Void-Filled Riprap Construction Guidance Checklist

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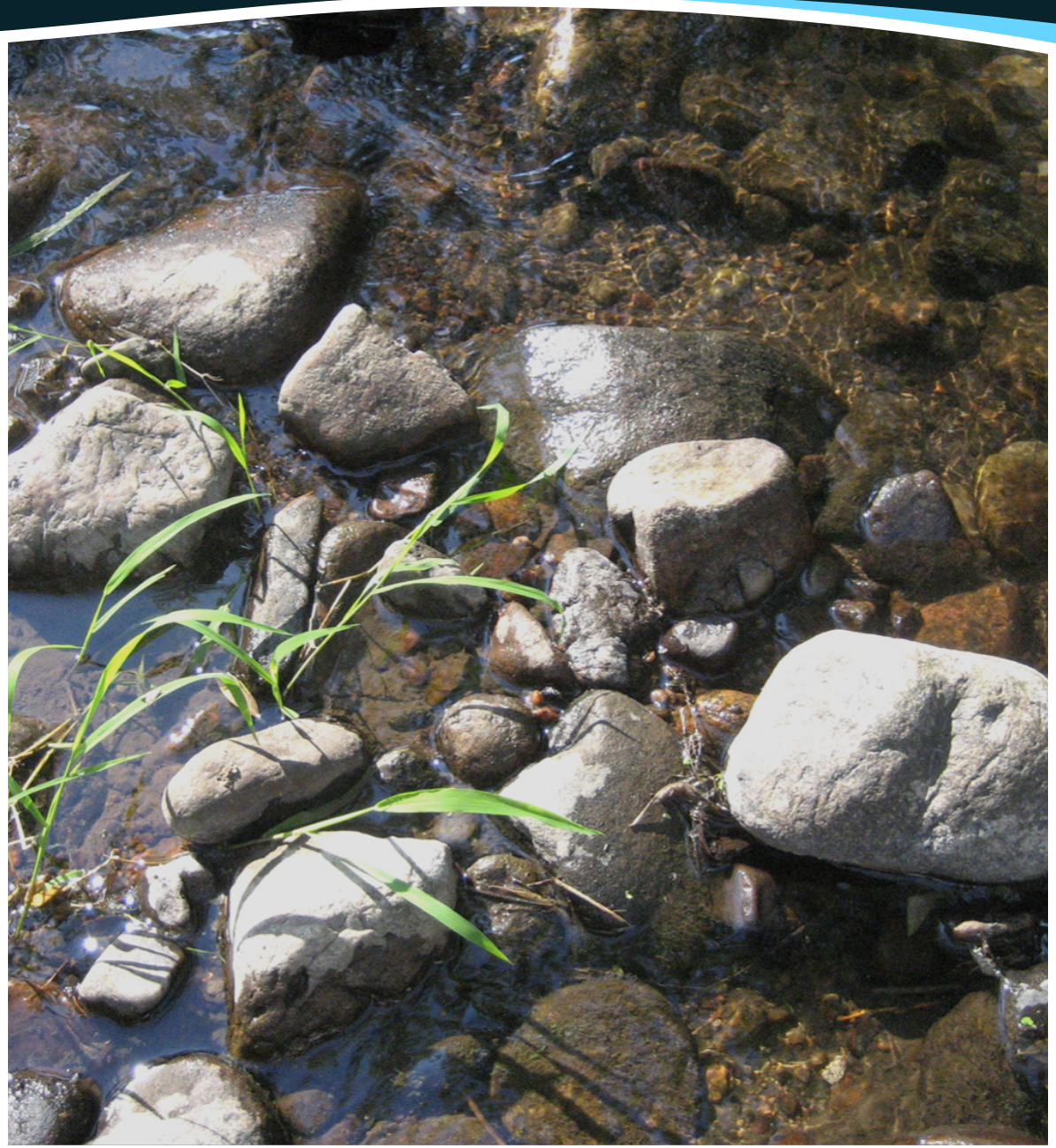
VFR Introduction

Void-filled Riprap (VFR) is a construction material used to emulate natural riffle rock found in coarse gravel and cobble bed streams.

VFR Introduction

- VFR uses materials readily available from local quarries and gravel pits.
- The primary ingredient is conventional riprap. The goal of VFR is to fill the voids of the conventional riprap using a broad range of materials (cobbles, gravels, sands, and onsite soils) to emulate natural riffle rock. Avoid displacing any of the conventional riprap and merely fill the voids.
- The mixture should create a dense, interlocking mass that keeps water flowing on the surface, mimicking a natural mountain stream bed.



