Rock Sizing for Batter Chute Outlets

STORMWATER MANAGEMENT PRACTICES

Photo 1 – Rock-lined drainage chute

Photo 2 – Rock-lined drainage chute used in the stabilisation of a gully

1. Terminology

In the stormwater industry, a 'chute' is a steep drainage channel, typically of uniform cross-section, that passing down the face of a slope. The channel gradient is usually steeper than 10%. Common terminology also includes 'batter chutes' and 'drainage chutes'.

The term 'outlet structure' refers to a wide range of outlet control devices constructed at the base of chutes to control soil erosion adjacent to the outlet and to dissipate the flow energy. These outlet structures typically consist of rock pads, rock mattress aprons, or various types of concrete energy dissipaters.

2. Design of rock pad outlet structures for batter chutes

The following design procedure is not appropriate for the design of energy dissipaters at the base of dams or basin spillways.

The critical design parameters are the mean rock size (d_{50}) and length of rock protection (L).

The recommended rock sizing design charts/tables are based on the acceptance of some degree of rock movement (rearrangement) following the first few storm events.

Recommended mean (d_{50}) rock sizes and length (L) of rock protection for minor chutes are presented in Tables 1 and 2. These rock sizes are based on information presented within ASCE (1992) rounded up to the next 100 mm increment, with a minimum rock size set as 100 mm.

Table 1 – Mean rock size, d_{50} (mm) for batter chute outlet protection [1]

Depth of approach flow (mm) [2]	Flow velocity at base of *Chute* (m/s)						
	2.0	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**
50	100	100	100	200	200	200	300
100	100	100	200	200	300	300	400
200	100	200	300	300	400	[3]	[3]
300	200	200	300	400	[3]	[3]	[3]

[1] For exit flow velocities not exceeding 1.5 m/s, and where growing conditions allow, loose 100 mm rock may be replaced with 75 mm rock stabilised with a good cover of grass.

[2] This is the flow depth at the base of the chute as it approaches the outlet structure. The flow depth is based on the maximum depth, not the average flow depth.

[3] Consider using 400 mm grouted rock pad, or a rock-filled mattress outlet.

The rock pad lengths presented in Table 2 will not necessarily fully contain all energy dissipation and flow turbulence; therefore, some degree of scour may still occur downstream of the outlet structure. Extending the length of the rock pad will reduce the risk of downstream soil erosion.

Table 2 – Recommended length, L (m) of rock pad for batter chute outlet protection

Depth of approach flow (mm)	Flow velocity at base of *Chute* (m/s)						
	2.0	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**
50	1.0	1.5	2.1	2.6	3.1	3.6	4.2
100	1.3	2.0	2.7	3.4	4.1	4.8	5.5
200	2.1	2.7	3.4	4.3	5.2	6.1	7.0
300	2.7	3.6	4.3	4.8	5.8	6.8	7.9

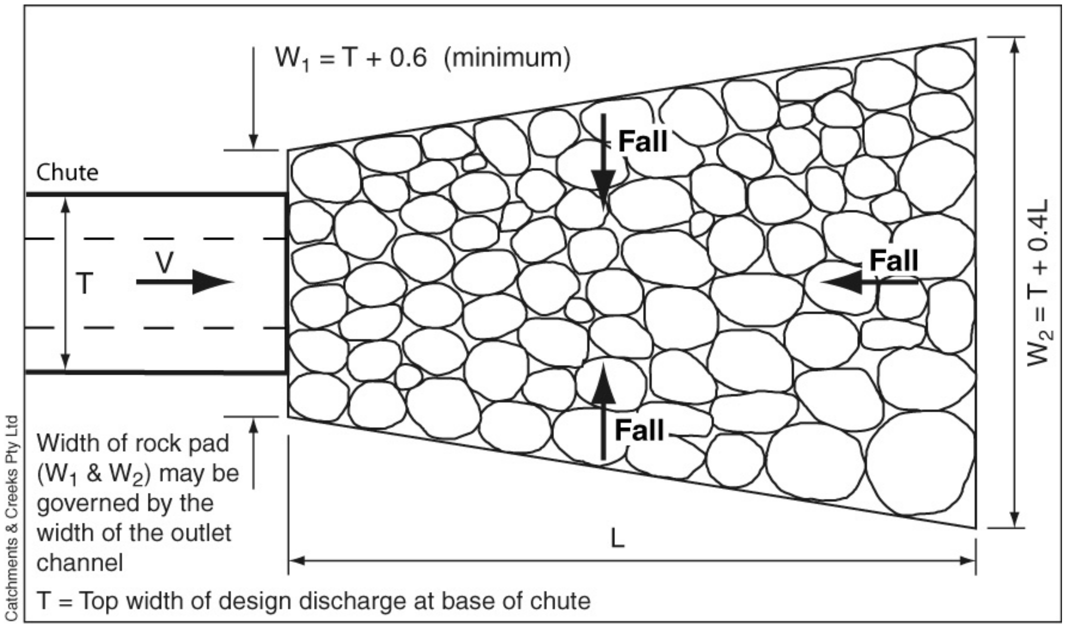

Figure 1 – Typical layout of a recessed rock pad for a chute (plan view)

As indicated in Figures 1, 2 and 3, outlet structures for minor chutes should ideally be recessed below the surrounding ground level to promote effective energy dissipation. Recessing the rock pad helps to ensure suitable tailwater conditions are achieved. The recommended recess depth (Z) can be determined from Table 3.

