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Standard Practice for Evaluation of Rock to be Used for Erosion Control[1]

This standard is issued under the fixed designation D4992; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice covers the evaluation of rock to be used for erosion control. The complexity and extent of this evaluation will be governed by the size and design requirements of the individual project, the quantity and quality of rock required, and the potential risk for property damage or loss of human life.

1.2 It is not intended that all of the evaluations listed in this practice be addressed for every project. For some small, less critical jobs, a visual inspection of the rock may be all that is necessary. Several of the evaluations listed may be necessary on large, complex, high-hazard projects. It is the responsibility of the designer to determine the intensity and number of evaluations made on any one project.

1.3 Examination of the rock at the source, evaluation of similar rock exposed to the environment at any field installations, as well as laboratory tests may be necessary to determine the properties of the rock as related to its predicted performance at the site of intended use (**1**, **2**, **3**, **4**, **5**, **6**).[2]

1.4 The examination of the rock at its source is essential to its evaluation for erosion control and aids in the planning of the subsequent laboratory examinations. Very large pieces of rock up to several tons weight are used in the control of erosion; take great care with the field descriptions and in the sampling program to assure that zones of impurities or weaknesses that might not occur in ordinary size specimens are recorded and evaluated for their deleterious potential under the conditions of intended use. It is necessary that the intended method of rock removal be studied to ascertain whether the samples taken will correspond to the blasting, handling, and weathering history of the rock that will finally be used (**3**).

1.5 The specific procedures employed in the laboratory examinations depend on the kind of rock, its characteristics, mineral components, macro and micro structure, and perhaps most importantly, the intended use, size of the pieces, and the exposure conditions at the site of use (**1**, **2**, **3**, **4**).

1.6 It is assumed that this practice will be used by personnel who are qualified by education and experience to plan the necessary evaluations and to conduct them so that the necessary parameters of the subject rock will be defined. Therefore, this practice does not attempt to detail the laboratory techniques required, but rather to mention them and only detail those properties that are of special concern in the course of the examination for rock to be used for erosion control.

1.7 *Units*—The values stated in SI units are to be regarded as standard. The inch-pound units given in parentheses are provided for information only.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—Erosion stone pieces can weigh from several hundred pounds to several tons. Exercise caution at all times as the mass of each piece represents a potential pinch point and a lifting, handling, and carrying hazard.

1.9 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.17 on Rock for Erosion Control.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

*A Summary of Changes section appears at the end of this standard

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C294 Descriptive Nomenclature for Constituents of Concrete Aggregates
C295/C295M Guide for Petrographic Examination of Aggregates for Concrete
C535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D3042 Test Method for Insoluble Residue in Carbonate Aggregates
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D3967 Test Method for Splitting Tensile Strength of Intact Rock Core Specimens
D5121 Practice for Preparation of Rock Slabs for Durability Testing
D5240/D5240M Test Method for Evaluation of the Durability of Rock for Erosion Control Using Sodium Sulfate or Magnesium Sulfate
D5312/D5312M Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions
D5313/D5313M Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions
D6473 Test Method for Specific Gravity and Absorption of Rock for Erosion Control
D8281/D8281M Test Method for Determining the Presence of Expanding Clays in Rock for Erosion Control Using Ethylene Glycol

3. Terminology

3.1 *Definitions*—For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *shot rock, n*—(synonym for quarry run); unprocessed stone produced from a source primarily by blasting. The term does not indicate stone size or gradation.

3.2.2 *shard, n*—a small piece of stone broken off from erosion stone , typically as the result of handling and stockpiling operations.

3.2.2.1 *Discussion*—Some erosion stone specifications define shards as broken pieces weighing less than two pounds.

4. Significance and Use

4.1 The field examination, sampling, and petrographic examination in this practice along with appropriate laboratory testing may be used to determine the suitability of rock for erosion control. Factors to consider include identification and delineation of areas or zones of the rock, beds, and facies of unsuitable or marginal composition and properties due to weathering, alteration, structural weaknesses, porosity, and other potentially deleterious characteristics.

4.2 Evaluate both the rock mass properties and the rock material properties.

4.2.1 The rock mass properties are the lithologic properties of the in situ rock that are evaluated on a macroscopic scale in the field. These properties include features such as fractures, joints, faults, bedding, schistosity, and lineations, as well as the lateral and vertical extent of the rock unit.

