BC Ministry of Forests

Riprap Standards

October 26, 2022

1.0 Use

Typically for ministry bridge projects, riprap shall be used to prevent or retard erosion and scour in the vicinity of bridge piers and abutments. Bank erosion near abutments may result from natural shifting of the stream channel or from disturbances to natural banks caused by bridge and road construction. Bed scour near piers and abutments may result from severe floods, degradation of the stream profile over time, local eddy currents around piers and projecting abutments, or lateral shifting of the thalweg (deepest part of channel).

2.0 Sources

Riprap shall be made of sound, durable quarry or talus rock that will not deteriorate during freeze-thaw cycles or on exposure to water or the atmosphere. Durability testing and approval of rock sources may be required. Where quarry rock is not reasonably obtainable, non-rounded boulder sources may be approved. Average solid density shall not be less than 2.4 tonnes per cubic metre.

3.0 Nominal Size

Riprap particles shall be of a nominal size of at least 200 mm (as measured along the rock's intermediate axis), and in a mixture in which no more than 50 percent by mass is finer than the median (D_{50}) size.

4.0 Size Selection

The nominal size for a specific application should be selected according to the expected local flow velocity under design flood conditions, according to Table 1. Local velocity means the vertically averaged value at a specific point on the channel cross-section. In case of doubt as to the appropriate velocity, the next larger nominal size should be used.

Velocities may be estimated from actual flood observations and adjusted to design flood conditions, or from calculation of flood depths and velocities using the gradient, cross-section and estimated roughness of the stream channel. In estimating local velocities, cross-sectional shape and plan curvature shall be taken into account.

Alternatively, from extensive experience, riprap sizes may be based on the performance of equivalent installations on the same stream or in hydraulically similar situations. In streams with coarse alluvial beds, a rough guide is to ensure the nominal size of bank riprap is at least twice the size of the largest stones on the stream bed.

Table 1: Riprap Size Classes and Allowable Velocities

Nominal (D_{50}) size (mm)	Equivalent mass (kg)	Maximum allowable velocity (m/s)
200	10	2.5
300	35	3.0
450	125	3.6
600	280	4.2
800	700	4.8
1000	1300	5.3
1300	2800	6.0

5.0 Gradation and LayerThickness

The gradation of riprap and thickness of riprap layers shall be in accordance with Table 2 (reference: Section 205-*Standard Specifications for Highway Construction (TRAN)*)

Table 2: Riprap Gradation and Layer Thickness

Class of Riprap (kg)	Nominal Thickness of Riprap (mm)	Rock Gradation- Percentage Smaller Than Given Rock Mass (kg)		
		15%	50%	85%
10	350	1	10	30
25	450	2.5	25	75
50	550	5	50	150
100	700	10	100	300
250	1000	25	250	750
500	1200	50	500	1500
1000	1500	100	1000	3000
2000	2000	200	2000	6000
4000	2500	400	4000	12000

Where the gradation specified in Table 2 is not reasonably obtainable, more widely graded or quarry-run material of equivalent nominal size may be considered by the ministry if a greater thickness is provided. Gap-graded material liable to excessive segregation is not acceptable.

Where practicable, the ratio of D_{100} size to nominal size should not exceed 1.5.

6.0 Underlayer

Where riprap is placed on top of soil such as fine gravel, sand or silt, a containment layer of coarse gravel or equivalent quarry rock not less than 100 mm thick shall be placed between the soil and the design layer of riprap. If necessary, additional layers of intermediate sized riprap shall be used to contain underlying layers that could reasonably be expected to be susceptible to erosion underneath the design layer of rip rap.

7.0 Rock Shape

On average, the ratio of long axis to short axis in a rock should not exceed 2, and no rock should have a ratio exceeding 3.

8.0 Bank Slope

Riprap on stream banks should normally be placed on a slope of 1 vertical to 2 horizontal. Steeper slopes may be approved where there would otherwise be excessive encroachment into the channel or difficulty in matching natural slopes, but in no case should the slope be steeper than 1 to 1.5. Where a slope steeper than 1 to 2 is used, a larger rock size shall be used.

