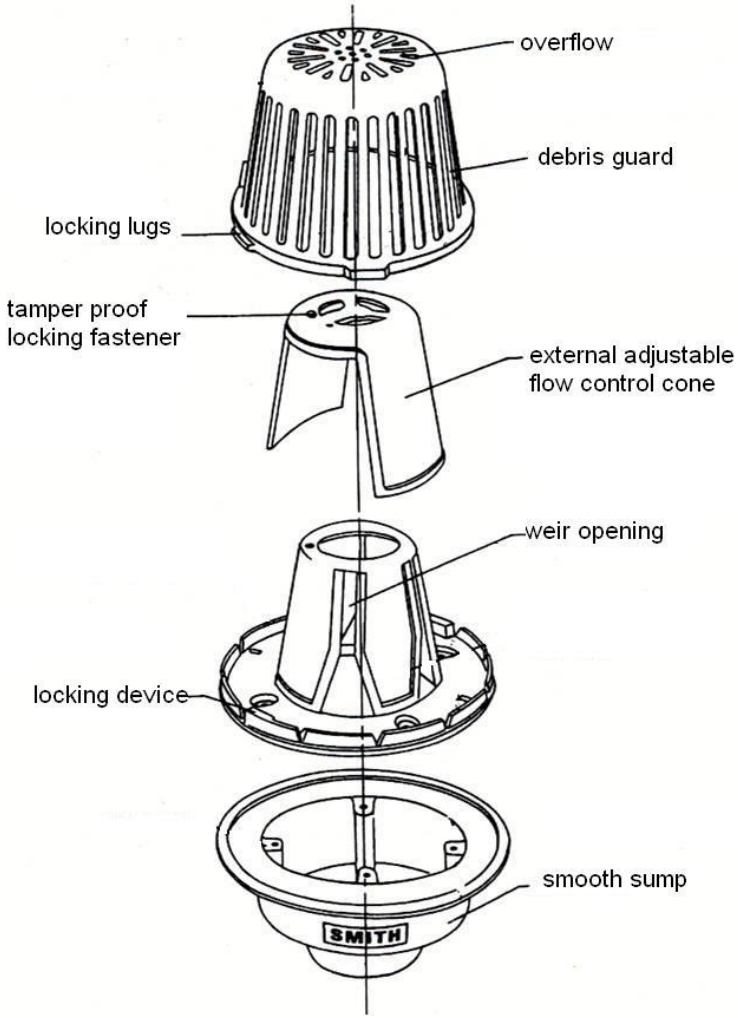
Example (7)



3
2
4
1



Tributary Areas
4
3
(3)
2
(2)
(2)
1
(1)
(1)
(1)
50%
35%
50%
0%
Add to 100% of roof area.