4.2.2 The rock material properties are those lithologic properties that may be evaluated using small specimens and thus can be subject to meaningful laboratory testing. These properties would include mineral composition, grain size, rock hardness, degree of weathering, porosity, unit weight, and many others.

4.3 Rock proposed for use in erosion control applications are normally classified as either filter bedding stone, riprap stone, armor stone, or breakwater stone. However, these procedures may be also extended to rocks used in groin and gabion structures.

4.4 In cases in which only stockpile samples are to be obtained for laboratory testing, a full quarry geological examination may not be required. It is the responsibility of the specifier of this standard to indicate which sections of this Practice apply to the specific project.

NOTE 2—The quality of the result produced by this standard is dependent upon the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluation some of those factors.

5. Planning

5.1 Plan and schedule the field examination and subsequent laboratory examination including a review of available information about the source rock and the purpose for which it is intended. State geological surveys, geological divisions of state transportation departments, and geology/environmental departments of universities near the source to be examined are generally good sources of information. Consult local engineering geologists to gain collateral information that might be useful in examining the source site and any project installations, and in the planning of the laboratory test requirements.

5.2 This review may provide the name of the rock unit and key to lithologic descriptions, previous examinations, and structural and compositional characteristics affecting the rock in its intended use, as well as test data. The information may further assist in planning the examinations and alternatives to problems such as vertical quarry faces.

6. Materials and Equipment for Examinations

6.1 Equipment for the field examination will be at the investigator's discretion. A checklist of equipment may include, but not be limited to, the following:

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6.1.1 *Geologists's Pick or Hammer.*
6.1.2 *Hand Lens.*
6.1.3 *Sledge Hammer.*
6.1.4 *Bottle of Dilute Hydrochloric Acid (3 parts water, 1 part HCl).*
6.1.5 *Tape or Scale.*
6.1.6 *Rock Scratching Tool, Knife, or Dissecting Needle.*
6.1.7 *Brunton Compass.*
6.1.8 *Photographic or Video Camera.*
6.1.9 *Note Book.*
6.1.10 *Sample Bags.*
6.1.11 *Indelible Marking Pens, Paint, or Spray Paint.*

6.2 *Apparatus and Supplies for Petrographic Examination:*

6.2.1 The apparatus and supplies listed for petrographic examination in Practice C295/C295M are those required for this standard practice. Use larger equipment for handling larger size pieces as outlined below.

6.2.1.1 *Circular Diamond Saw,* of the type described in Practice D5121.

NOTE 3—Some laboratories have fabricated reciprocating saws that cut with diamond powder in a slurry. Such saws can be made capable of cutting almost any size rock specimen.

6.2.1.2 *Horizontal Grinding Wheel,* minimum of 400 mm (16 in.) diameter.

6.2.1.3 *Polishing Wheel,* minimum of 400 mm (16 in.) diameter.

NOTE 4—When the first saw cut is smooth, as when fabricated with a smooth edged circular diamond saw running in an oil bath, vibrating laps may be substituted for the horizontal grinding wheel and the polishing lap. These laps may be obtained in sizes up to 675 mm (27 in.) in diameter. These large vibratory laps will be a useful addition and will completely substitute for the polishing lap.

6.2.1.4 *Stereoscopic Microscope*—A stereoscopic microscope that provides final magnifications that range from 10× to approximately 80× is recommended. It is preferable that the microscope be equipped with an imaging system to enable the operator to photograph salient features for inclusion in a report or for retention for future reference.

6.2.1.5 *Petrographic Microscope,* as described in Practice C295/C295M. Optionally, for the detection of very small microcracks, it may be equipped with incident ultraviolet light for use with thin sections impregnated with a fluorescing dye (**7**).

NOTE 5—Special types of thin sections will probably require additional preparation equipment. An example is given in Ref (7).

6.3 *Thin Section Fabrication:*

6.3.1 Laboratories may find that they can obtain good, rapid, individualized service from a geological laboratory that specializes in the fabrication of thin sections. Choose such a laboratory considering the following:

6.3.1.1 Time between sending off the rock fragments or prepared chips and return of the finished sections.

6.3.1.2 Will adjacent rock fragments or slices be returned for further examination or archival use, or both?

6.3.1.3 Costs involved.

6.3.1.4 Charges and any extra time required for specially prepared sections: special large size, epoxy impregnated, impregnated with special dyes, and thin sections thinned to less than the standard 30 µm (10 to 15 µm required for fine grained rock and for detection of fine microcracking, certain deleterious textures and substances).

