

PART 1 - GENERAL

1.1 SCOPE OF WORK

- .1 This section covers the supply, transport and placement of various quarried stone products as required to construct the armourstone revetment.

1.2 RELATED WORK

- .1 Excavating, Trenching and Backfilling - Section 31 23 10

1.3 REFERENCES

- .1 ASTM C88-05, Test Methods for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate
- .2 ASTM C127-15, Test Method for Specific Gravity and Absorption of Coarse Aggregate
- .3 ASTM C136-14, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
- .4 ASTM C535-12, Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- .5 ASTM D5312-2012, Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions
- .6 ASTM D5313-2012, Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions.

1.4 DEFINITIONS

- .1 In describing stone construction, reference will be made to Courses, Neat Lines, Survey Control Lines, Maximum Allowable Void, Quality Control and Quality Assurance. The following definitions will pertain to these terms:
- .1 Course - A course of stone is defined as the overall thickness for the given stone classification as shown on the Contract Drawings.
- .2 Neat Lines - These are the lines shown on the drawings which depict the limits of the various types of stone materials. The tolerances for stone placement, as described in this section, will be measured from the neat lines.
- .3 Survey Control Lines (SCL) - These are the lines to which all stone structure surveys shall be referenced. The structure centerline shall be used as the SCL for each structure, as shown on the Contract Drawings.

.4 Maximum Allowable Void - When placing armour stone, the maximum allowable space between armour stones in the finished structure shall be such that a 250mm nominal diameter stone cannot pass through the finished course of armour stone.

.5 Quality Control (QC) - Contractor is responsible for the development and implementation of a QC program throughout the project to assure compliance with the specifications.

.6 Quality Assurance (QA) - QA activities will be performed by the Departmental Representative, with the support of the Contractor. These activities are intended to provide independent observations of conformance to the specifications, and in no way relieve the Contractor of his responsibilities for Quality Control.

1.5 Source Approval

- .1 Source(s) of all stone materials to be incorporated into the work requires the approval of the Departmental Representative.
- .2 Inform the Departmental Representative of proposed source(s) of materials and submit stone quality test results at least one (1) week prior to shipping material to site.
- .3 Rip-Rap shall be individually selected at the source and marked for delivery to the site by the Contractor.
- .4 Acceptance of material at the source does not preclude future rejection at the site if it fails to conform to the requirements specified.

1.6 STONE MATERIALS QC/QA PROGRAM

- .1 Quality Control (QC) Program:
 - .1 The Contractor is responsible for, and shall establish and maintain, Quality Control for all stone production, hauling and placement under this contract to assure compliance with the specifications.
 - .2 The Contractor shall exercise care in loading, hauling, unloading and placing of stone during all phases of construction to prevent cracking and splitting that would otherwise lead to rejection at the job site.
 - .3 The Contractor shall be responsible for:
 - .1 Maintaining a daily log, compiled in tabular format, presented in a clear and

legible fashion indicating the following as a minimum:

- .1 quantity of stone produced to date for each stone type,
 - .2 quantity of stone shipped to date for each stone type.
 - .2 Loading trucks with stone from one classification only.
 - .3 Maintaining separate stockpiles of stone materials by stone classification. Stone may only be shipped to the site from stockpiled materials.
 - .4 Visually inspecting all armour stone for blast fractures, size and quality factors to verify that stone meets the quality requirements of this section.
 - .5 Conducting stone gradations and elongation tests, and making appropriate production modifications on each stone classification as required to verify that they meet the gradation and geometric requirements of this section.
- .2 Quality Assurance (QA) Activities:
- .1 Quality Assurance activities will be performed by the Departmental Representative. These activities are intended to provide independent observations of conformance to the requirements of this section prior to shipment of the stone to the site, and in no way relieve the Contractor of his responsibilities for Quality Control (QC) and in-place requirements.
- .3 The Departmental Representative may also perform Quality Assurance (QA) activities at the project site.
- 1.7 STONE
GRADATION TEST
REQUIREMENTS
- .1 Armour Stone:
- .1 It is anticipated that approximately two Quality Assurance gradation tests will be conducted for the armour stone, unless gradation test results or observations of stone materials indicate additional gradation tests are required.
 - .2 The Departmental Representative will randomly select a representative sample of stone equal to at least 30 times the median stone weight for the stone classification being sampled. The total sample shall be accurately weighed to within 1%. Each individual stone in the sample will then be measured along three mutually perpendicular axes (dimensions a, b and c) and the measurements recorded. Individual

stone weights will then be initially estimated based on the measured volume (e.g., measured volume = $a \times b \times c$) multiplied by the saturated surface dry (SSD) stone density for that stone type. The individual initial estimated weights shall then be "adjusted" by an adjustment factor equal to the ratio of the actual total sample weight divided by the sum of the individual initial estimated weights. The resulting "adjusted" stone weights will be used to assemble a gradation curve for the sample. Alternatively, the Contractor may elect to weigh every stone in the sample, in which case the gradation curves will be assembled using the actual measured stoneweights.