Controlled Flow Roof Drain

An engineered-design system

An alternative sizing method for storm drains

Utilized pre-calibrated weirs on the roof drains to control the flow

Controlled Flow System Scupper Overflow

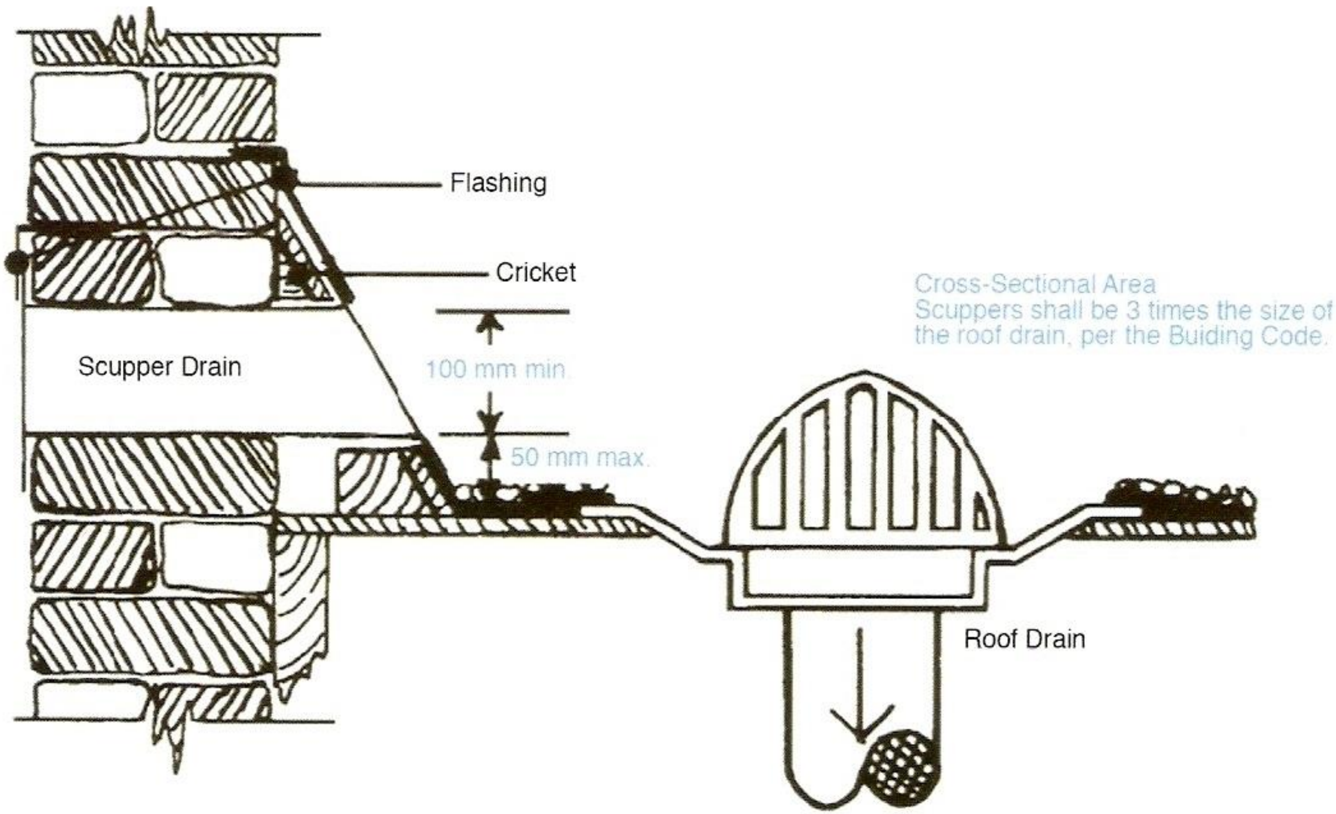


Figure 11-25
Scupper Opening

Table for ceiling suspended gravity horizontal RWP design

	CAPACITY OF DRAINS													
	Table C.1- Discharge values , filling degree 70%, (h/d=0.7)													
slope	dn100		DN125		DN150		DN200		DN225		DN250		DN300	
/	Qmax	V	Qmax	V	Qmax	V	Qmax	V	Qmax	V	Qmax	V	Qmax	V
cm / m	1/s	M/S	1/s	M/S	1/s	M/S	1/s	M/S	1/s	M/S	1/s	M/S	1/s	M/S
0.50	2.9	0.5	4.8	0.6	9.0	0.7	16.7	0.8	26.5	0.9	31.6	1.0	56.8	1.1
1.00	4.2	0.8	6.8	0.9	12.8	1.0	23.7	1.2	37.6	1.3	44.9	1.4	80.6	1.6
1.50	5.1	1.0	8.3	1.1	15.7	1.3	29.1	1.5	46.2	1.6	55.0	1.7	98.8	2.0
2.00	5.9	1.1	9.6	1.2	18.2	1.5	33.6	1.7	53.3	1.9	63.6	2.0	114.2	2.3
2.50	6.7	1.2	10.8	1.4	20.3	1.6	37.6	1.9	59.7	2.1	71.1	2.2	127.7	2.6
3.00	7.3	1.3	11.8	1.5	22.3	1.8	41.2	2.1	65.4	2.3	77.9	2.4	140.0	2.8
3.50	7.9	1.5	12.8	1.6	24.1	1.9	44.5	2.2	70.6	2.5	84.2	2.6	151.2	3.0
4.00	8.4	1.6	13.7	1.8	25.8	2.1	47.6	2.4	75.5	2.7	90.0	2.8	161.7	3.2
4.50	8.9	1.7	14.5	1.9	27.3	2.2	50.5	2.5	80.1	2.8	95.5	3.0	171.5	3.4
5.00	9.4	1.7	15.3	2.0	28.8	2.3	53.3	2.7	84.5	3.0	100.7	3.1	180.8	3.6