In circumstances where it is not practical to recess the rock pad (e.g. for safety or mosquito breeding concerns), appropriate steps should be taken to increase the depth of flow (i.e. tailwater conditions) at the base of the chute.

Table 3 – Recommended recess depth, Z (m) for batter *Chute* outlet protection

Depth of approach flow (mm)	Flow velocity at base of *Chute* (m/s)						
	2.0	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**
50	0.13	0.20	0.28	0.36	0.43	0.50	0.60
100	0.14	0.23	0.32	0.42	0.50	0.60	0.70
200	0.12	0.21	0.31	0.42	0.50	0.60	0.70
300	0.07	0.16	0.25	0.35	0.44	0.55	0.65

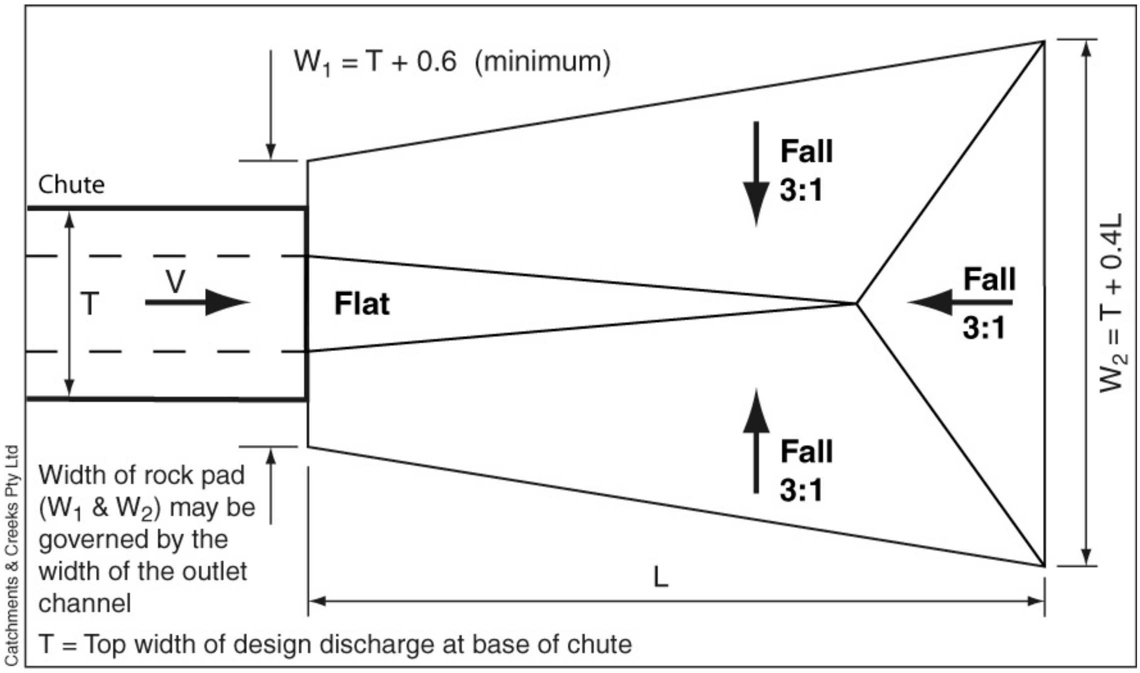

Figure 2 – Typical arrangement of a recessed outlet structure (plan view)

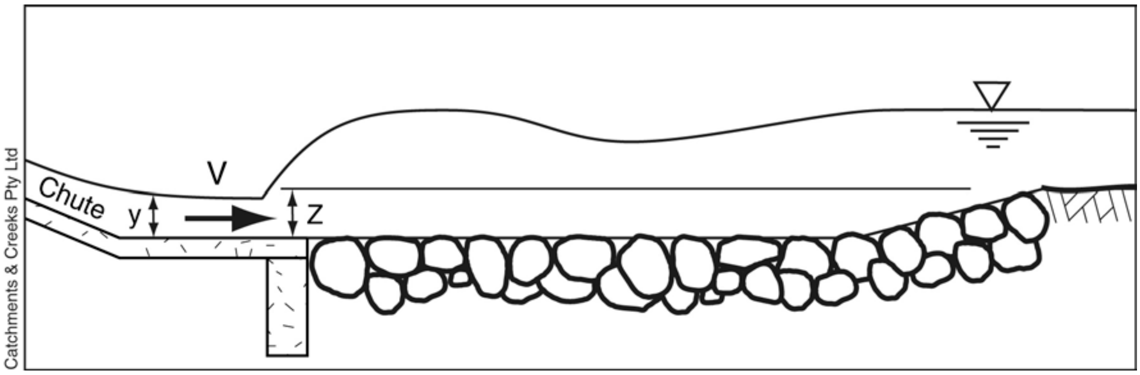

Figure 3 – Typical profile of a recessed outlet structure (side view)

3. Reference

ASCE 1992, *Design and construction of urban stormwater management systems*. ASCE Manuals and Reports of Engineering Practice No. 77, and Water Environment Federation Manual of Practice FD-20, American Society of Civil Engineers, New York.