.2 Filter Stone:

.1 It is anticipated that approximately two Quality Assurance gradation test will be conducted for the filter stone, unless gradation test results or observations of stone materials indicate additional gradation tests are required.

.2 Quality Assurance gradation tests for filter stone shall be undertaken in accordance with Article 1.7.1.2 above, with a minimum sample size of 3,000 kg. Alternative methods may be considered, subject to approval by the Departmental Representative.

- .3 Contractor shall provide Departmental Representative with loaders, certified scales, other equipment, and operators of such equipment as required to gather samples and measure/weigh each individual stone. Methods used to weigh each individual stone must be accurate to ± 5 kg for stones larger than 50 kg, and to ± 0.5 kg for stones smaller than 50 kg.

1.8 STONE
PLACEMENT QC/QA
PROGRAM

.1 Quality Control (QC) Program:

.1 The Contractor is responsible for, and shall establish and maintain Quality Control for all work performed at the job site to assure compliance with the specifications.

.2 The Contractor shall maintain records of all Quality Control tests, surveys, inspections, and corrective actions, and submit copies to the Departmental Representative.

.3 The Contractor shall handle, transport and store stone to ensure that stockpiles are not contaminated with other soils and materials and to limit the segregation of material sizes.

.4 The Contractor shall provide range poles, marker buoys, templates, batter boards and/or any other means of guidance and control as necessary to construct the stone courses to the required tolerances.

.5 The Contractor shall maintain temporary vertical and horizontal control monuments in the immediate vicinity of the work being performed.

.6 The Contractor shall perform construction surveys as necessary to perform the work required by the Contract Documents. Equipment and methods by which construction surveys are performed are the Contractor's option.

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Quality Assurance (QA) Activities:

.1 The Contractor shall perform verification surveys as the work progresses to verify that lines, grades and thicknesses for the completed work are within the specified tolerances. Verification surveys shall be performed with a GPS Topographic Survey Equipment total station survey instrument and range pole-mounted prism; surveyor's level, range pole and surveyor's tape; tag line and sounding basket; or other methods that are consistent with the requirements of this section and subject to the approval of the Departmental Representative. Range poles, if used, shall be fitted with a flat, durable, 0.3 metre diameter base. The Contractor shall provide personnel and other equipment necessary to adequately and safely perform verification surveys.

.2 Verification surveys shall be conducted in the presence of the Departmental Representative unless waived by the Departmental Representative.

.3 Survey existing conditions (i.e. original or excavated surfaces, rock faces or seabed) prior to placement of stone materials. Survey lines shall be measured perpendicular to the Survey Control Line (SCL), spaced at no more than 5 m apart, with elevation readings taken every 2m along each line, and at every break in grade. All surveys shall extend at least 3 m (horizontally) beyond the extents of the proposed stone work.

.4 Survey each stone course following placement. Survey lines shall be measured at the same locations as the existing conditions surveys. Elevation readings shall be taken every 2m in along each line, and at every break in grade. All surveys shall extend at least 3m

in (horizontally) beyond the extents of the stone work.

.5 All verification surveys shall be horizontally referenced to the Survey Control Line (SCL) and vertically referenced to Geodetic Datum.

.6 For each verification survey performed, the Contractor shall transmit a verification survey record containing the following information to the Departmental Representative:

- .1 structure and stone type surveyed;
- .2 verification survey location (station along the SCL);
- .3 date and time of survey;
- .4 weather conditions;
- .5 names of participants;
- .6 field notes;
- .7 cross-section plot showing SCL, neat lines and individual elevation readings referenced to CD.

.7 The exact format of the verification survey record is subject to the approval of the Departmental Representative. A sample shall be submitted to the Departmental Representative for approval prior to the commencement of stone placement and shall include transmittal of the verification survey ASCII file on a daily basis.

.8 Before any stone placement over existing grade, excavated grade or a previously placed stone type, surveys of the existing grade, excavated grade or previously placed stone type must be verified by the Departmental Representative.

.9 Approval of a cross-section shall not constitute final acceptance.

1.9 PRODUCTION SCHEDULE

- .1 All stone materials shall be produced and prepared for delivery according to the construction schedule of the Contractor.