9.0 Placement

Riprap shall be laid out to ensure an even distribution of rock sizes over the area covered. The placed material shall be tamped or otherwise treated to provide an even, dense surface with a minimum of voids.

Use of hand-placed rock or grouted riprap of smaller size and thickness may be approved by the ministry in special cases.

10.0 Length of Bank Riprap

Where the bridge is located in a reasonably straight reach and the abutments are at or near the stream banks, bank riprap should normally be provided on both banks on either side of the bridge centreline (Figure 1). The length along each bank shall not be less than the width of the disturbed zone resulting from road and bridge construction, or less than 20 percent of the channel width, whichever is greater.

Where the bridge is located in a channel bend and there is evidence that one bank is subject to erosion and the other to accretion, riprap may be restricted to the eroding bank only. In bends where both banks may be subject to erosion, smaller riprap may be placed on the inner bank.

The ends of bank riprap shall be keyed at least 1 m into the bank in trenches, as indicated in Figure 2.

11.0 Cross-section of Riprap

The upper limit of riprap shall be the top of the bank or the design flood level, whichever is lower. A horizontal apron or a thickened toe shall be provided, containing a sufficient volume of rock to cover potential scour development (see Figure 2). Scour level shall be taken as no higher than the deepest point in the channel in the general vicinity of the bridge, or as 1.5 m below local bed level, whichever is lower.

12.0 Pier Riprap

Riprap may be required around the foundations of in-channel piers. Pier riprap shall consist of a horizontal apron flush with the stream bed, extending all around the pier or footing for a distance equal to at least 1.5 times the pier width (see Figure 1.)

Figure 1: Plan - Bank and Pier Riprap

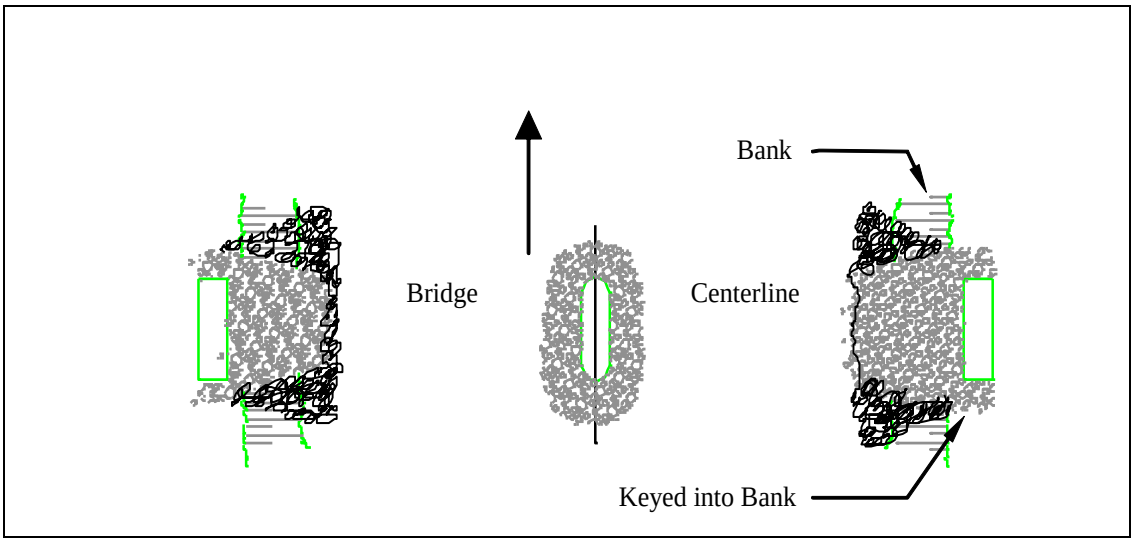

Figure 2: Section – Bank Riprap