

Part 1 General

1.1 SCOPE

- .1 This section covers stone production, including the Departmental Representative's acceptance process and the applicable quality control and quality assurance processes. The Contractor is responsible for quality control (QC), while the Departmental Representative is responsible for quality assurance (QA).

1.2 RELATED SECTIONS

- .1 Section 01 29 00 – PAYMENT
- .2 Section 01 33 00 – DOCUMENTS AND SAMPLES TO SUBMIT
- .3 Section 02 41 19 – EXCAVATION OF STONE AND DOLOSSE
- .4 Section 35 31 25 – STONE PLACEMENT

1.3 REFERENCES

- .1 The latest edition of each of the standards below are part of this document, within the indicated limits.
 - .1 American Society for Testing and Materials (ASTM)
 - ASTM C88: Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
 - ASTM C127: Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
 - ASTM C136: Sieve Analysis of Fine and Coarse Aggregates
 - ASTM C295: Petrographic Examination of Aggregates for Concrete
 - ASTM D4992: Evaluation of Rock to be Used for Erosion Control
 - ASTM D6928: Standard Test Method for Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
 - ASTM D7012: Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

1.4 DOCUMENTS AND SAMPLES TO SUBMIT

The following information must be submitted to the Departmental Representative in compliance with the requirements laid out in section 01 33 00 - Documents and samples to submit.

.1 Information on stone sources

The Contractor must submit the following information about all proposed stone sources within twenty (20) business days of contract award:

- .1 name and location of quarry
- .2 areas and lifts of the quarry to be worked
- .3 specific geological strata to be utilized
- .4 results of all required laboratory tests (table 2) on samples that represent each of the areas and strata to be worked. These tests must have been performed specifically for this project
- .5 list of marine structures that have been built with the same stone

.2 Stone materials control plan and staffing

The Contractor must submit a written stone materials control plan within twenty (20) business days of contract award. This plan must describe the means, methods and equipment to be used for production, handling, transportation and placement of the stone, as well as for the inspections and the follow-up to ensure the stone is of a satisfactory quality.

The stone materials control plan must include the names and qualifications of the supervisor and of a licensed professional geologist (or geological engineer).

.3 Pre-production stones

The Contractor must submit a set of pre-production stones within twenty-five (25) business days of contract award. These stones will be evaluated at the source by the Departmental Representative. At least 25 pre-production stones must be provided for each stone category to be produced at each source.

.4 Revision of the stone materials control plan and staffing

The Contractor must submit proposed revisions to the stone materials control plan no later than five (5) days before they plan to implement the revision. The Contractor must not implement the revision before it has been reviewed by the Departmental Representative. Proposed staff changes must also be submitted for review.

.5 Stone materials control plan reports

The Contractor must keep daily logs of all work performed as part of the approved stone materials control plan. These logs must be available for the Departmental Representative to review upon request. They must also be collated at the end of each week and submitted to the Departmental Representative weekly. Daily logs must be written by each inspector and must include the following information:

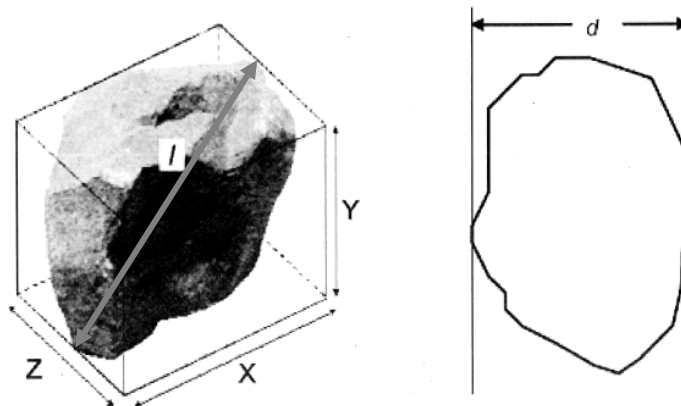
- .1 inspector name
- .2 identification of stone-handling equipment for each work phase and the names of the equipment operators who prepared the stone for inspection;
- .3 date of stone inspection
- .4 weather conditions, including temperature
- .5 date and weather conditions for the day the stone was removed from the quarry face and date and details of blasting, if applicable
- .6 strata and location (horizontal and vertical) from which the stone was extracted in the quarry
- .7 colours and characters used by the inspector for spray paint marks and the relevant code for stones which are individually sorted (versus mechanically sorted) and for any rejected stone
- .8 breakdown of the approximate quantity, by category, of stones accepted and rejected throughout the day
- .9 a summary of the reasons for rejecting the stone throughout the day
- .10 total amount of each type of stone removed to date

.6 Gradation tests

Submit all gradation tests results for examination, including test data sheets, calculations and a graphic presentation of the results.