1.10 SUBMITTALS

- .1 At least two weeks prior to the commencement of stone placing operations, the Contractor shall submit his intended construction procedures to the Departmental Representative. These procedures shall contain the following information as a minimum:
 - .1 Material sources and test results for stone materials in accordance with the requirements of this section.

- .2 Method of transport for stone materials.
- .3 Details of the intended stone placement methods and sequence.
- .4 Survey control and verification survey procedures.

- .2 Submit gradation test results, stone quantity tabulations, or other data required for the stone Quality Assurance program at any time during the project as requested by the Departmental Representative or as directed by the Contract Documents.
- .3 Stone source inspector and loading facility logs shall be made available at any time during the project for review by the Departmental Representative.

1.11. MEASUREMENT FOR
PAYMENT

- .1 New materials for this project, including armour stone, filter stone, corestone, will be measured in tonnes (1,000 kg).
- .2 The weight of materials will be determined from weigh scale tickets provided by the Contractor and certified by the Departmental Representative or his representative. The scale shall be approved and certified as correct by the Department of Consumer and Corporate Affairs, Weights and Measures Inspection Branch. Weigh scale tickets shall show gross, tare and net weight and will not be accepted for payment unless they are initialled by the trucker and the Departmental Representative's representative at the time of delivery.
- .3 Material placed beyond the specified tolerance limits, if allowed to remain in place by the Departmental Representative, will be deducted from the payment quantity. Calculation of material placed beyond the tolerance limits shall be based on verification surveys performed during construction (refer to Section 1.8.2). The volume of this material will be determined by the average end area method. This volume will be converted to tonnes using 1.7 tonnes/m³ and the resultant tonnage will be deducted from the payment quantity. Any materials wasted or used by the Contractor for other purposes and any material not placed in the work in accordance with the requirements of the specifications will also be deducted from the payment quantity.

- .4 Materials that do not meet the specified requirements for quality, shape and gradation will be rejected.
- .5 Rejected materials will not be measured and all costs associated with rejected materials, including removal from the site and disposal, will be the responsibility of the Contractor.

1.12 EXISTING
CONDITIONS

- .1 Contractors intending to bid on Work visit the site and ascertain what preparatory work will be required to complete the Work as shown on the Project Drawings. Contractor is to be aware of:
 - .1 Condition of existing structures and pavements over which material must be hauled.
 - .2 Limits of work.
 - .3 Contractor shall be solely responsible for construction and maintenance of temporary structures, roadways or platforms which may be required to carry out the work. All temporary structures shall be considered incidental to the work. All temporary structures shall be removed at the completion of the project and the land restored to its original condition.
 - .4 All costs associated shall be included in unit rates.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 All stone materials to be furnished under this Contract shall meet all requirements specified in this section of the specifications. The Departmental Representative, at any time during the Contract, may reject materials at the source or at the project site for failure to meet the specified requirements. Acceptance of material at the source does not preclude future rejection at the site if it fails to conform to the specified requirements. Materials that have been delivered to the project site and are rejected, whether in stockpile or in place in a structure, shall be removed from the project at no additional cost to the Owner.

2.2 STONE QUALITY

- .1 General:
 - .1 All stone shall be dense, hard, sound, close-grained, durable rock, free of overburden

material, and highly resistant to weathering and disintegration under freezing/thawing and wetting/drying conditions and shall be of a quality to ensure permanence of the structure in the climate in which it is to be used.

.2 All stone shall be free from detrimental cracks, seams and other defects that tend to increase deterioration from natural causes or cause breakage in handling and/or placing. Stone with high argillaceous or shale content is more susceptible to weathering, abrasion, thin bedding, close fracturing and other undesirable rock properties and will not be accepted.

.3 The stone shall be free from damage as a result of blasting during production. Blast damage is a significant cause of rejection of stone. Blast cracks that have the potential of causing more than 20% loss of weight of an individual stone, if the crack opens in service, are not acceptable. Stones with minor cracking may be reworked at the Contractor's option, with cracked portions being removed by jacking or other suitable method. The remaining stone, if within the gradation limits, may be re-evaluated for acceptance.

.4 Miscellaneous stone materials excavated from the site may be suitable for reuse in the new structures if they meet the requirements for gradation, quality and shape specified herein. Reuse of excavated stone materials requires the approval of the Departmental Representative.

.2 Stone Quality/Durability Tests:

.1 Stone materials to be used in Work shall be tested for quality/durability during quarry start-up and production operations at the Contractor's expense.

