

Item No. 591S
Riprap for Slope Protection

591S.1 Description

This item shall govern the excavation of all materials encountered for placing riprap, disposal of excess material and backfilling around the completed riprap to the grade indicated on the Drawings. The work shall include all pumping and bailing, furnishing and placing riprap of rock or concrete in accordance with the details and to the dimensions indicated on the Drawings.

This specification is applicable for projects or work involving either inch-pound or SI units. Within the text, the inch-pound units are given preference followed by SI units shown within parentheses. The work conducted under this item pertains to riprap for protection of slopes, cuts, fills, drainage facilities and other features susceptible to erosion.

* See Modifications for additional information

591S.2 Submittals

The submittal requirements for this specification item shall include:

- A. The type, size, gradation and source of riprap material (rock or broken concrete),
- B. Aggregate types, gradations and physical characteristics for the Portland cement concrete mix,
- C. Proposed proportioning of materials for the mortar mix,
- D. Type, details and installation requirements for reinforcement, joint material, tie backs and anchors,
- E. Description of filter fabric including characteristics, test data and manufacturer's recommendations for installation.
- F. The type, size, gradation and source of granular filter material.

* See Modifications for additional information

591S.3 Materials

- A. Rock

Rock used for riprap shall be hard, durable, and angular in shape and consist of clean field rock or rough unhewn quarry rock as nearly uniform in section as practicable. The rocks shall be dense, resistant to weathering and water action, free of overburden, spoils, shale and organic material; and shall meet the gradation requirements for the rock size specified. Neither the width nor the thickness of a single stone should be less than one third of its length. Shale, chalk and limestone with shale or chalk seams are not acceptable. Rounded rock (river rock) shall not be acceptable. Minimum density for acceptable dry rock riprap shall be 150 pounds per cubic foot or a specific gravity of 2.4.

The rock shall be suitable in all respects for the purpose intended. The sources from which the stone will be obtained shall be selected well in advance of the time

when the stone will be required and pre-approved by the Engineer. Control of gradation and material adequacy will be accomplished by visual inspection and field measurement as needed for rock sizes that cannot be analyzed via sieve or mechanical sorting machines. The contractor shall provide two samples of rock meeting the gradation for the size class specified. The samples shall be used as frequent reference for judging the gradation of the riprap supplied. Any difference of opinion between the engineer and the contractor shall be resolved by dumping two random truckloads of stone and performing manual field measurements of individual stones to compute a gradation. Any measured rock size dimensions shall be based on the length of the intermediate axis of each stone. Labor, equipment and site location needed to assist in checking gradation shall be provided by the contractor at no additional cost to the owner.

B. Broken Concrete

The rock used for mortar riprap may consist of broken concrete removed under the contract or obtained from other approved sources. Broken concrete shall be as nearly uniform in section as practicable and of the sizes indicated in Section 591S.5, "Dry Riprap".

C. Concrete

Cast in place concrete shall be Class A Concrete and shall conform to Standard Specification Item No. 403S, "Concrete for Structures".

D. Grout and Mortar

Grout and mortar shall consist of 1 part Portland Cement and 3 parts sand, thoroughly mixed with water. Mortar shall have a consistency such that it can be easily handled and spread by trowel. Grout shall have a consistency such that it will flow into and completely fill all joints.

E. Reinforcement

Reinforcement shall conform to Standard Specification Item No. 406S, "Reinforcing Steel".

F. Joints

Premolded expansion joint material shall conform to Standard Specification Item No. 408, "Concrete Joint Material".

G. Tie Backs and Anchors

Galvanized tie backs and anchors shall be as indicated on the Drawings.

H. Filter Fabric

Filter Fabric shall conform to Standard Specification Item No. 620S, "Filter Fabric".

I. Granular Filter

Aggregate used for granular filters shall conform to Standard Specification Item No. 403S "Concrete for Structures".

* See Modifications for additional information

591S.4 Construction Methods

Prior to commencement of this work, all required erosion control and tree protection measures (Standard Specification Item 610S, "Preservation of Trees and Other Vegetation") shall be in place and utilities located and protected as set forth in the "General Conditions". Construction equipment shall not be operated within the drip line of trees unless indicated on the Drawings. Construction materials shall not be placed under the canopies of trees. No excavation or embankment shall be placed within the drip line of trees until tree wells (Standard Detail Number 610S-6, "Tree Protection, Tree Wells") are constructed. Spalls and small stones used to fill open joints and voids in rock riprap shall be rocked and wedged to provide a tight fit.

