

## **Part 1           General**

### **1.1               SCOPE**

- .1       This section treats the production of stone for the extension of rock filling and the stone ballast in the wooden, including the process of acceptance of stone sources by the Departmental Representative, and quality assurance checks that apply. The Contractor is responsible for quality control (QC), while the Departmental Representative is responsible for quality assurance (QA).

### **1.2               RELATED SECTIONS**

- .1       Section 31 36 19 – Gabion mattresses
- .2       Section 35 31 25 – Placement of stone

### **1.3               REFERENCES**

- .1       The latest editions of the standards and publications listed below form a part of this specification to the extent referenced.
- .2       American Society for Testing and Materials (ASTM)
  - .1       ASTM C88-05 : Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
  - .2       ASTM C127-07 : Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
  - .3       ASTM C136-06 : Sieve Analysis of Fine and Coarse Aggregates
  - .4       ASTM C295-03 : Petrographic Examination of Aggregates for Concrete
  - .5       ASTM D4992-07 : Evaluation of Rock to be Used for Erosion Control
  - .6       ASTM D6928-06 : Standard Test Method for Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
  - .7       ASTM D7012-07 : Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures.

### **1.4               MEASUREMENT AND PAYMENT**

- .1       Measure
  - .1       All the stones shall be measured for the payment in the metric tons (1,000 kg) for materials accepted for the implementation in the work according to the weighing tickets of the certified scale as described below.
    - .1       The Contractor has to proceed to the installation and the certification of an electronic balance before the transport of stone. The balance has to be of type (chap) register and has to be of a capacity to weigh the stone and the means of transportation. The dimensions (size) of the balance have to allow to receive all the wheels of means of transportation used by the Contractor.

- .2 The Contractor shall provide the departmental representative of the copies of the tickets of all stones delivered on-site weight every day.

## 1.5 SUBMITTALS

- .1 The following information shall be submitted to the Departmental Representative.
  - .1 Stone source information:

Within 15 working days of notice of acceptance of offer, the Contractor shall submit the following information for all proposed stone sources for each stone size classification:

    - .1 Name and location of quarry;
    - .2 Areas and lifts of the quarry to be worked;
    - .3 Specific geological stratum or strata to be used;
    - .4 Laboratory test records and results (refer to requirements in Table 1) representation of areas and lifts to be worked for this project;
    - .5 List of completed marine projects constructed using the same stone to be furnished for this project.
  - .2 Gradation tests  
Submit all gradation tests for review, complete with gradation test data sheets, calculations and graphical presentation of results.
  - .3 Installation and certification of weigh scale  
The Contractor shall make arrangements for the installation and certification of an electronic weigh scale at the work site before shipping the stones as indicated in 1.4.1.1. Weigh scale installation and certification are provided at Contractor's expense.  
At least 5 working days before loading, submit the details concerning the location and the type of weigh scale installed for the purpose of the project as well as a document certifying the accuracy of the scale(s) under Industry Canada.
  - .4 Weigh scale operators  
The Contractor shall provide weigh scale operators and pay all costs involved.
  - .5 Other weighing devices  
Submit the details of the equipment incorporating load cells or other devices to weigh stones individually. These devices are provided at Contractor's expense.
  - .6 Certified weight scale tickets  
A copy of each weight scale tickets, including certification of exact weight, time of weighing and of delivery shall be submitted to the Departmental Representative the day following the weigh-in.

## 1.6 TERMINOLOGY

The following definitions shall pertain to these terms :

- .1 Dimensional ratio (l/d) – report between the length (l) and the thickness (d) measured on three axes mutually perpendicular. The length of the stone (l) is the most long distance between two points on the stone (between two opposite corners). The thickness of the stone (d) is the minimal dimension of two opposite faces of the stone.

- .2 The word “ton” (t) refers to the metric ton (1 t = 1 000 kg).

## **1.7 QUALITY CONTROL**

- .1 The SMC Plan shall be incorporated into the Contractor’s overall Quality Control Program (QCP) in accordance with Section 01 45 00.

## **1.8 QUALITY CONTROL STAFFING**

### **.1 General**

- .1 The Contractor shall provide a qualified full-time Stone Materials Control (SMC) Field Supervisor, and appropriate stone source and loading facility inspector(s). In addition, the Contractor shall retain the services of a Licensed Professional Geologist to assist the SMC Field Supervisor on an “as required” basis throughout the duration of the Work. The SMC staff shall verify that all stone produced, delivered to the Project site, and placed in the Works conforms to the requirements of the Contract Drawings and Specifications.