.2 The following rock durability test specifications must be met or exceeded by all stone materials:

| <u>Description</u> | <u>Test Method</u> | <u>Acceptance Criteria</u> |
|-----------------------------|--------------------|--|
| Specific Gravity | ASTM C127 | minimum 2.6 |
| Absorption | ASTM C127 | maximum 2% |
| LA Abrasion | ASTM C131 | maximum 20% loss after 500 revolutions |
| MgSO ₄ Soundness | ASTM C88 | maximum 10% loss after 5 cycles |

- .3 If these test results suggests borderline or questionable material, the following additional tests shall be conducted:

| <u>Description</u> | <u>Test Method</u> | <u>Acceptance Criteria</u> |
|--------------------|--------------------|--------------------------------|
| Freeze-Thaw | ASTM D5312 | max. 0.5% loss after 40 cycles |
| Wet-Dry | ASTM D5313 | max. 0.5% loss after 80 cycles |

- .4 Test samples of the proposed stone shall be obtained by the Contractor at his own expense. Samples selected for testing shall be representative of material formations in the quarry to be used for this project. The Departmental Representative must be present for and agree upon the selection of all test samples prior to shipment. The Departmental Representative may personally select all samples if he so elects.
- .5 The samples shall be shipped or delivered by the Contractor, at his expense, to a suitable testing facility.
- .6 The Contractor is responsible for allowing sufficient time for the testing to be completed such that there are no delays in the start of construction.
- .7 Previous test results for stone materials quarried from the same area (ie. the same working face and rock unit) of the quarry may be accepted at the discretion of the Departmental Representative.

- .8 Submit stone quality test results at least one (1) week prior to shipment of stone to site.

2.3 GRADATION
AND SHAPE
REQUIREMENTS

- .1 Material meeting the gradation and shape requirements listed below shall be placed in the work at the locations as shown on the Contract Drawings. Gradation limits are in-place requirements. Adjustments in production, transportation and placement methods shall be made as necessary to assure final placed materials are within specified ranges. Stone shall be well graded, and shall not exhibit gap grading or scalping from individual size ranges.
- .2 5500 kg Armour Stone:
 - .1 All armour stone shall be angular in shape, with the ratio of maximum to minimum dimensions (aspect ratio) not exceeding 2.5.
 - .2 Armour stone shall conform to 4 tonne to 7 tonne Class designation, 5.5 tonne median weight and:
 - .1 No more than 5% shall be less than 2400 kg.
 - .2 No more than 10% shall be less than 3700 kg.
 - .3 No less than 70% shall be less than 7300 kg.
 - .4 No less than 97% shall be less than 11000 kg.
 - .3 Armour stones outside of the specified ranges may be acceptable for use at the discretion of the Departmental Representative.
- .3 900 kg Armour Stone:
 - .1 All armour stone shall be angular in shape, with the ratio of maximum to minimum dimensions (aspect ratio) not exceeding 2.5.
 - .2 Armour stone shall conform to 500 kg to 1500 kg Class designation, 900 kg median weight and:
 - .1 No more than 5% shall be less than 300 kg.
 - .2 No more than 10% shall be less than 450 kg.
 - .3 No less than 70% shall be less than 1500 kg.
 - .4 No less than 97% shall be less than 2300 kg.
 - .3 Armour stones outside of the specified ranges may be acceptable for use at the discretion of the Departmental Representative.

- .4 550 kg Filter Stone:
 - .1 All filter stone shall be angular in shape, with the ratio of maximum to minimum dimensions (aspect ratio) not exceeding 3.
 - .2 Filter stone shall conform to 300kg to 1000 kg Class designation, 500 kg Median weight and:
 - .1 No more than 5% shall be less than 180 kg
 - .2 No more than 10% shall be less than 280 kg
 - .3 No less than 70% shall be less than 920 kg.
 - .4 No less than 97% shall be less than 1400 kg.
- .5 90 kg Filter Stone:
 - .1 All filter stone shall be angular in shape, with the ratio of maximum to minimum dimensions (aspect ratio) not exceeding 3.
 - .2 Filter stone shall conform to 50 kg to 300 kg Class designation, 90 kg Median weight and:
 - .1 No more than 5% shall be less than 20 kg
 - .2 No more than 10% shall be less than 40 kg
 - .3 No less than 70% shall be less than 180 kg.
 - .4 No less than 97% shall be less than 270 kg.
- .5 Core Stone:
 - .1 All core stone shall be angular in shape, with the ratio of maximum to minimum dimensions (aspect ratio) not exceeding 3.
 - .2 Core stone shall be graded from 90 to 250 mm with a median size of 200 mm (D50) and:
 - .1 No more than 5% shall be less than 45 mm
 - .2 No more than 10% shall be less than 90 mm.
 - .3 No less than 70% shall be less than 250 mm.
 - .4 No less than 97% shall be less than 360 mm.