1.5 TERMINOLOGY

- .1 The terms below are defined as follows:
 - .1 The term “tonne” (t) refers to the metric ton (1 t = 1,000 kg)
 - .2 Dimension ratio (l/d) - ratio of the maximum length (l) to minimum thickness (d) measured between the two closest parallel lines through which the stone can pass.



1.6 QUALITY CONTROL STAFF

.1 General

The Contractor must provide a designated supervisor for the stone quality control process. They must also provide skilled inspectors in the quarry and at the loading point. Furthermore, the Contractor must retain a licensed professional geologist (or geological engineer) to help the supervisor as needed throughout the project. Staff must ensure that all stone that has been produced, delivered to the construction site and placed in the structure meets the requirements laid out in the plans and the specifications document.

.2 Supervisor qualifications and responsibilities

The supervisor is responsible for implementing all elements of the stone materials control plan. He must have at least two (2) years of specialized experience inspecting and evaluating armour stone for marine structures. This experience must have been obtained by evaluating the quality of stones of similar type and size to the ones used for this project. If the primary contractor obtains the stone for this project through a subcontractor, the supervisor shall not to be employed by said subcontractor.

The supervisor assumes responsibility for implementing and executing the stone materials control plan, including management, supervision and examination of inspectors' work. The inspection staff must be qualified and suitable for the work. The supervisor is responsible for replacing any inspector that does not perform their duties satisfactorily. The supervisor is also responsible for the quality of all stone.

.3 Geologist (or geological engineer) qualifications and responsibilities

The geologist (or geological engineer) must have at least three (3) years of practical experience inspecting and evaluating armour stone. They must assist the supervisor in selecting the stone sources. This includes assisting with visual and petrographic examinations (tables 1 and 2), identification of acceptable and unacceptable zones and layers of stone in the quarry, collecting samples for laboratory testing and choosing pre-production stones. The geologist (or geological engineer) must be retained during stone production if permanent quality control (QC) and quality assurance (QA) processes indicate that the stone is questionable or does not meet the requirements, according to the Departmental Representative's instructions.

.4 Inspector qualifications and responsibilities

Inspectors must have adequate training and at least one (1) year of relevant experience that allows them to competently and independently perform the following tasks under the general supervision of the supervisor.

- .1 Assist in selecting pre-production stones and evaluating stones placed in storage piles.
- .2 Keep a clear and legible daily log of their activities and observations, in a format approved by the Departmental Representative. Write daily inspection reports and submit them in a timely manner.

- .3 Visually inspect stones to ensure that they meet the quality requirements listed in this section. The inspection must focus on the quality and characteristics of the stone, the presence of fractures and any other features that could cause the stone to deteriorate as or after it is placed in the structure.
- .4 Clearly mark all armour stone (stone weighing 1–3 t or more) with spray paint, using a colour and symbol system that has been approved by the Departmental Representative. Unless otherwise indicated, each stone must be marked on three mutually perpendicular sides. Inspection must also involve the identification and marking of stones that do not meet the acceptability criteria in terms of size, shape and/or quality. Unacceptable stones must be spray-painted with a red X on three mutually perpendicular sides.
- .5 Measure each stone on three (3) mutually perpendicular sides and reject any stones that do not meet the dimension ratio requirements.
- .6 Ensure that all armour stone (stone weighing 1–3 t or more) is weighed individually, using the appropriate equipment. Estimate the weight of the filter stone (stone weighing 800–1,200 kg or less) using the dimensions and unit weight for that type of stone.
- .7 Maintain separate piles for each category of stone.
- .8 Ensure that rejected stones are placed in a “reject” pile or are immediately removed from the site once they are marked. Rejected stones must never be mixed with accepted stones.
- .9 Perform gradation tests so that production changes can be made to ensure that the stones meet the requirements laid out in this section.
- .10 If the stones are being transported by barge, ensure that the different categories of stone are kept separate during loading and unloading. Provide total tonnages for each category of stone for each barge before transport.
- .11 Periodically check the accuracy of gauges and other weighing devices on the equipment to ensure that they are weighing the stone accurately for gradation tests and quality control purposes.