### **.2 Supervisor’s qualifications and duties**

- .1 The supervisor is responsible for implementing all the elements in the control plan for stones. He has at least 2 years of specialised experience in the inspection and assessment of armour stone for marine projects. The experience must have been acquired in the quality assessment of the type and size of stone involved in the project at hand. Where the Contractor obtains the stones for this project from a subcontractor, the supervisor shall not be an employee of the latter.
- .2 The supervisor shall be responsible for the implementation and fulfilment of the control plan for stones, including the management, control and assessment of the work performed by all the inspectors. He shall provide qualified inspection personnel at all times and replace any person whose performance is unsatisfactory. The supervisor is responsible for the quality of all stone produced.

### **.3 Qualifications and Duties of Geologist**

- .1 The Geologist shall be a Licensed Professional Geologist, with at least one year of practical experience in armour stone inspection and assessment. The Geologist shall provide assistance to the SMC Field Supervisor during stone source selection, including the completion of visual and petrographic examinations (refer to Table 1), identification of specific areas and lifts of acceptable and unacceptable stone at the source(s) and the selection of Pre-Production Reference Stones. In addition, the Geologist shall be retained during stone production if ongoing Quality Control (QC) or Quality Assurance (QA) activities indicate that the quality of stone being furnished is not as specified or is questionable, as directed by the Departmental Representative.

### **.4 Qualifications and Duties of Inspectors**

- .1 The SMC inspectors shall be persons with sufficient training and a minimum of one year of relevant experience to competently and independently perform the tasks itemized below while under the general supervision of the SMC Field Supervisor.
  - .1 Participate in the selection of stone for the Pre-Production Reference Stones and in the evaluation of stone placed in the stockpiles.

- .2 Maintain a clear, legible daily log of activities and observations in a format to be approved by the Departmental representative. Prepare daily inspection reports and submit in a timely manner.
- .3 Visually inspect every Armour stone to verify that the stone meets the quality requirements of this Section. The examination shall focus on stone quality, fractures, stone geology and other detrimental features that may cause the stone to deteriorate into smaller pieces after it is in place in the Work.
- .4 Measure one representative sample along three mutually perpendicular axes and estimate its weight, based on the unit weight of that stone type, and its aspect ratio.
- .5 Proceed to regular checks of estimated weights against the scaled weights using a weight measurement method approved by the Departmental Representative.
- .6 Build and maintain separate stockpiles for each category of stone.
- .7 Ensure that rejected stones are stockpiled in the “reject” pile or that they are removed without delay from the site after being marked. Rejected stones shall always be segregated from accepted stones.
- .8 Perform periodic checks that load cells or other equipment-mounted weight scale devices are accurately weighing stone for quality control.

#### **1.9 ACCEPTANCE DETERMINATION FOR STONE SOURCE(S)**

- .1 The Departmental Representative reserves the right to undertake independent investigations and evaluations as necessary to verify whether or not materials meeting the requirements of these specifications can be produced from the proposed source(s), including the stone quality tests listed in Table 1. Any additional testing shall be undertaken on stone samples selected by the Departmental Representative. All costs associated with independent investigations and evaluations of the originally proposed stone source(s) shall be the responsibility of the Departmental Representative.
- .2 The Departmental Representative will make an acceptance determination for the Contractor’s proposed stone source(s) and SMC Plan, including SMC staff, based on the following information:
  - .1 Review of the Contractor’s Stone Source Information
  - .2 Visual inspection of stones
  - .3 Assessment of this information relative to the specified requirements for stone quality and stone gradation and shape;
  - .4 Review of results of additional laboratory testing.
- .3 The Departmental Representative will provide a determination of acceptance or rejection of the stone source(s) and staff proposed by the Contractor within 10 working days of the date of Departmental Representative inspection or receipt of additional laboratory test results
  - .1 If the stone source, SMC Plan and SMC staff are determined to be acceptable, the Contractor may then proceed with the production of materials for this Contract.
  - .2 If the stone source(s) is rejected, the Contractor is responsible for finding a new source(s), and undertaking additional sampling and testing as required for source

approval by the Departmental Representative. The Contractor is responsible for all costs associated with changing stone sources. In addition, no extension in the required completion date for this Contract will be allowed because of changing stone sources.

- .4 No additional time will be added to Contract milestones or delivery dates for the time required for the Departmental Representative to make a determination of acceptance or rejection of the proposed source(s).

