Rock Sizing for Energy Dissipaters

STORMWATER AND WATERWAY MANAGEMENT PRACTICES

Photo 1 – Plunge pool energy dissipater outlet structure

Photo 2 – Rock-lined grade control (drop) structure

1. Introduction

Energy dissipaters generally contain two zones where rock stabilisation may be used. Zone 1 is the primary energy dissipation zone where turbulence and energy losses are the greatest. Zone 2 is the area immediately downstream of Zone 1 where flows are allowed to return to normal 'uniform' flow conditions prior to entering the receiving channel.

Concrete is more commonly used in the Zone 1, however rock has also been used. In some cases the stability of the rock is increased by filling all voids with grout (e.g. a grouted boulder energy dissipater).

Rock is commonly used for scour control within Zone 2.

2. Sizing rock placed downstream of energy dissipaters

Equation 1 is recommended for sizing rock placed within the zone of highly turbulent water immediately **downstream** of the end sill of an energy dissipater (i.e. Zone 2). This equation is based on the recommendations of Bos, Reploge, and Clemmens (1984).

$$d_{40} = 0.038\, V^{2.26} \qquad (1)$$

If it is assumed that $d_{40}/d_{50} = 0.75$, then Equation 1 converts to:

$$d_{50} = 0.050\, V^{2.26} \qquad (2)$$

If it is assumed that Equation 1 was based on rock of a specific gravity (s_r) of 2.6, then:

$$d_{50} = \frac{0.08\, V^{2.26}}{(s_r - 1)} \qquad (3)$$

Alternatively, Peterka (1984) presented the following equation for sizing riprap **downstream** of stilling basins (i.e. Zone 2):

$$d_{50} = 0.04\, V^{2} \qquad (4)$$

Equation 4 is possibly best replaced by the following equation (based on Isbash, 1936) to account for varying rock density.

$$d_{50} = \frac{K_1 . V^2}{14.5\,(s_r - 1)} \qquad (5)$$

where:

d_{50} = nominal rock size (diameter) of which 50% of the rocks are smaller [m]

K_1 = correction factor for rock shape

= 1.0 for angular (fractured) rock, 1.36 for rounded rock (i.e. smooth, spherical rock)

s_r = specific gravity of rock (e.g. sandstone 2.1–2.4; granite 2.5–3.1, typically 2.6; limestone 2.6; basalt 2.7–3.2)

V = (in Zone 1) the 'jet' velocity immediately upstream of the dissipation pool [m/s]

= (in Zone 2) the depth-average flow velocity at location of rock [m/s]

Rock sizing for other types of energy dissipaters, such as plunge pool systems, should be based on design guidelines specifically developed for the given type of energy dissipater.

2.1 Thickness of rock layer

The thickness of the armour layer should be sufficient to allow at least two overlapping layers of the nominal rock size. The thickness of rock protection must also be sufficient to accommodate the largest rock size.

It is noted that additional thickness will **not** compensate for undersized rock.

In order to allow at least two layers of rock, the minimum thickness of rock protection (T) can be approximated by the values presented in Table 1.

Table 1 – Minimum thickness (T) of rock lining

Min. Thickness (T)	Size distribution (d_{50}/d_{90})	Description
1.4 d_{50}	1.0	Highly uniform rock size
1.6 d_{50}	0.8	Typical upper limit of quarry rock
1.8 d_{50}	0.67	Recommended lower limit of distribution
2.1 d_{50}	0.5	Typical lower limit of quarry rock

2.2 Backing material or filter layer

The rock must be placed over a layer of suitably graded filter rock or geotextile filter cloth (minimum 'bidim A24' or the equivalent). The geotextile filter cloth must have sufficient strength and must be suitably overlapped to withstand the placement of the rock.

If the rock is placed on a dispersive (e.g. sodic) soil (a condition **not** recommended), then prior to placing the filter cloth, the exposed bank **must** first be covered with a layer of non-dispersive soil, typically minimum 300 mm thickness.

3. References

Bos, M.G., Reploge, J.A. and Clemmens, A.J. 1984, *Flow measuring flumes for open channel systems*, John Wiley & Sons, New York.

Isbash, S.V. 1936, *Construction of dams by depositing rock in running water*, Transactions, Second Congress on Large Dams, Washington, D.C. USA.

Peterka, A.J. 1984, *Hydraulic Design of stilling basins and bucket energy dissipators*. USBR Engineering Monograph 25, U.S. Department of the interior, Bureau of Reclamation, Denver.

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