6.3.1.5 Workload.

6.3.1.6 Quality of work.

6.3.2 As the knowledge of the rock material accumulates through examination of finely lapped slabs and hand specimens, and from the results of laboratory testing, it will invariably be found that the first estimate of the proper number, location of "chips" and types of thin sections requires amending.

6.4 *Photographic or Video Facilities, or Both, Capable of Producing the Following:*

6.4.1 Images of quarries and other rock sources, in use placements of rock and natural outcrops of rocks under the proposed conditions of exposure,

6.4.2 Close-up images of rock specimens, cores, chunks, and slabs,

6.4.3 Images taken through the stereoscopic microscope (easily usable equipment can be obtained from the microscope manufacturer), and

6.4.4 Images taken through the petrographic microscope (easily usable equipment can be obtained from the microscope manufacturer).

7. Field Examination

7.1 The field examination is an integral part of the total evaluation of the rock for its use in erosion control projects. The geologic scientist conducting the field examination must have knowledge of the intended use of the rock and of the size pieces that will be required and the environment to which the rock will be subjected. The scientist must also be familiar with the laboratory tests that are most apt to be conducted in order that appropriate samples may be obtained.

7.2 During the field examination determine the following:

7.2.1 The type of quarry and its development plan. The blasting procedures that are or will be employed. Note blasting hole diameter, hole depth, spacing, angle, amount of overburden, types of explosives, distribution, and sequences. The expected 'curing time,' the interval between blasting or other removal from the bedrock, and the size sorting and final inspection and evaluation for use in the intended placement (**1, 2, 3, 4, 8, 9, 10**).

7.2.2 The general lithology and, if possible, geologic unit and age.

7.2.3 Homogeneity throughout the proposed source. In particular note the stratigraphic facies, metamorphic and weathering phases, and lateral extent of each.

7.2.4 Record dip and strike of the bedding, lineation, or both, as well as the dip and strike of any structural features, zones of brecciation, partings, solution features, schistosity, foliation, diastrophic joints, faults, folds, dikes, veins, and etc. Record any joints due to overburden-relief.

7.2.5 The thickness of the bedding, and the presence and distance between any poorly indurated beds or facies. Record the distance between any regular zones of weakness such as joints, weakly filled veins, etc., as this will be a major control of the size fragments available.

7.2.6 Make notations of any fragments of the rock that have been exposed to weather for a long period of time. If these are not available at the proposed site of rock removal, make an effort to find such weathered examples of this rock at other sites.

7.2.7 Investigate any examples of this rock in use in a manner similar to the proposed use for evidence of durability. In conjunction with this examination, examine natural occurrences of this rock at sites similar to the proposed use; for example, a natural outcrop on a river bank, or even better, an outcrop as a local base-level at the rapids of a stream.

7.3 Record observations made during the field examination in writing using standard nomenclature (**8**, **9**, **11**), in a designated field notebook in a manner that will allow future reference.

7.4 Document by use of photographs or videos, or both.

8. Sampling

8.1 This practice provides guidance on sampling a source of rock.

8.2 Design the sampling plan and labeling plan to identify the location from which the sample was derived, the stratigraphic unit or facies, and the orientation; for example, up versus down, east versus west, north versus south. Identify cores in a manner that will allow sequential matching of the pieces.

8.3 Whenever practical, include pieces of the size that will be required for the final placement of the rock, or, select smaller pieces of the largest practical dimensions, that contain features of similar interest, if large pieces are not practical to obtain, or are not manageable by the laboratory.

8.4 Determine the number of samples and the number of pieces of rock in each sample and the specimens taken for archival use upon the nature of the rock, the amount of material required for the erosion prevention placement, and the variability of the rock within the mass proposed for use.

8.5 Obtain samples for testing that are representative of the rock to be used on a project.

8.6 Select samples of such dimensions as to minimize mechanical reduction (breaking) of the specimen prior to testing, with the exception of specimens that are sawed prior to examination or testing. The latter specimens may be taken from oversize specimens.