1.7 PRE-PRODUCTION STONES

.1 Preparation

The Contractor must submit a set of pre-production stones within twenty-five (25) business days of contract award. Alongside the geologist (or geological engineer), the supervisor must choose the pre-production stones for evaluation by the Departmental Representative. These stones must be located at the source and must be arranged in rows. At least 25 pre-production stones must be provided for each category of stone to be produced at each source. They must be representative of each zone, geological unit, face and layer in the quarry, as well as of the quality of stone and the sizes range for each category.

.2 Inspection of pre-production stones

The Contractor's supervisor and inspectors must accompany the Departmental Representative during the inspection the stones. The Contractor must ensure that the faces of the stones are not covered in dust or mud, and that the stones can be turned as needed to facilitate the Departmental Representative's inspection. The Departmental Representative will mark unacceptable stones with a red X on three mutually perpendicular sides. If twenty percent (20%) or more of the stones in a set of pre-production stones are found to be unacceptable, the Contractor must replace the unacceptable stones and have them re-inspected. If the Contractor is unable to provide a full set of acceptable pre-production stones with this second attempt, the quarry will be refused. The Contractor will then be asked to find a new stone source for approval. The Contractor will assume all costs related to the replacement of stones in the pre-production stone sets, as well as any costs related to changing quarries. No deadline extensions will be granted due to a change of quarry.

.3 Maintenance of pre-production stones as examples

Acceptable and typically unacceptable stones (as determined by the Departmental Representative) shall remain on display in the quarry so that they can be used as examples of the quality, size and shape requirements. They must remain exposed for the duration of the transportation process. The weight of each pre-production stone must be clearly indicated on the stone itself.

1.8 ACCEPTANCE OF STONE SOURCES AND STONE MATERIALS CONTROL PLAN

- .1 The Departmental Representative reserves the right to perform independent investigations and evaluations, including additional stone quality tests and thin-section petrographic examinations, to check whether the proposed sources can produce stones that meet the requirements of this document. All additional tests will be performed on stone samples that have been chosen by the Departmental Representative. Additional testing will be at the Departmental Representative's expense.
- .2 The Departmental Representative will decide whether to accept the Contractor's proposed stone sources and stone materials control plan, including staff, based on the following information:
 - .1 examination of the stone sources and stone materials control plan submitted by the Contractor (see subparagraphs 1.4.1 and 1.4.2)
 - .2 inspection of pre-production stones (see paragraph 1.8)
 - .3 evaluation of information related to the requirements for stone quality (see paragraph 2.3 and tables 1 and 2), gradation tests and stone shape (see paragraph 2.4)
 - .4 examination of other laboratory test results, if applicable (see subparagraph 1.9.1)

- .3 The Departmental Representative will accept or reject the Contractor's proposed stone sources, stone materials control plan and staff within ten (10) days of inspecting the pre-production stone or receiving the latest laboratory test results, whichever is later.
 - .1 If the stone source, the stone materials control plan and staff are deemed acceptable, the Contractor may continue producing materials, as long as they are similar to the approved pre-production stones.
 - .2 If the stone materials control plan is rejected, the Contractor must prepare a new plan, including new staff if necessary. This plan must be accepted by the Departmental Representative before stone can be produced for this project. No additional payments will be made until a satisfactory plan has been submitted to the Departmental Representative. The Contractor must assume all costs related to producing a new plan. Additionally, no deadline extensions will be granted if a new plan is needed.
 - .3 If the stone sources are rejected, the Contractor is responsible for finding new sources, including performing the sampling and testing needed to obtain the Departmental Representative's approval. The Contractor is responsible for any costs resulting from a change of quarry. Additionally, no deadline extensions will be granted due to a change of quarry.
- .4 No deadline extensions will be granted for the time taken by the Departmental Representative to approve or reject the proposed sources.