Unsuitable excavated materials or excavation in excess of that needed for construction shall be known as "Waste" and shall become the Contractor's property and sole responsibility to dispose of this material in an environmentally sound manner off the limits of the right of way at a permitted disposal site.

All blasting shall conform to 01550, "Public Safety and Convenience." The Contractor shall comply with all laws, ordinances, applicable safety code requirements, International Fire Code Chapter 27 "Hazardous Materials General Provisions" and Chapter 33 "Explosives and Fireworks" and any other regulations relative to handling, storage and use of explosives. In all cases, a Blasting Permit must be obtained in advance from the appropriate City agency.

Areas to be protected by rock riprap shall be free of brush, trees, stumps and other objectionable materials and be graded to a smooth compacted surface. All soft or spongy material shall be removed and replaced with appropriate material to the depths shown on the plans or as directed by the engineer. Fill Areas, unless otherwise specified will be compacted in accordance with 132S - Embankment. Unacceptable subgrade conditions shall be reworked according to the Engineer's recommendations. Excavation areas shall be maintained until the riprap is placed.

591S.5 Dry Rock Riprap

The mass of rock riprap shall be placed as to be in conformance with the required gradation mixtures, to the lines, grades and layers thickness that is shown on the drawings. The range of rock sizes for the mixture shall conform to the following recommended gradation requirements relative to the specified median rock size (D50).

| Relative Stone Size (inches) | Percent of Gradation Smaller than | Stone Size Designation |
|------------------------------|-----------------------------------|------------------------|
|------------------------------|-----------------------------------|------------------------|

| | | |
|-----------------|-----|------|
| 1.7 - 2.0 * D50 | 100 | D100 |
| 1.3 - 1.7 * D50 | 85 | D85 |
| 1.0 - 1.3 * D50 | 50 | D50 |
| 0.5 - 1.0 * D50 | 15 | D15 |

At least 50% of the rocks shall weigh more than the D50 rock size. When the riprap will be placed on an erodible soil, as determined by the Engineer or designated representative, a layer of geotextile filter fabric or a granular filter layer shall be placed, prior to placement of the riprap material. In some cases multiple layers of granular filter material of varying gradations may be required. The median rock riprap size (D50), rock riprap layer thickness, filter type, when applicable the number of granular filter layers, granular filter aggregate gradations (grade/size classification), granular layer thicknesses shall be specified on the plans. The minimum granular filter layer thickness shall be 4 inches (102 mm). Geotextile filter fabric shall conform to Standard Specification No. 620 and be installed with sufficient anchoring and overlap between seams according to the manufacturer's recommendations to ensure full filter barrier protection of the subgrade after riprap installation. When specified on the plans a four (4) inch minimum thickness granular cushion layer of gravel or sand may be placed over the filter fabric to prevent damage the fabric during placement of rock riprap.

Rock riprap shall be machine placed and distributed such that there will be no large accumulations of either larger or smaller sizes. Placing rock riprap by dumping into chutes or similar methods shall not be permitted. The rocks shall be placed in a single layer with close joints. The rock riprap layer thickness shall be no less than the maximum stone size (D100) or 1.5 times the D50, which ever produces the greater thickness. In areas exposed to flowing water the rock riprap layer thickness should be no less than 2.0 times the D50. The upright axis of the rocks shall make an angle of approximately 90 degrees with the embankment slope. The courses shall be placed from the bottom of the embankment upward, with the larger rocks being placed on the lower courses. Open joints shall be filled with spalls. Rocks shall be arranged to present a uniform finished top surface such that the variation between tops of adjacent rocks shall not exceed 3 inches (75 mm). Rocks that project more than the allowable amount in the finished work shall be replaced, embedded deeper or chipped.