8.7 Samples may be obtained from a quarry face, shot rock, or stockpile. Compare samples of shot or stockpiled rock to stratigraphic units visible on a quarry face. Soft or fractured stratigraphic units which are reduced to small sizes during blasting and end up as detritus (shards) will not need to be sampled. These units will not be included in a stockpile or in rock loaded for delivery to a project. The finished product is the preferred source of the samples.

9. Preparation of Specimens for Laboratory Examination

9.1 The details of the specimen preparation are left to the discretion of the geological scientists and engineers involved, and to preparation required by the selected laboratory methods. Many laboratory tests such as freeze-thaw, wet-dry, and others require special specimen preparation. Partition test specimens based upon the number of specialized tests required. In the general case, the petrographic procedures require the least mass, but the most careful selection; therefore these specimens are often selected first.

9.2 Valuable data can be gained by careful observation of the bulk samples specimens as received in the laboratory. Spot tests with acid and dyes will often indicate general composition. The fine structure of a specimen can often be made visible by smoothing and etching, or staining, or combinations thereof, one large surface. These methods often indicate which further test procedures should be used on which specimen pieces and therefore which preparation methods are required.

9.3 *Sample Preparation for Petrographic Examination*—The minimum requirements of specimen preparation for petrographic methods include:

9.3.1 The preparation of a finely lapped slab of as large a size as possible from each of the lithologies and qualities of that lithology that are being considered for use as erosion control rock. Maintain vibratory laps and abrasives in a clean and contamination free condition.

9.3.2 The preparation of "chips," shaped blanks for thin sections. If thin sections are fabricated by an outside laboratory, prepare at least two "chips" per lithology and quality. If time is a factor, send these chips to the fabricating laboratory immediately. If thin sections are fabricated in house, prepare and reserve one such "chip." When desired, another "chip" can be prepared from specially selected areas of the back side of the slab or from hand samples. The petrographer may request that the second thin section be prepared in a special manner.

9.3.3 The observation of "hand" specimens, fist-sized chunks of the rock, representative of each lithology, facies, phase, and quality of the entire mass of rock being considered for use in an erosion control project is recommended.

10. Petrographic Examination

NOTE 6—No attempt is made to detail the procedures to be used in the petrographic examinations. The decisions concerning methods and the various specimen preparations are left to the discretion of the petrographer, taking into account the nature of the rock and the purposes for which it is intended. It is usually best if the exact plan of examination develops as information concerning the nature of the samples is collected and correlated. The examinations often employ acids, stains, and spot chemical tests. Items to be reported on include but are not limited to the subjects listed within this section.

10.1 *Stereomicroscopic Examination*—Examine hand specimens and the finely lapped slabs, surfaces of core specimens, etc. for features affecting durability. The examination with the stereomicroscope will often include the selection or preparation of materials, or both, (grain-mount, thin-section, etc.) for study with the higher powered microscopes.

10.1.1 Preliminary identification of mineral composition and petrographic name of the rock as in Descriptive Nomenclature C294.

10.1.2 Major and minor cracks and crack patterns.

10.1.3 General quality including degree and kind of weathering, induration or cementation, or a combination thereof.

10.1.4 The presence of any zones of weaknesses, clay seams or partings, veins, stylolites, void structures, or micro breccias.

10.1.5 Directional and diastrophic features such as bedding, foliation, schistosity, lineation (gneissic or otherwise), micro-folding, flow structures, and micro-cracking.

10.1.6 Vugs (mineral filled or open), large pores, nodules, concretions, etc.

10.2 *Petrographic Microscope Examination*—Perform examinations with the petrographic (polarizing) microscope, at the discretion of the petrographer, including the study of grain amounts, thin-sections (may be etched or dyed, or both), and small polished sections. The study with the petrographic microscope will generally give more detailed information concerning the same features discussed in 10.1. In addition, it will be possible to study the microtexture or fabric and the degree of interlock of the crystals or sedimentary particles. If desired, a point-count or Wentworth (Chayes) count may be made to determine the relative percentages of the major minerals; this may result in a more classical identification of the rock type than can be determined otherwise.