VFR Materials

Step 1:

Verify that void-fill riprap materials are placed in separate piles when delivered to the site.

VFR Materials

Step 2:

Confirm that void-filled riprap materials delivered to the site meet requirements specified for color, size, and gradation. Sizes/gradations should be confirmed by checking delivery tickets, using a tape measure to estimate dimensions of materials in stockpiles, and comparing to pre-approved samples. Materials for "VFR with River Cobbles", which produces a more natural-looking riverbed material, include:

- Standard Riprap
- 7-inch Minus Crushed Surge
- 4-inch Minus Pit Run
- 2 to 4-inch cobbles
- Type II Bedding
- Native Topsoil
- 4 to 12-inch Cobbles (for top dressing)

Materials for "VFR without River Cobbles" are the same as above except that:

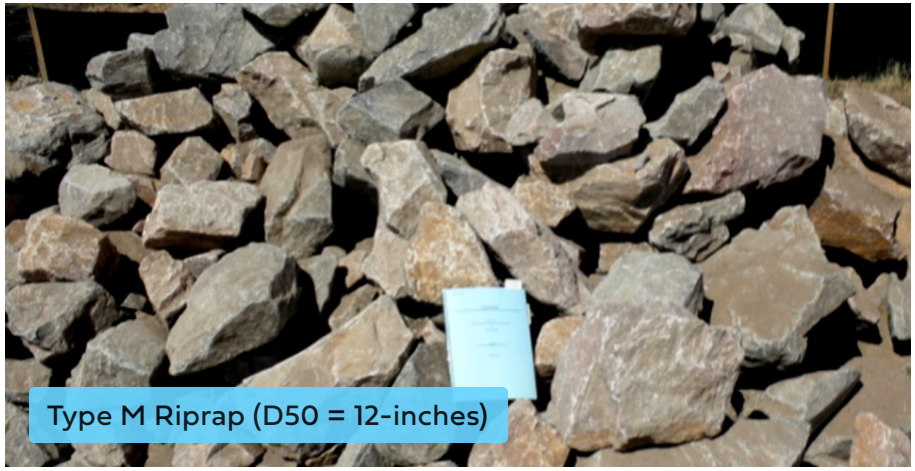
- 2 to 4-inch Crushed Rock is used in place of 2 to 4-inch cobbles.
- 4 to 12-inch Cobbles for top dressing is eliminated.

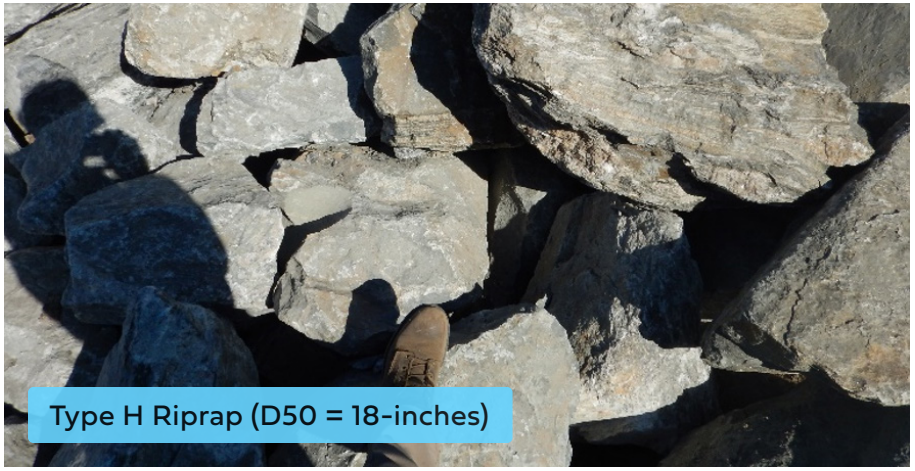
Standard Riprap:

In VFR applications, the following 4 standard riprap gradation types are used.


Type VL Riprap (D50=6-inches)


Type L Riprap (D50 = 9-inches)


Type M Riprap (D50 = 12-inches)


Type H Riprap (D50 = 18-inches)

VFR Materials

Void-Fill Materials:

- 7-Inch Minus Crushed Surge Rock: used to fill the voids of large riprap like Type M and Type H.
- 4-Inch Minus Pit Run: used to fill the voids of the 7-inch surge rock.