591S.6 Mortared Rock Riprap

Rock for this purpose, as far as practicable, shall be selected as to size and shape in order to secure fairly large, flat-surfaced rock which may be laid with a true and even surface and a minimum of voids. Fifty percent of the mass rock shall be broad flat rocks, weighing between 100 and 150 pounds (45 and 69 kilograms) each, placed with the flat surface uppermost and parallel to the slope. The largest rock shall be placed near the base of the slope. The spaces between the larger rocks shall be filled with rocks of suitable size, leaving the surface smooth, reasonably tight and conforming to the contour required on the Drawings. In general, the rocks shall be placed with a degree of care

that will insure plane surfaces with variation from the true plane of no more than 3 inches in 4 feet (no more than 60 mm per meter). Warped and curved surfaces shall have the same general degree of accuracy as indicated for plane surfaces.

Before placing mortar, the rocks shall be wetted thoroughly and as each of the larger rocks is placed, it shall be surrounded by fresh mortar and adjacent rocks shall be shoved into contact. After the larger rocks are in place, all of the spaces or opening(s) between them shall be filled with mortar and the smaller rocks then placed by shoving them into position, forcing excess mortar to the surface and insuring that each rock is carefully and firmly embedded laterally. After the work described above has been completed, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints then shall be pointed up roughly, either with flush joints or with shallow, smooth raked joints.

591S.7 Concrete Riprap

Concrete for riprap shall be placed as indicated on the Drawings or as directed by the Engineer or designated representative. Unless otherwise indicated on the Drawings, concrete riprap shall be ~~reinforced using wire or~~ bar reinforcement.

Concrete shall be Class A or as indicated otherwise on the Drawings and shall conform to Standard Specification Item No. 403S, "Concrete for Structures".

~~When welded wire reinforcement is indicated, it shall be a minimum of 6 x 6 W1.4 x W1.4 (150 x 150 MW9 x MW9) with a minimum lap of 6 inches (150 mm) at all splices. At the edge of the riprap, the wire fabric shall not be less than 1 inch (25 mm) nor more than 3 inches (75 mm) from the edge of the concrete and shall have no wires projecting beyond the last member parallel to the edge of the concrete.~~

When bar reinforcement is used, the sectional area of steel in each direction shall not be less than the sectional area of the wire fabric described above. The spacing of bar reinforcement shall not exceed 18 inches (450 mm) in each direction and the distance from the edge of concrete to the first parallel bar shall not exceed 6 inches (150 mm).

Reinforcement shall be supported properly throughout the placement to maintain its position approximately equidistant from the top and bottom surface of the slab.

Unless otherwise noted, expansion joints of the size and type indicated on the Drawings shall be provided at intervals not to exceed 40 feet (12.2 meters) and shall extend the full width and depth of the concrete. Marked joints shall be made 3/8 inch (9.5 mm) deep at 10 foot (3 meter) intervals. All joints shall be perpendicular and at right angles to the forms unless otherwise indicated on the Drawings.

Slopes and bottom of the trench for toe walls shall be compacted and the entire area sprinkled before the concrete is placed.

After the concrete has been placed, consolidated and shaped to conform to the dimensions indicated on the Drawings and has set sufficiently to avoid slumping, the surface shall be finished with a wooden float to secure a reasonably smooth surface.

Immediately following the finishing operation, the riprap shall be cured conforming to Standard Specification Item No. 410S, "Concrete Structures".

591S.8 Pneumatically Placed Concrete Riprap, Type I and Type II

Pneumatically placed concrete for riprap shall be placed as indicated on the Drawings or as established by the Engineer or designated representative. Pneumatically placed concrete shall conform to Standard Specification Item No. 404S, "Pneumatically Placed Concrete". Reinforcement shall conform to the details indicated on the Drawings and Standard Specification Item No. 406S, "Reinforcing Steel". Reinforcement shall be supported properly throughout placement of concrete. All subgrade surfaces shall be moist when concrete is placed.

The surface shall be given a wood float finish or a gun finish as indicated on the Drawings.

The strength and design of Pneumatically Placed Concrete Riprap shall be either Type I or if indicated, Type II conforming to Standard Specification Item No. 404S, "Pneumatically Placed Concrete".

Immediately following the finishing operation, the riprap shall be cured conforming to Standard Specification Item No. 410S, "Concrete Structures".