## **1.10 QUALITY ASSURANCE**

### **.1 General**

- .1 Quality Assurance (QA) activities shall 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 and in-place requirements.
- .2 The Contractor shall provide equipment and operations to turn and handle disputable stone that should be revaluated by the Departmental Representative.
- .3 In the event that the Departmental Representative's QA activities indicate non-conformance to the requirements of this Section, the Departmental Representative will reject the non-conforming stones. Materials rejected at the source shall be immediately marked (with a red "X" on three mutually perpendicular sides), segregated and removed from the the stockpile area.
- .4 If the Departmental Representative, during his QA activities, finds that the quality of stone being furnished is not as specified or is questionable, additional sampling and laboratory testing may be required. The selection of samples (from stockpiles at the site, source or intermediate location, such as a loading dock), and the required testing of stones, shall be as directed by the Departmental Representative. The Contractor shall pay all costs associated with the additional sampling and laboratory testing of stone.
- .5 Continued non-conformance will be considered justification for rejection like describe in section.

## **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 to the deposit site and are rejected.
- .2 The SMC Plan and QC/QA activities shall be systematically applied throughout the duration of quarry and construction operations for this project.

### **2.2 MATERIALS**

- .1 Stones must be uniformly distributed between the minimal and maximal values for all the categories asked in specifications.

- .2 Petrographic maximum number: 130.

### **2.3 STONE SOURCES**

- .1 The Contractor shall be solely responsible that the selected source(s) can meet the delivery schedule and produce the quality and quantity of stone required for the project.
- .2 If the Contractor is unable to obtain a sufficient quantity of acceptable stone materials from the original source(s) during the Contract, the Contractor may request approval to use an alternative source(s). The Contractor will be responsible for all costs associated with changing stone sources, including additional sampling, and testing as required for source approval. In addition, no extension in the required completion date for this Contract will be allowed.
- .3 The implemented stone must be extracted from a quarry of hard stone and sustainable.

### **2.4 STONE QUALITY REQUIREMENTS**

- .1 General (All stone)
  - .1 All stone shall be highly resistant to weathering, deterioration or disintegration under freeze-thaw 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. The stone shall be durable, sound and free from detrimental cracks, seams and other defects, which tend to increase deterioration from natural causes or cause breakage during handling and/or placing. Argillaceous stone or stone with high shale content is more susceptible to weathering, abrasion, thin bedding, close fracturing and other undesirable rock properties and shall not be accepted. Inclusions of dirt, sand, clay, shale, chert, micaceous minerals, pegmatite, oil and oil-stained stones and rock fines or any organic or other deleterious material will not be permitted.
  - .2 The use of shale or slate and round stones will not be accepted in any part of the project. The stones used will be free from elements such as stratification, bedding, cracks, mudstone, etc.
- .2 Armour Stone A-Class
  - .1 Sandstone and conglomerate materials will NOT be acceptable as Armour stone for this project, whatever the conformity of other specifications.
  - .2 Is there an uncertainty for sandstone or not, the stone shall have a petrography exam (ASTM C295-03). The laboratory fees will be Contractor's expenses.
  - .3 Categories for stone A class are:
    - .1 350 to 450 mm diameter
    - .2 500 to 1500 kg
    - .3 50 to 150 kg

### **2.5 TESTS**

- .1 Inform the Departmental Representative of the proposed source for rocks and stones, and ensure access to that source for sampling, at least four (4) weeks before the start of production at the quarry.

- .2 During this period of four (4) weeks, a minimum period of two (2) weeks is required for laboratory tests.
- .3 The Departmental Representative could request for other tests during the project. The cost for laboratory tests shall be paid by the Departmental Representative unless the tests show some irregularities of materials, in which case the Contractor shall bear the costs.
- .4 At all times, the stone samples for testing will be collected in the presence of the representative of the laboratory or the Departmental Representative.

## **2.6 SORTING OF THE STONES**

- .1 Each stone category to be used will be sorted and placed in separate piles in the quarry.
- .2 The stones deemed out of the established limits must be removed and replaced with others that meet the requirements. They can be rejected be it at the quarry or at the site.

## **2.7 TOLERANCE ON THE SHAPE OF THE STONES**

- .1 Ballast stones: the smallest size of stones should not be less than 305mm.
- .2 All stones with a ratio from the largest size to the smallest which is greater than 3 will be rejected.
- .3 The stones with ratios from the largest sizes to the smallest between 2.5 and 3 shall not be laid flat on the slope or under water when they are being placed.
- .4 For stones whose ratio from the largest size to the smallest is less than 2.5 can be used in the structure without any particular placement criteria.
- .5 The stone will be transported by category and the supervisor must be notified in advance of the categories of stone to be transported and where it will be used on the structure.

