HOW TO DETERMINE ROOF GUTTER SIZE?

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A roof serves as the upper covering of a building, primarily protecting it from weather exposure while contributing to safety, insulation, and privacy. Various roof types exist, including flat, gable, hip, and shed roofs.

A rain gutter, also known as a roof gutter, is an essential component of a building's water discharge system. It collects rainwater runoff from the roof and channels it to downpipes, directing water away from the building's foundation and discharging it into the nearby drainage system.

Importance of Proper Gutter Sizing

Choosing the correct gutter size is critical for effective drainage and long-term property protection. Key benefits include:
- ✓ Enhanced Drainage: Properly sized gutters accommodate increased water flow.
- ✓ Damage Mitigation: Reduces the risk of water-related damage to the building.
- ✓ Property Integrity: Maintain structural integrity by preventing overflow and dampness.
- ✓ Maintenance Reduction: Minimizes clogs and decreases the need for frequent repairs.

Factors Influencing Gutter Size

Several factors must be considered when sizing gutters and downpipes:
1. Rainfall Intensity: The average rainfall rate in your area.
2. Roof Catchment Area: The total catchment area of the roof that drains into the gutter.
3. Flow Capacity: The ability of the gutter to handle expected water flow.
4. Gutter Falls: The slope of the gutter that facilitates drainage.
5. Bends and Outlets: The location of bends and outlet positions affect flow efficiency.
6. Gutter Cross Sectional Area: The dimensions of the gutter itself.
7. Roof Slope: Steeper roofs lead to faster runoff.

Types of Gutters

In Malaysia, two common types of gutters are:
- Eaves Gutters: Positioned on the exterior of a building.
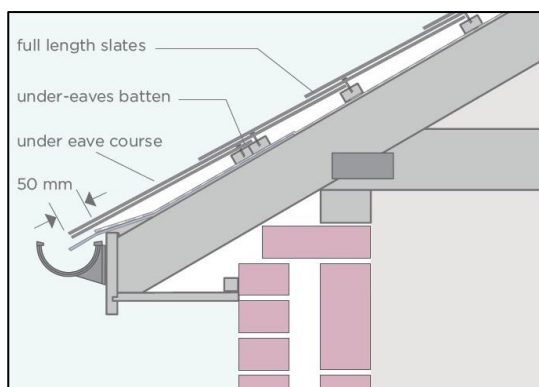- Box Gutters: Located within the building's plan area or at roof intersections.
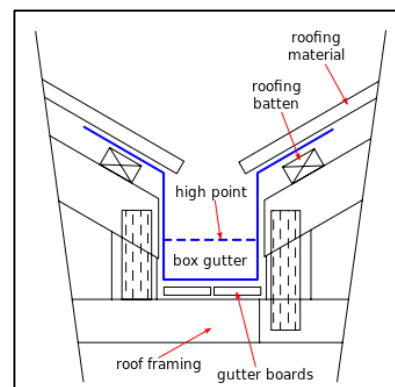

Figure 1: Eaves Gutter [1]

Figure 2: Box Gutter [2]

Design ARIs for Roof Drainage

The critical storm duration of 5 minutes should be adopted for all roofs unless special circumstances justify a longer duration [3].

Table 1: Design ARIs for Roof Drainage [3]

Property Type	Eaves Gutter	Valley & Box Gutter
All Buildings	20 year ARI	50 year ARI

Note that if water flows back into the building, overflow measures are required. A higher design ARI shall be adopted for buildings located at hillside areas.

Determination of Roof Catchment Area

Wind can cause rain to slope, creating a horizontal component of rainfall, which becomes significant on vertical walls or sloping roofs. The maximum rainfall slope is assumed to be 2 vertical to 1 horizontal. The roof catchment area for a single sloping roof fully exposed to wind can be determined using the formula [3]:

$$A_c = A_h + \frac{A_v}{2}$$ ----- Equation 1

Where A_h is the plan area and A_v is the vertical area.
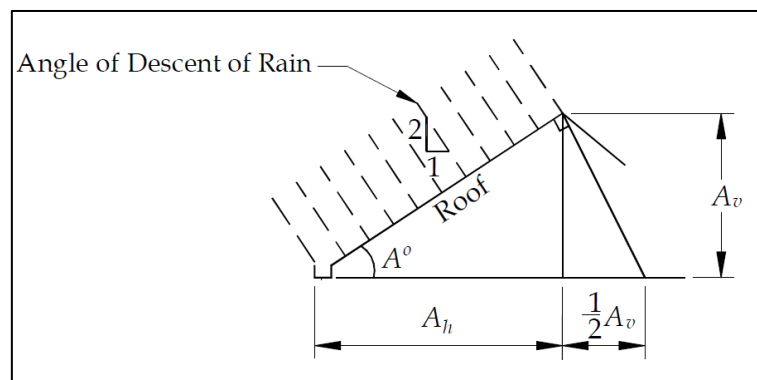

Figure 3: Single Sloping Roof that Freely Exposed to Wind [3]

Design of Eaves Gutter

For a simple sloping (gabled) roof, the minimum gradient of an eave gutter shall be 1:500 to provide adequate fall and minimize the risk of ponding. Eaves gutters are generally known as half-round, ogee, or quad.