10.3 Ethylene glycol (**12**) used as a supplementary method for igneous rocks containing smectite to give advance notice of subsequent deterioration. Test Method D8281/D8281M presents a qualitative and quantitative method to determine the presence of expanding clays using ethylene glycol.

10.4 The Methylene Blue Absorption (MBA) test is used to detect smectite (**13**). This procedure is especially applicable where only small amounts of joint or crack filling are available as the test requires only a 2-g sample.

11. Laboratory Tests

11.1 Engineers, geologists, and others involved in the evaluation of rock durability for erosion control applications generally divide the laboratory durability tests into those that simulate accelerated weathering and those that measure physical properties.

11.2 Accelerated weathering tests available that aid in the evaluation of rock durability generally include wet-dry, freeze-thaw, sodium sulfate soundness, and magnesium sulfate soundness. Currently there is no consensus opinion as to which test or tests best represents the actual field performance (**14**). The choice as to which one(s) to run is generally based on experience, the particular use of the rock, and its required design life. The intent of this practice is not to prioritize or favor any test, but to provide a short description with a reference for those who wish additional details.

11.2.1 *Wet-Dry*—This accelerated weathering test is designed to simulate summer-time conditions of alternating rainfall and subsequent drying by the summer sun. It also simulates the rise and fall of tidal movements and water levels in reservoirs, lakes, rivers, etc. Specimens are alternately soaked in water and heated for a specified number of cycles. Specimens are prepared according to Practice D5121 and the procedure is specified in Test Method D5313/D5313M (**4, 14, 15**).

11.2.2 *Freeze-Thaw* (**4, 15, 16**)—This test simulates the type of exposure to which the rock specimens would be subjected under winter-time conditions. Specimens are soaked in an alcohol-water solution followed by alternating cycles of freezing and thawing for a varying number of cycles. Specimens are prepared according to Practice D5121 and the procedure is specified in Test Method D5312/D5312M.

11.2.3 *Freeze-Thaw*—Another test method uses 73 mm (2⅞ in.) cubes that are subjected to 250 cycles of 1½ to 3 h exposure at freezing temperatures of −12.2°C (10°F) and thawing temperatures of 21.2°C (70°F). Termination of the test is 250 cycles or when a 25 % loss of rock mass is attained (**17**).

11.2.4 *Sodium or Magnesium Sulfate Soundness Test*—This test is an indirect attempt to simulate the expansion of water on freezing. Rock slab specimens, sawn from intact pieces, are subjected to alternating cycles of immersion in saturated solutions of sodium or magnesium sulfate followed by oven drying. Specimens are prepared according to Practice D5121 and the soundness testing procedure is described in Test Method D5240/D5240M.

11.3 Physical property tests available that aid in evaluating rock durability include bulk specific gravity, absorption, Los Angeles Abrasion test, and the splitting strength tensile test.

11.3.1 *Bulk Specific Gravity Test* determines the bulk specific gravityof the rock which is an indicator of rock quality and a consideration in determining the resistance of a rock to movement by wave action or flowing water (**4**). Specimens are prepared according to Practice D5121 and the procedure is described in Test Method D6473.

11.3.2 *Absorption Test*—This test is an indicator of the amount of moisture that is absorbed by the rock. It is also an indicator of the porosity of a given rock; however, it is not an indicator of susceptibility to freeze-thaw action. Pore size is more important in evaluating freeze-thaw durability than percent absorption. Specimens are prepared according to Practice D5121 and the procedure is described in Test Method D6473.

11.3.3 *Large-Size Coarse Aggregate Los Angeles Abrasion Test*—This test is used as an indicator of the wearing resistance of rock and is normally used only when petrographic examination indicates a potential problem regarding the softness or lack of abrasion resistance. The procedure is described in Test Method C535 except for the size of the test specimens. Use Grading 1 in Table 1 of Test Method C535 when abrasion testing is performed.

NOTE 7—Sources of abrasion that cause breakage and other deterioration of erosion stone include handling, stockpiling, transporting, and placing, of the stone.

NOTE 8—Perform the Los Angeles Abrasion test on the largest size grading stated in Test Method C535.

11.3.4 *Splitting Tensile Strength Test* (**18**)—This test determines the tensile strength of disk-like rock core while the disk is undergoing diametral compression. It is useful for the approximate tensile stress needed to fracture the rock and in determining the velocity of the shock wave required to