## **2.8 TOLERANCE ON THE WEIGHT OF THE STONES**

- .1 At least 90% of stone weight, of same class, listed placed in work shall weight a mass included within this class weight limits.
- .2 At most 5% of stone weight, of same class, listed could weight between 0.75 time and one time minimum required weight for this class.
- .3 Any stone whose weight will be inferior to 0.75 time minimum weight of superior to 1.25 times maximum weight of class in which it is classified will be refused, removed from quantities and shall be removed from worksite.
- .4 In case of contestation about Departmental Representative's decision, Contractor shall demonstrate that involved stones totally meet preceding criteria.
- .5 Every broken stones during handling or shipping shall be revaluated based on previous criteria.
- .6 Stones in the same category shall be evenly distributed according to their sizes (following allowed values) in all armour rock protection, so as to avoid concentration of stones with the same sizes in some areas within a given category.
- .7 The stone shall be angular or oblong shape with a ratio short-dimensional (l/d) up to 3/1. It should not be more than 10% of stone having a dimensional ratio greater than 2.5/1.

**Table 1 - Quality tests required for stone - Delivery methods and criteria**

Name of test	Testing method	Delivery criteria
		Class 'A' stone
<b>On-site review / Visual observation / Evaluation</b>		
On-site review <sup>1</sup>	ASTM D4992-07	No sand or cement No deleterious materials; excellent quality for earmarked usage
Petrographic review <sup>2</sup>	ASTM C295-03	No deleterious materials; excellent quality for earmarked usage
Resistance to alteration	Visual	IA – fresh unaltered stone IB – slightly altered stone (marks on the main boundary surfaces)
<b>Laboratory tests</b>		
Density, SSD	ASTM C127-07	2.65 to 2.85
Water absorption <sup>3</sup>	ASTM C127-07	≤ 0.5%
Compression Strength <sup>4</sup>	ASTM D7012-07	≥ 100 MPa
Micro-Deval wear resistance <sup>5</sup>	ASTM D6928-06	≤ 15
MgSO integrity <sup>4</sup>	ASTM C88-05	≤ 1.5% loss after 5 cycles
Petrographic review <sup>2</sup>	ASTM C295-03	No deleterious materials; excellent quality for earmarked usage

**Notes:**

- 1 The on-site assessment must include a report which will summarize the characteristics of the quarry and propose a development plan for it in accordance with ASTM D4992-07 standards: general lithology; geological unit and age; homogeneity of the source; stratigraphic faces; metamorphic and alteration phases; the dip, direction and thickness of the stratification; proposed blasting procedure and scheduled duration of curing.
- 2 Petrographic review must be repeated before and after MgSO<sub>4</sub> integrity tests. It should be summarized in a written report, with the geological name of the stone, state of alteration, main constituents, texture, anisotropy and porosity. In addition, the report must indicate the presence of constituents, the presence of micro-fractures and / or induced stress signs (and, therefore, any possible stress release - see Section 3.2) that can be a source of problems for the proposed use and discussions thereof.
- 3 The water absorption test should be repeated on five (5) different pieces of stone.
- 4 The compression strength test should be repeated on three (3) different pieces of stone.
- 5 The micro-Deval wear resistance test should be repeated on two (2) different pieces of stone.

**Part 3 EXECUTION**

**3.1 PRODUCTION QUALITY CONTROL**

- .1 The Contractor shall perform Quality Control activities throughout the duration of stone production and placement operations in accordance with the requirements of this Section and Section 01 45 00
- .2 Weighing of stones or re-measuring them shall be performed to verify computed weights when the Department Representative brings the size of specific stones into question, or when the SMC inspector observes the need to do so.
- .3 Drop tests shall be performed when the Departmental Representative questions the quality or integrity of specific armour stones, or when the SMC inspector observes the need to do so. Drop tests shall be undertaken as follows:
  - .1 Visually inspect all sides of the stone, and mark/record existing cracks;
  - .2 Lift and drop stone from a height of 3 m onto a rigid surface (bedrock, or similarly sized stone);
  - .3 Visually inspect all sides of the stones for cracks for the opening of existing cracks and/or the development of new cracks;
  - .4 Repeat at least 3 times, as directed by Departmental Representative;
  - .5 Stone is acceptable for use if there is no opening of existing cracks and no development of new cracks.

**3.2 TRANSPORTATION AND TEMPORARY STOCKAGE**

- .1 The Contractor must arrange transport, loading and implementation of the stones to ensure that the categories are not contaminated by dirt and other materials and to reduce the segregation of materials by size.
- .2 Storage, loading and implementation of stones following the dispatch of the quarry shall be subject to the approval of the Department Representative.

**END OF SECTION**