1.9 QUALITY ASSURANCE

.1 General

- .1 Quality assurance (QA) activities will be performed by the Departmental Representative. Quality assurance activities are intended to provide independent observations about compliance with the requirements in this section before the stone is sent to the work site. They do not release the Contractor from their responsibilities in any way.
- .2 The Contractor must provide the necessary equipment and operators to turn and move questionable stone that needs to be re-evaluated by the Departmental Representative.
- .3 If the Departmental Representative's QA activities find that the requirements of this section are not being met, they will reject the non-compliant stones. Stones that are rejected at the source must be immediately marked with a red X on three mutually perpendicular sides, then separated and removed from the storage area. Stones rejected on the work site must be removed from the site at once. They will be excluded from measurements for payment purposes. The Contractor will bear the cost for removing rejected stones.
- .4 If, during QA activities, the Departmental Representative finds that the quality of the stone is questionable or does not meet the requirements, they may request additional samples and laboratory tests. Sample selection and testing of chosen stones must comply with the directions of the Departmental Representative. The Contractor will bear the costs of additional sampling and laboratory testing of the stones.

- .5 If the stone continues to be found non-compliant, it may be used as justification for rejecting the stone materials control plan, as described in sub-subparagraph 1.8.3.2, and/or rejecting the source of the stone, as described in sub-subparagraph 1.8.3.3.

.2 Gradation tests

- .1 For quality assurance (QA) purposes, the Departmental Representative may perform supplementary gradation tests. Gradation tests for QA purposes will be performed at intervals determined by the Departmental Representative. The Representative will choose a random sample of stone to submit for testing. If the QA gradation test or stone observation indicates that the stones do not meet the requirements, production procedures must be modified. Additional QA and QC gradation tests will be required to validate the corrective measures.
- .2 The Contractor must provide the Departmental Representative with all loaders, certified scales, equipment operators and staff needed to take samples, weigh individual stones and weigh the total sample.

Part 2 PRODUCTS

2.1 GENERAL

- .1 All stones must meet all of the requirements in this section of the specifications document. At any time during the contract, the Departmental Representative may reject materials at the source or on the work site if they do not meet the requirements. Materials that have been delivered to the work site then rejected, either from a pile or once they have been placed in the structure, must be removed at the Contractor's expense.
- .2 The stone materials control plan and QA/QC activities must be applied systematically throughout the duration of quarry and construction phases of this project.

2.2 STONE SOURCES

- .1 The Contractor is solely responsible for ensuring that the chosen quarries will produce the desired quality and quantity of stones for the project within the specified delivery schedule.
- .2 If they are unable to obtain enough acceptable stones from the original source during the contract, they may request authorization to use another source. The Contractor is responsible for any fees related to a change of quarry, including fees for sampling and testing. Additionally, no deadline extensions will be granted due to a change of quarry.
- .3 Part of the stone in the existing structure must be reused for this project. The definition of this stone can be found in section 02 41 19.

2.3 STONE QUALITY REQUIREMENTS

.1 General

All stone must be extremely resistant to bad weather, wear and disintegration due to freezing and thawing and water exposure. The stone must be of a high enough quality to ensure that the structure is able to withstand the climatic conditions in which it is going to be used. The stone must be produced from a quarry and must be angular and irregular in shape. It must be durable, sound and free from detrimental cracks, seams and other defects that would tend to increase deterioration from natural causes or lead to breakage during handling or placement. Inclusions of dirt, sand, clay, shale, quartz, mica, pegmatite, iron oxide, oil, nodes or veins of iron sulfide, as well as oil-stained stones and rock fines or any organic material or other deleterious material are not permitted.

.2 Additional specifications for certain stone types

.1 Sandstone:

- .1 Sandstone is NOT to be used for this project, even if it meets the other acceptability criteria.
- .2 If the Contractor is unsure whether a stone is sandstone or not, the stone must be submitted to thin-section petrographic examination (ASTM C295). The Contractor will assume the cost of this examination.