Rainwater Vertical gravity pipe New NBC 2016 table

Vertical RWP sizing Refer Pg 7 of NBC (Clause 4.5.11.6.8) page 49						
Table for CI pipe with coefficient of roughness 0.013 (New NBC)						
	Average rate of rainfall(mm/h)					
Pipe Dia in mm	50	75	100	125	150	200
50	29.7	19.8	14.85	11.88	9.9	7.42
65	57.23	38.15	28.61	22.89	19.08	14.31
75	81.84	54.56	40.92	32.74	27.28	20.46
100	168	112	84	67.2	56	42
125	293.48	195.66	146.74	117.39	97.83	73.37
150	462.95	308.64	231.48	185.18	154.32	115.74
Table for PVC pipe with Coefficient of roughness 0.009 (Clause 4.5.11.6.8) page 49						
	Average rate of rainfall (mm/h) NEW					
Pipe Dia in mm	50	75	100	125	150	200
50	42.90	28.60	21.45	17.16	14.30	10.72
65	82.67	55.11	41.33	33.06	27.56	20.67
75	118.21	78.81	59.11	47.29	39.40	29.55
100	242.67	161.78	121.33	97.07	80.89	60.67
125	423.92	282.62	211.96	169.56	141.31	105.98
150	668.71	445.81	334.36	267.48	222.91	167.18

Storm Water Design

Points to considered for designing:

1 Storm water Discharge is calculated as :

Q=C*i*A/360 where C = Coefficient of runoff

i= Rainfall intensity in mm / hr

A: Surface Area in hecter

2 The velocity of flow for circular pipe is calculated as :

V=1/n X R 2/3 x S 1/2 (Manning's Formula)

where n= Manning coefficient (n=0.015)

R = Hydraulic Radius in meters

S = Slope

3 Calculate the actual velocity for the flow i.e 'v' The actual velocity (v) provided is more than the required Permissible velocity is between 0.7 to 3 m/sec.

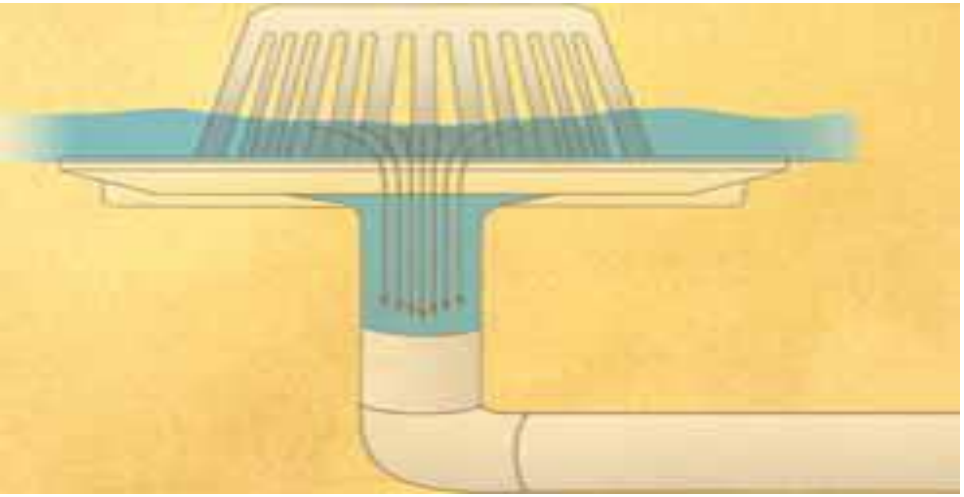
Following are important design criterion for storm water design

- RWP size shall be designed for a maximum rainfall intensity of 60 minutes duration , local IMD data shall be referred.
- Time of concentration:- It is time required for the rainwater from the farthest area of the catchment to reach to the stormwater outlet
- Return period or design storm frequency:-It is average no of years between occurrences of a storm of that given intensity.
- IDF Curve:-Intensity-duration-frequency curve. The curve for a given frequency(return period) is a plot of several storms of varying lengths, not a single storm plotted against time. These curve are helpful in getting design rainfall intensity which is equal to storm of your site time of concentration.