591S.9 Measurement

* See Modifications for additional information

Measurement of acceptable riprap will be made on the basis of the (a) area in square yards (square meters: 1 square meter equals 1.196 square yards) indicated on the Drawings, complete in place or (b) the volume of concrete placed in cubic yards (cubic meters: 1 cubic meters equals 1.308 cubic yards), complete in place as indicated on the Drawings for the thickness specified.

Concrete toe walls will not be measured separately but shall be included in the unit price bid for riprap of the type with which it is placed.

* See Modifications for additional information

591S.10 Payment

The riprap quantities, measured as provided above, will be paid for at the unit bid prices per square foot or per cubic yard as indicated for riprap of the various classifications. The Unit Bid Price shall include full compensation for furnishing, hauling and placing all materials, including toe walls, geotextile filter fabric, granular filter material, granular cushion, reinforcement and premolded expansion joint material and for all labor, tools, equipment and incidentals necessary to complete the work.

Payment for excavation of toe wall trenches and for all necessary excavation below natural ground or the bottom of excavated drainage channels will be included in the unit bid price for riprap. Excavation, grading and fill materials required to shape drainage channels shall not be included in the unit bid price for riprap.

Payment for excavation required for shaping of slopes for riprap shall be included in the unit bid price for riprap, except for the situation when the header banks upon which the riprap is to be placed are built by prior contract. In this specific case the excavation for shaping of slopes, will be paid for conforming to Standard Specification Item No. 401, "Structural Excavation and Backfill".

Payment will be made under one of the following:

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|-----------------------------|--|-------------------------|
| Pay Item No. 591S-A: | Dry Rock Riprap | Per Square Yard. |
| Pay Item No. 591S-B: | Dry Rock Riprap | Per Cubic Yard. |
| Pay Item No. 591S-D: | Mortared Rock Riprap | Per Square Yard. |
| Pay Item No. 591S-F: | Concrete Riprap, ___ In. | Per Square Yard. |
| Pay Item No. 591S-G: | Concrete Riprap | Per Cubic Yard. |
| Pay Item No. 591S-P: | Pneumatically Placed Concrete Riprap, | Per Square Yard. |
| | ___In. | |

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| <u>SPECIFIC</u> CROSS REFERENCE MATERIALS |
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| Specification 591S, "Riprap for Slope Protection" |
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International Fire Code

| Designation | Description |
|--------------------|--------------------------|
| Chapter 27 | Hazardous Materials |
| Chapter 33 | Explosives and Fireworks |

City of Austin Standard Contract Documents

| Designation | Description |
|--------------------|-------------------------------|
| 01550 | Public Safety and Convenience |

City of Austin Standard Specifications

| Designation | Description |
|--------------------|--|
| Item No. 403S | Concrete for Structures |
| Item No. 404S | Pneumatically Placed Concrete |
| Item No. 406 | Reinforcing Steel |
| Item No. 408 | Concrete Joint Material |
| Item No. 410 | Concrete Structures |
| Item No. 610S | Preservation of Trees and Other Vegetation |
| Item No. 620S | Filter Fabric |

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| <u>RELATED</u> CROSS REFERENCE MATERIALS |
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| Specification 591S, "Riprap for Slope Protection" |
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City of Austin Standard Specifications

| Designation | Description |
|--------------------|---------------------|
| Item No. 623S | Dry Stack Rock Wall |

Engineering Design Manuals

Federal Highway Administration, 1989, Design of Riprap Revetment, Hydraulic Engineering Circular HEC-11, FHWA-1P-89-016.

National Cooperative Highway Research Program, 2006, Riprap Design Criteria, Recommended Specifications, and Design Criteria, NCHRP Report 568.

United States Bureau of Reclamation, 1983, Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25.

U.S Department of Agriculture, 1983, Soil Conservation Service, Riprap for Slope Protection Against Wave Action, Technical Release No. 69, February.

Current Version: September 26, 2012
City of San Marcos Adopted 05/15/2014
Revised 06/01/2018

PREVIOUS VERSIONS: 9/1/2011, 3/26/08, 2/17/00,
8/17/94

US Army Corps of Engineers, 1994. Hydraulic Design of Flood Control Channels, US Army Corps of Engineers Engineer Manual EM 1110-2-1601.

Federal Highway Administration, 1998. "Geosynthetic Design and Construction Guidelines," FHWA-HI-95-038.