The required size of an eaves gutter with a gradient of 1:500 or steeper can be determined in Figure 4. The graph in Figure 4 assumes the least favorable positioning of the downpipe and bends within the gutter length. The rainwater outlet to a vertical downpipe is located centrally in the sole of the eaves gutter. It applies to half round, quad, ogee, or square types of eaves gutter [4].

The graph limits the catchment area per downpipe at 100m^2 and the effective cross-sectional area of the eaves gutter, A_g at 18,000 mm^2. For roof catchment area exceeds 100m^2, different outlet or bend to outlet position, the required cross-sectional area of the gutter can be calculated using the following formula [5]:

$$a_{gutter} = \left[\frac{10.44\, A_c\, i}{1+x}\right]^{0.8}$$ ----- Equation 2

Where
a_g = Required cross-sectional area of gutter for discharge (mm^2);
x = Gutter design coefficient (Figure 5);
A_c = Catchment area (m^2)
i = Rainfall intensity (mm/hr)

Note that if the gutter has a rectangular cross-section, as distinct from a rounded one, the required cross-sectional area of the gutter shall be increased by 10% [5].
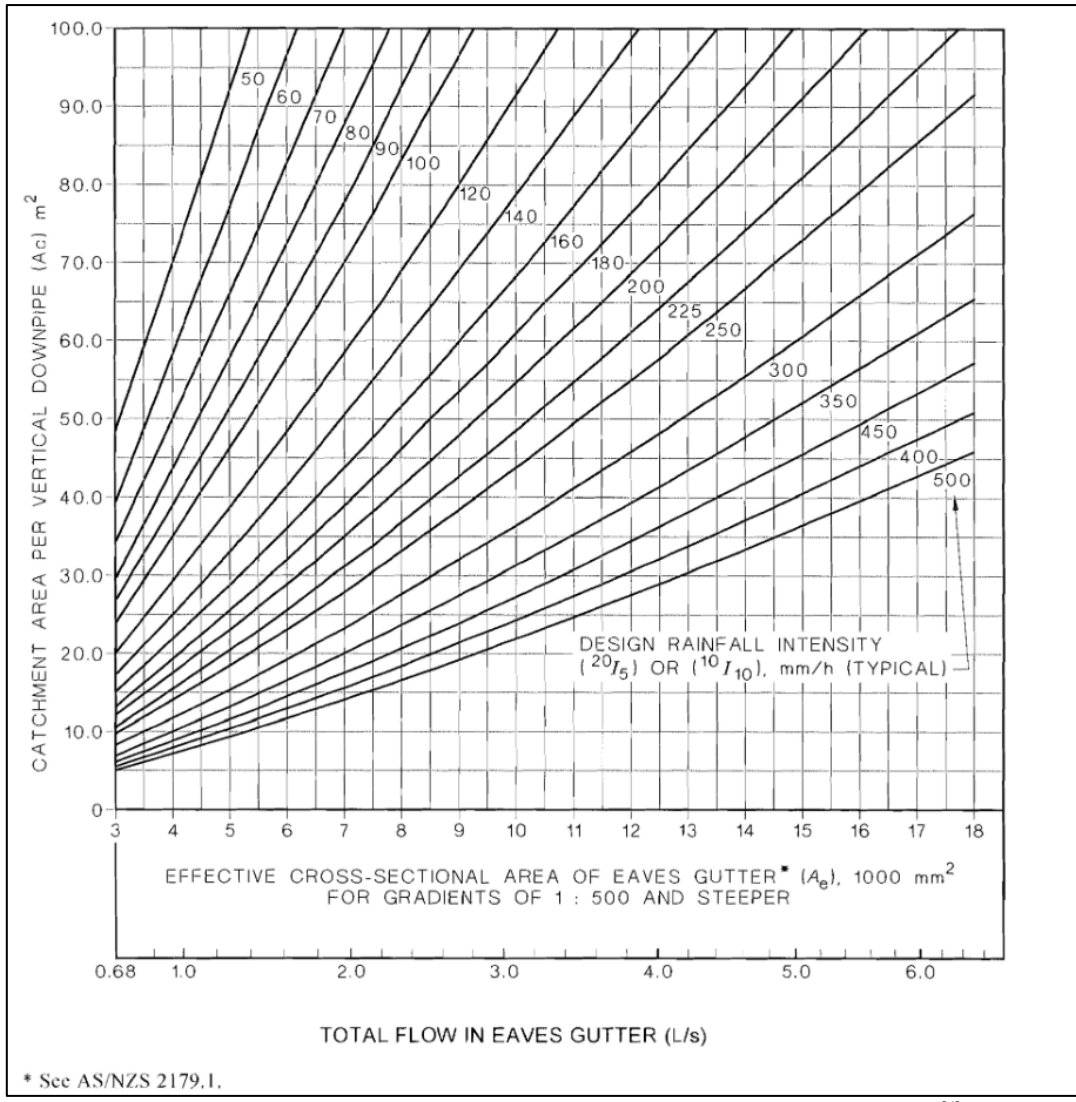
Figure 4: Required Size of Eaves Gutters for Gradient of 1:500 and Steeper [4]