(Note: These two materials are processed through only one screen at the quarry, so gradations can vary quite a bit depending on the source of the materials.)

7-inch Minus Crushed Surge Rock

4-inch Minus Pit Run

VFR Materials

Void-Fill Materials:

Because of the variability of the 7-inch crushed surge and 4-inch minus pit run, two additional materials are included in the mix:

- Type II gravel bedding
- 2 to 4-inch cobbles


Type II Gravel Bedding


2 to 4-in Cobbles

VFR Materials

VFR Materials:

- Native Onsite Topsoil: topsoil, combined with the sandy 4-inch minus pit run material, provides growing medium for vegetation.

- 4 to 12-Inch Cobbles: used for top dressing of the VFR.


Native Topsoil


4 to 12-inch Cobbles

Step 3A (Mixing):

An “initial test batch” of void-filled riprap should be mixed with the Inspector and Engineer. A minimum of 2 batches (or double the proportions specified) should be mixed for the “test” batch. It is recommended that the equipment operators involved in the test batch be the same operators involved in future mixing operations.

Step 3B (Mixing):

A front end loader should be used to scoop up each of the different materials according to the number of “loader buckets” specified and add them into a combined mixing pile. Verify that the operator is filling each loader bucket with an “equal” volume of material. Make sure the bucket size is large enough for the operator to scoop the entire gradation of riprap (small and large material).

Step 3C (Mixing):

Once all ingredients are added to the mixing stockpile, verify that the materials are thoroughly mixed using a loader or large track excavator to fill the voids of the riprap without displacing the riprap or creating pockets of finer material.

Step 3D (Mixing):

Tweaking of material proportions is sometimes necessary to create VFR that resembles natural riffle material. These adjustments should be done during the initial test batch phase under the approval of the Inspector and Engineer. For example, because surge and pit run materials can vary, it is sometimes necessary to adjust mix proportions:

- If the 4-inch minus pit run is lacking in cobbles, the proportion of 2 to 4-inch cobbles can be increased.
- If the 4-inch minus pit run has a lot of cobbles, then the proportion of 2 to 4-inch cobbles can be decreased.
- If the 7" crushed rock is lacking fines, more pit run can be added.
- For Type H VFR, some Type M riprap (12-inch D50) can be added if there seems to be too much of a gap between the Type H riprap gradation (18-inch D50) and the 7-inch minus crushed rock.

Example of pit run lacking cobbles

Mixing VFR

How finished VFR that is well mixed looks in stockpile!

STEP 4:

Verify that the subgrade is suitably compacted.

STEP 5 (Hauling):

Verify that the contractor takes care to minimize segregation when hauling the mixed material from the stockpile to the installation location. VFR has a tendency to segregate in transit operations. The finer sands and gravels tend to separate from the larger riprap.

STEP 6A (Placing):

Verify that additional mixing is performed with a track excavator after the initial placement to make sure that the VFR is thoroughly mixed and that there is no segregation or areas where the VFR consists primarily of the smaller void-fill materials.

STEP 6B (Placing):

Confirm that the mixing and placement process results in some of the larger riprap flush and visible on the surface with rock arranged to minimize voids, and smaller material filling the voids between the larger material. We don't want all of the larger riprap to settle into the bottom, and we don't want all of the finer materials to remain on the surface.

STEP 7 (Top Dressing):

Confirm that top dressing of the larger cobbles (if specified) are added after the VFR has been loosely placed and prior to compaction. This should be done by sprinkling a few cobbles such that they cover approximately 15-percent of the surface.

Step 8 (Wash-In):

The fine materials have a tendency to migrate to the bottom during placement despite remixing efforts. In these situations, add smaller material at the direction of the Engineer. Use a 50:50 mixture of the 4-inch minus pit run and Type II bedding and sprinkle it on the surface and then wash it in using a high pressure hose to fill any voids that may exist below the surface . Make sure this is done prior to compaction.

STEP 9 (Compaction):

Verify that the loosely placed VFR is compacted with a large track excavator or loader.

Finished VFR

The finished VFR after placement and compaction should result in the larger riprap flush and visible on the surface with rock arranged to minimize voids, and smaller material filling all the voids!

Completed Riffle Drop Structure Using Void-Filled Riprap