.2 Conglomerates:

- .1 In order to be accepted for this project, conglomerates must meet all of the requirements in tables 1 and 2.
- .2 Density and absorption tests must be performed on pieces that are at least 200 mm in diameter, without crushing.
- .3 Conglomerates with particles larger than 100 mm in diameter must not be used for laboratory testing (table 2).

.3 Stone sampling and testing methods

- .1 References for the testing methods are listed in section 1.3 - References.
- .2 Stone samples used for laboratory testing must be representative of each lithostratigraphic unit of each quarry that is to be used under this contract.
- .3 Sampling for laboratory tests must be performed jointly, i.e. in the presence of both the geologist (or geological engineer) hired by the Contractor and the geologist (or geological engineer) hired by the Departmental Representative. The Contractor must plan the sampling consequently.

Table 1 – Conglomerate-specific acceptance criteria

Parameters		Acceptability criteria
Matrix	Composition	Calcareous
	State	Hard and not friable
Particles	% of particles with shale texture (shale, mudstone and siltstone)	$\leq 1 \%$
	% of terrigenous particles	$\leq 5 \%$
	Contact particle-matrix	Particles must be welded to the matrix. Stones having a separation between the particles and the matrix are rejected.
Long-term behaviour		A geological expertise must prove that the conglomerate in the quarry has been used in an existing marine structure for at least five (5) years and has not deteriorated prematurely.
Geological age		Conglomerates from the Silurian period and later are not permitted.

2.4 STONE SHAPE AND GRADATION

- .1 Production, transportation and placement methods must be adjusted as needed to ensure that the materials meet the gradation and shape requirements.
 - .1 For gradation tests, a random sampling of stones will be chosen. Together, these stones must be at least twenty-five (25) times the average weight of the category being tested. Each stone in the sampling must be weighed individually. A grading curve for the sample will be produced from this information.
 - .2 In addition to having an even distribution of sizes, at least fifty percent (50%) of the stones by number must be larger than the median stone weight for that category.
 - .3 The stone should be angular or short oblong in shape, with a maximum dimension ratio (l/d) of 3:1. No more than ten percent (10%) of the stones by number in each category can have a dimension ratio greater than 2.5:1.
 - .4 The Contractor must generate and submit the production and pre-production gradation tests results as indicated in table 3.

Test name	Test method	Acceptance criteria
Field/Visual observation/Assessment		
Field examination ¹	ASTM D4992	Without sandstone No deleterious materials; good to excellent quality for the intended usage
Petrographic examination ²	ASTM C295	No deleterious materials; good to excellent quality for the intended usage
Weathering grade	Visual	IA - Fresh, unweathered rock IB – Faintly weathered rock (staining on major discontinuity surfaces)
Laboratory tests		
Bulk specific gravity, SSD	ASTM C127	2.65 to 2.85
Water absorption ³	ASTM C127	≤ 0.5%
Compression strength ³	ASTM D7012	≥ 100 MPa
Wear resistance Micro-Deval ⁴	ASTM D6928	≤ 15
MgSO ₄ soundness ³	ASTM C88	≤ 1.5% loss after 5 cycles
Resistance of large unconfined aggregates to freeze/thaw cycles ³	CAN/CSA A23.2-24A	≤ 5 % loss after 5 cycles
Petrographic examination ²	ASTM C295	No deleterious materials; good to excellent quality for the intended usage

Table 2 – Required stone quality tests for all stone – Test methods and acceptance criteria

Notes:

- 1 Field examination must include the preparation of a written report, which is to include a summary of the quarry and proposed development plan in compliance with standard ASTM D4992, including: general lithology; geological unit and age; homogeneity of the source; stratigraphic faces; metamorphic and weathering phases; dip, strike and thickness of the bedding; proposed blasting procedure; and expected curing time.
- 2 The petrographic examination must be performed before AND after MgSO₄ soundness tests. It must be summarized in a written report that includes the rock's geological name, weathering state, main constituents, texture, anisotropy and porosity. This report must also identify and discuss whether the stone contains any constituents, micro-fractures and/or signs of induced stress (and therefore possible stress release – see paragraph 3.1) that may be of concern for the proposed use.
- 3 Water absorption, compression strength, MgSO₄ soundness, and freeze/thaw resistance on large unconfined aggregates tests must be performed on pieces from five (5) different stones.
- 4 The wear resistance Micro-Deval test must be performed on pieces from three (3) different stones.