TABLE 2
VALUES OF THE EAVES GUTTER DESIGN COEFFICIENTS*

Case	Sloping	Level	Less than 6 ft Sloping	Less than 6 ft Level	6–12 ft Sloping	6–12 ft Level	Greater than 12 ft Sloping and level	Central	Slightly displaced	Considerably displaced	End	Gutter design coefficient (x)
1	0.4		−0.25					1.00				1.15
2		0		−0.20				1.00				0.80
3	0.4				−0.125			1.00				1.275
4		0				−0.10		1.00				0.90
5	0.4						0	1.00				1.40
6		0					0	1.00				1.00
7	0.4		−0.25						0.66			0.81
8		0		−0.20					0.66			0.46
9	0.4				−0.125				0.66			0.935
10		0				−0.10			0.66			0.56
11	0.4						0		0.66			1.06
12		0					0		0.66			0.66
13	0.4		−0.25							0.33		0.48
14		0		−0.20						0.33		0.13
15	0.4				−0.125					0.33		0.605
16		0				−0.10				0.33		0.23
17	0.4						0			0.33		0.73
18		0					0			0.33		0.33
19	0.4		−0.25								0	0.15
20		0		−0.20							0	−0.20
21	0.4				−0.125						0	0.275
22		0				−0.10					0	−0.10
23	0.4						0				0	0.40
24		0					0				0	0

* After Martin (1965).

Figure 5: Values of the Eave Gutter Design Coefficients [5]

Example Calculation of Eave Gutter Sizing

A calculation of an eave gutter sizing is demonstrated below using ARI data of Hulu Jabor, Kemaman, and Terengganu.
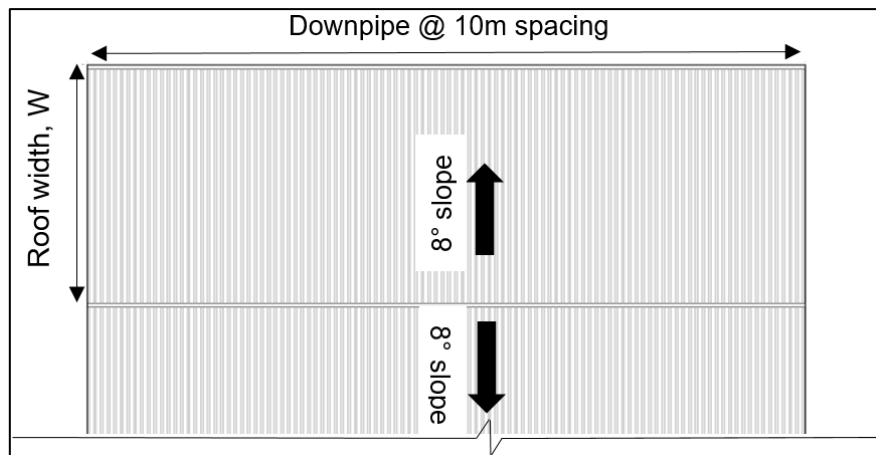

Figure 6: Plan of a 8° Pitched Roof

Table 2: Fitting Constants for The IDF Empirical Equation for Hulu Jabor, Kemaman, Terengganu, Malaysia for High ARIs Between 2 and 100 Years and Storm Durations from 5 Minutes to 72 Hours [3]

State	Station ID	Station Name	Constants			
			λ	κ	θ	η
Terengganu	3933001	Hulu Jabor, Kemaman	103.519	0.228	0.756	0.707

Solution:

1. **Calculate rainfall intensity**

   Using historical data for rainfall intensity over a 5-minute duration with a 20-year Average Recurrence Interval (ARI) specific to Hulu Jabor, Kemaman, and Terengganu.

   $$i = \frac{\lambda T^K}{(d+\theta)^\eta}$$ ----- Equation 3

   T = 20 years
   λ = 103.519
   K = 0.228
   θ = 0.756
   η = 0.707
   d = 0.0883 hr

   i = [(103.519)(20)$^{0.228}$] / [(0.0883+0.756)$^{0.707}$] = 232 mm/hr

2. **Calculation of catchment area (A_c) and required gutter area (A_g)**

   Determine the gutter design coefficient, x by knowing the following criteria:
   Is the gutter sloping or level?   = Sloping (Gradient 1:500 or steeper)
   Bend distance to downpipe   = Less than 6 ft
   Downpipe position along gutter   = End
   From Figure 5, hence x   = 0.15
   Sectional type of gutter   = Rectangular, hence A_g is increased by 10%

The calculation of the 8° pitched roof catchment area and cross-sectional area of the gutter at 5m width interval and 10m constant spacing of downpipes is tabulated as follows.

Table 3: Calculation of Roof Catchment Area and Required Gutter Cross Sectional Area per 10m Spacing of Downpipes for 8° Pitched Roof

Roof width, W (m)	Roof catchment area at 10m span, A_c (m^2)	Required cross sectional area of gutter for discharge, A_g (mm^2)
5m	53.75 m^2	12,147 mm^2
10m	107.50 m^2	21,149 mm^2
15m	161.25 m^2	29,252 mm^2
20m	215.00 m^2	36,822 mm^2
25m	268.75 m^2	44,019 mm^2
30m	322.50 m^2	50,931 mm^2
35m	376.25 m^2	57,616 mm^2
40m	430.00 m^2	64,111 mm^2
45m	483.75 m^2	70,446 mm^2
50m	537.50 m^2	76,641 mm^2

3. **Determine the gutter minimum size**

The effective cross-sectional area, A_e shall be obtained from a manufacturer's technical data. To check the provided effective cross-sectional area by a manufacturer, for an eave gutter with external brackets, the A_e shall be calculated from the line at least 10mm below the overflow. For internal brackets, the projected gross area of the edge of the internal bracket may be deducted not more than 15% of the original cross-sectional area of the gutter [4].
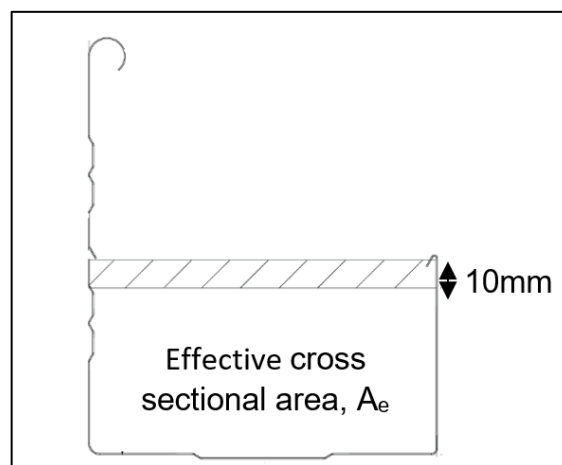

Figure 7: Effective Cross-Sectional Area of a Gutter

The nominal downpipe sizes to match eave gutter size are referred to Australian Standards [4] as guidance. Assuming a rectangular gutter with external bracket installation is used in this calculation, the width to depth ratio be 2:1, and the minimum eaves gutter dimensions are tabulated in Table 4.

Table 4: Required Size of Downpipe for Eaves Gutter

Required Cross Sectional Area of Gutter, A_g (mm²)	Minimum Nominal Downpipe Size to suit Gutters (mm)		Minimum Eaves Gutter Dimension		
	Circular	Rectangular	Width (mm)	Depth (mm)	Effective A_e (mm²)
9,600	125	100 x 75	150	75	9,750
12,800		100 x 100	175	90	14,000
16,000	150	125 x 100	190	95	16,150
18,400		150 x 100	205	105	19,475
19,200	160		215	110	21,500
20,000		125 x 125			
22,000	200	150 x 125	220	110	22,000
31,500		NA	270	135	33,750
32,000	250				
49,000			325	165	50,375
49,100	315				
53,000			340	170	54,400
61,500			365	185	63,875
78,000			410	205	79,950

Conclusion

Accurate sizing of roof gutters is essential for effective drainage and long-term maintenance. By considering various factors such as rainfall intensity and roof characteristics, property owners can ensure their buildings remain protected from water damage.

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