2.4 STONE SOURCES

- .1 By providing a bid for this project, the Contractor is representing that he has the capability to produce the quantity required of the quality, sizes and gradations specified in

the time frame allocated for this project. The Departmental Representative is relying upon such representation.

PART 3 - EXECUTION

3.1 EXCAVATION AND GRADING

- .1 Excavate and/or grade backshore, beach and seabed to lines and grades shown on the drawings in such manner that geosynthetic and stone layers/courses can be placed to the required thicknesses and grades.
- .2 Fill materials to be placed only in unfrozen condition.
- .3 Refer also to Section 31 23 10

3.2 FILTER STONE

- .1 Equipment suitable for handling stone of the specified size shall be used. The material shall be handled in such a manner as to minimize damage to the stones and the structure, and to minimize disturbance, slumping and degradation of the adjacent materials and/or underlying beach or seabed.
- .2 Dumping and dozing of stone materials will only be allowed if it can be demonstrated that the resulting gradation meets the requirements specified in Section 2.3, including the maximum allowable percentage below the minimum stone size.
- .3 Place stone on geotextile so as to avoid puncturing geotextile. Patch or replace punctured or torn geotextile.
- .4 All material shall be placed uniformly within the lines and grades indicated on the drawings and within the tolerances described in this section. The volume of placed filter stone should have an average of 30% voids.
- .5 The material shall be handled and placed in such a manner as to minimize segregation and provide a well graded mass.
- .6 Shaping and finishing to the required tolerances, as well as verification surveys of intermediate stone courses, shall be performed immediately prior to the commencement of placement of overlying stone courses.

3.3 ARMOUR STONE

- .1 Equipment suitable for handling armour stone of the specified size shall be used. The material shall be handled in such a manner as to minimize damage to the stones and the structure, and to minimize disturbance, slumping and degradation of the adjacent materials and/or underlying riverbed. Excessive drops or tumbling of stones shall not be permitted.
- .2 Armour stones shall be placed individually in a manner that best utilizes the natural shape of the stone within the grades and tolerances specified. The volume of placed armour stone should have an average of 35% voids.
- .3 Commence placement at base of structure and proceed upwards. Place each stone so that it is stable, secure and supported by stones below. Offset gaps between stones in adjacent layers.
- .4 The armour stones must be stable, tightly placed and interlocked together, with stone to stone contact and no overhanging or loose stones. The Contractor will select, rotate, rehandle after initial placement, and replace stones as required to achieve a stable and interlocked mass to the Departmental Representative's satisfaction and approval.
- .5 The overall uniform appearance of the placed armour stone is important. The Contractor may be required, at his own expense, to remove and/or reset stones in order to obtain a smooth and uniform structure.
- .6 All undersize material, including that resulting from breakage, as determined by the Departmental Representative, shall be removed at the Contractor's expense.
- .7 Armour stones shall not be placed over snow or ice.
- .8 Armour stone placement shall be such that a 250 mm diameter sphere (the minimum nominal dimension of the core stone) can not pass through the gaps between the armour stones.
- .9 Select and sort stones during placement as required to meet these placement specifications.

3.4 TOLERANCES

- .1 General:
 - .1 The layer thicknesses and slopes shown on the Contract Drawings shall be considered the target thicknesses and grades.
 - .2 Finished surfaces of core, bedding and armour stone courses shall not deviate from the lines and slopes shown on the Contract Drawings by more than 150 mm above grade line, but not uniformly high or low.
 - .3 The extreme limits of these tolerances shall not be continuous over an area greater than 50 square metres.

3.5 PROTECTION

- .1 The Contractor will be responsible for all necessary repair to the work during construction, including reshaping of slopes and replacement of materials displaced by waves, currents or any other cause.
- .2 Take into account anticipated weather conditions and degree of exposure of site in setting requirements for protection.
- .3 Schedule and carry out construction so that each phase of work is not left exposed longer than necessary.
- .4 Progress of placement of core and stone to be recorded daily by Departmental Representative with Contractor's concurrence. Replacement of material lost due to storm wave action or tidal erosion damage to be based on daily journal of work progress and to be considered incidental to the Work.

3.6 ROADWAYS

- .1 Construction, maintenance and removal of working roadway layers to be the responsibility of the Contractor and is to be considered incidental to the Work.
- .2 Construction, maintenance and removal of causeways, fills, etc. as required, to be the responsibility of the Contractor and is to be considered incidental to the Work.