Siphonic Roof Drainage System

Siphonic roof drainage systems shall be designed in accordance with applicable standards and manufacturers' recommendations.

With a higher flow capacity, siphonic drainage has advantages over conventional systems.



Unlike traditional roof drainage system, in which pipe is flowing partially full , in siphonic system operates at full capacity, when water is sucked or syphoned from the roof down into the drain at high velocity.

The full flow system allows architects, consultants and contractors alike to utilise a lower number of roof outlet drains and have them flow into a significantly less down pipe.

A conventional outlet is simply a hole in the form of outlet the siphonic outlet has anti-vortex plate. This prevent air going in the system resulting in to full flow.

Different Stages in Siphonic system

Flow pattern 1(gravity flow)

Initially, during rainstorms of up to 10% of the design storm, the flow through the siphonic system will be as it would be in a gravitational system resulting in a partially filled pipe.

Flow pattern 2(plug flow)

As the storm would intensify the water level above the siphonic outlet would increase, submerging the anti-vortex plate within the outlet preventing air from entering the piping system and increasing the flow rate. At the interface where the fast moving water meets

The slow moving water within the pipe a plug of water is formed. The action of the plug of water falling within the down pipe provides the initial siphonic action.

Flow pattern 3 (bubble flow)

Eventually the storm intensity increases to a point
Where the water entering the system is moving at such a rate that the individual plugs of water meet, forming a more or less continuous flow, but with air bubbles in evidence, hence
The term "bubble flow".

Flow pattern 4 (full bore flow)

When the design storm has reached its maximum Intensity, the siphonic system operates at its most efficient with The pipes flowing full of water. Once the intense part of the rain has dissipated the flow pattern within the pipe work returns to flow as per stage 3, 2 and finally 1.

The siphonic action relies on the point at which liquid exits the pipe (2) Being lower than the surface of the liquid that is being syphoned (1). The volume of liquid in the full flowing pipe between these two points can be described as the driving head. Gravity acting upon the column of water in the driving head causes a reduction in pressure towards the top of the pipe, this in turn leads to more liquid being forced into the pipe.

The driving head can be considered as creating the motivating force of a syphon therefore it is logical that the longer the driving head, the greater the capacity of the syphon. This is true because a larger driving head will create a larger pressure imbalance resulting in a higher velocity flow in the pipe. Triggered by the outlet & its component parts.

Siphonic outlet

The siphonic outlet is the mechanism which stimulates the onset of the siphonic action, ensuring the piping system runs full flow (full bore) by excluding air.

It is very essential to have a siphonic drainage system designed from a person / company specialising in the technology. Siphonic outlets is one of the important part of a total engineered solution offered by the manuefactuer.

A siphonic drainage engineer must be aware of the hydraulics and behaviour of water under different conditions. He should be qualified in solving relevant problems pertaining to fluid mechanics.

High end software is used to design siphonic drainage solutions for draining the most complex roofs. A system designer is fully qualified to provide full design service

Large no of international projects has been successfully designed and executed offering cost effective solutions in draining the most complex roofs.

Success of a well designed system is meaningless without proper installation and support.

International companies with its vast experience offers turnkey solutions by providing prefabricated engineered pipe frames ready for use at site. All factory fitted and tested pipe frames are supplied with numbered fabrication drawings.

Fabrication is done under strict supervision and quality - controlled factory environment.

Advantages of Siphonic system are as follows

- Siphonic rain water discharge systems are modern and evolve fairly sophisticated technology
- Reduces the down pipes as most of the run is horizontal
- The down pipe can be located at the convenience of the architect
- Reduces cost on aesthetically camouflaging down pipes
- More efficient since water flows full bore in the pipes
- Reduces underground drainage piping
- System uses full static head from gutter bottom to the 1st connecting drain level.

Thank you

Any Questions?

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