2.5 FREQUENCY OF STONE TESTING AND INSPECTION

- .1 The minimum required frequency of stone quality tests, visual inspections and gradation tests under the Contractor's stone materials control plan is indicated in table 3.

Table 3 – Stone quality test, visual inspection and gradation tests

Stone type	Stone quality tests	Visual inspection	Gradation tests
Armour stones (categories 1–3 t and larger)	Pre-production tests for each source and for each geological change in the quarry	Continuous	Continuous gradation verification from the stone materials control plan reports
Filter stone (categories 800–1200 kg and smaller)	Pre-production tests for each source and for each geological change in the quarry	Continuous	Sample every 3,000 tonnes for each category

Part 3 EXECUTION

3.1 STONE CURING AND WINTER QUARRYING

- .1 The Contractor must conduct curing operations on freshly quarried stone to permit it to release stored energy and moisture and demonstrate that the stone will not fracture during the energy release and drying stage. Before the stones can be inspected and approved for transport to the work site, they must be temporarily stored in a single layer at the quarry site for at least ten (10) consecutive calendar days without any occurrence of freezing weather (0 °C and below).

.1 Sedimentary rock quarries

- .1 When the ambient air temperature at the quarry reaches a 24-hour average of 0 °C for three consecutive days, quarrying operations are to cease for the winter. Quarrying operations are to restart the following May 15.
- .2 Stone that has been blasted fewer than two (2) weeks before operations cease will not be accepted unless the Contractor can provide and maintain an appropriate storage area that will allow stones to be inspected once quarrying operations restart. Special storage and handling techniques must be used.
- .3 The Contractor is responsible for maintaining a production operations schedule and managing operations to ensure that they have enough of the appropriate types of stone for the project.

.2 Igneous and metamorphic rock quarries

- .1 There are no weather-related restrictions for quarrying or curing operations. However, the stone must be cured for ten (10) days after blasting, in compliance with the requirements in subparagraph 3.1.1.

3.2 QUALITY CONTROL AND QUALITY ASSURANCE DURING PRODUCTION

- .1 The Contractor must perform quality control operations throughout the stone production and placement process. Operations must comply with the requirements in this section and in section 01 45 00.
- .2 If the Departmental Representative expresses doubts about the size of particular stones or if the inspector deems it necessary, the stones must be re-weighed or re-measured.
- .3 Drop tests must be performed if the Departmental Representative expresses doubts about the quality or integrity of particular stones. Drop tests must be performed as follows:
- .1 visually inspect all sides of the stone and note/register existing cracks
- .2 lift the stone, then drop it onto a rigid surface (bedrock or stone of similar dimensions) from a height equivalent to the average diameter of the stone
- .3 visually inspect all sides of the stone for new or progressing cracks
- .4 repeat at least three times, as per the Departmental Representative's instructions
- .5 the stone will be accepted if there is no opening of existing cracks and no development of new cracks
- .4 The Contractor must be aware that inclement weather (rain, snow, ice, frost and mud) can hide defects that might have otherwise been detected. Winter conditions may prevent the required inspections from being performed before the following spring. Stones are not to be transported to the work site before they have been accepted.
- .5 Any broken or cracked stone and any stone that is outside the size requirements or that has been improperly placed within the structure must be removed and replaced by an appropriate stone. The Contractor will bear the cost of this corrective measure. Rejected materials must be removed from the work site as soon as possible. They will be excluded from measurements for payment purposes.

3.3 TRANSPORTATION AND TEMPORARY STORAGE

- .1 The Contractor is responsible for transporting and storing stones in a way that limits size segregation and prevents contamination by dirt and other materials.
- .2 The storage area for stone that has been delivered to the site but not yet placed must be submitted to the Departmental Representative for approval. Storing stones underwater is prohibited.

3.4 STONE PLACEMENT

- .1 Consult section 35 31 25 for placement requirements.

END OF SECTION 35 31 24