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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 D 4992; 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.

ϵ^1 NOTE—Paragraph 1.9 was added editorially October 1998.

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. The intensity and number of evaluations made on any one project must be determined by the designer.

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)**.[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; thus great care must be taken 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 **(1)**.

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 **(3)**.

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 must be of special concern in the course of the examination for rock to be used for erosion control.

1.7 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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. Nat 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 88 Test Methods for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate[3]

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[3]

C 294 Descriptive Nomenclature of Constituents of Natural Mineral Aggregates[3]

C 295 Practice for Petrographic Examination of Aggregates for Concrete[3]

C 535 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine[3]

[1] This practice is under the jurisdiction of ASTM Committee D-18 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.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

D 653 Terminology Related to Soil, Rock, and Contained Fluids[4]
D 3967 Test Method for Splitting Tensile Strength of Intact Rock Core Specimens[4]
D 5121 Practice for Preparation of Rock Slabs for Durability Testing[5]
D 5240 Test Method for Testing Rock Slabs to Evaluate Soundness of Riprap by Use of Sodium Sulfate or Magnesium Sulfate[4]
D 5312 Test Method for Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions[5]
D 5313 Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *rock mass properties*—lithologic properties of rock and its discontinuities that must be evaluated on a macroscopic scale in the field.

3.1.2 *rock material properties*—lithologic properties of rock that can be evaluated using an in-hand sample either in the field or in the laboratory.

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

3.1.4 For other definitions of terms relating to this practice, refer to Terminology D 653.

4. Significance and Use

4.1 The field examination and petrographic examination in this practice along with appropriate laboratory testing may be used to determine the suitability of rock for erosion control. It should identify and delineate 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 Both the rock mass properties and the rock material properties must be evaluated.

4.2.1 The rock mass properties are the lithologic properties of the in situ rock that must be evaluated on a macroscopic scale in the field. These would 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 will normally be 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.

5. Planning

5.1 A plan and schedule of the field examination and subsequent laboratory examination should include a review of all 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. Any local engineering geologists should also be consulted, to gain all 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:

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 *Camera*.

6.1.9 *Note Book*.

6.1.10 *Sample Bags*.

6.1.11 *Marking Pens or Spray Paint*.

6.2 *Apparatus and Supplies for Petrographic Examination*:

6.2.1 The apparatus and supplies listed for petrographic examination in Practice C 295 will be those required for this standard practice except that some of the equipment for handling the large pieces of rock should be of larger size as outlined below.

6.2.1.1 *Rock Cutting Saw*, diamond edged blade at least 600 mm (24 in.) in diameter.

NOTE 1—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 2—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. Considerable effort must be expended to keep vibratory laps clean and the abrasives free of contamination.

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[4] *Annual Book of ASTM Standards*, Vol 04.08.
[5] *Annual Book of ASTM Standards*, Vol 04.09.

6.2.1.4 *Stereoscopic Microscope*—The stereoscopic microscope shall have a zoom lens from 10 to 120×. The microscope shall be mounted on an arm that can swing over the specimen or alternatively have a specially constructed stage of large size to facilitate the handling of the large specimen slabs that will be required.

6.2.1.5 *Petrographic Microscope*, shall be as described in Practice C 295. 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 **(4)**.

NOTE 3—Special types of thin sections will probably require additional preparation equipment. An example is given in Ref **(4)**.

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. When choosing such a laboratory, considerations should include 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 Laboratories should consider obtaining their own thin-section equipment whenever workload, space, and financial considerations permit if experienced personnel are available or obtainable to fabricate the sections. In-house equipment allows for much greater versatility of operation. 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 Facilities Should Be Capable of Producing the Following*:

6.4.1 Photographs 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 photographs of rock specimens, cores, chunks, and slabs,

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

6.4.4 Photographs 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, 5, 6, 7)**.

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 Dip and strike of the bedding, lineation, or both, should be noted 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. Any joints due to overburden-relief must be recorded.

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

7.2.6 Special note shall be taken 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, an effort shall be made to find such weathered examples of this rock at other sites.

7.2.7 Any examples of this rock in use in a manner similar to the proposed use shall be investigated for evidence of durability. In conjunction with this examination, natural occurrences of this rock at sites similar to the proposed use shall be sought and examined; 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 Observations made during the field examination shall be recorded in writing using standard nomenclature **(5, 6, 8)**, in a designated field notebook in a manner that will allow future reference.

7.4 Photographs shall be taken.

8. Sampling

8.1 The sampling plan and labeling plan shall be designed 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. Cores shall be identified in a manner that will allow sequential matching of the pieces.

8.2 The samples, whenever practical, should include pieces of the size that will be required for the final placement of the rock.

8.3 The number of samples and the number of pieces of rock in each sample and the specimens taken for archival use shall be completely dependent 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.

8.4 The samples chosen for testing shall be representative of the rock to be used on a project.

8.5 Samples shall be 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.

8.6 Samples may be obtained from a quarry face, shot rock, or stockpile. Samples of shot or stockpiled rock should be compared 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 waste 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 must be left to the discretion of the geological scientists and engineers involved. Many laboratory tests such as freeze-thaw, wet-dry, and others require special specimen preparation. The greater the number of specialized tests, the more careful the partitioning of the amount of specimen available must be. 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 combination thereof, one large surface. These methods will often indicate which further test procedures should be used on which specimen pieces and therefore which preparation methods will be 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.

9.3.2 The preparation of “chips,” shaped blanks for thin sections. If thin sections are fabricated by an outside laboratory there shall be at least two “chips” per lithology and quality. If time is a factor these chips shall be sent to the fabricating laboratory immediately. If thin sections are fabricated in house, one such “chip” shall be prepared and reserved. 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 wish 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 4—No attempt is made to detail the procedures to be used in the petrographic examinations. The decisions concerning methods and the various specimen preparations must be at the best judgment 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*—The hand specimens and the finely lapped slabs, the surfaces of core specimens, etc. should all be examined 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 C 294.

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), microfolding, flow structures, and micro-cracking.

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

10.2 *Petrographic Microscope Examination*—The examination with the petrographic (polarizing) microscope shall, at the discretion of the petrographer, involve 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 **(9)** may be used as a supplementary method for igneous rocks containing smectite and will give advance notice of subsequent deterioration. If used, rock specimens should be greater than 2.5 cm (smallest dimension) and should be soaked in ethylene glycol for at least 15 days before reaction to cracking, disintegration, etc., is evaluated and recorded.

10.4 The Methylene Blue Absorption (MBA) test may also be used to detect smectite **(10)**. 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 may 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 **(11)**. 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 guide 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. The procedure is specified in Test Method D 5313 **(1, 11, 12)**.

11.2.2 *Freeze-Thaw* **(1, 12, 13)**—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. The procedure is specified in Test Method D 5312.

11.2.3 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 **(16)**.

11.2.4 *Sodium or Magnesium Sulfate Soundness*—This test is an indirect attempt to simulate the expansion of water on freezing. Rock specimens 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 and the soundness testing procedure is described in Test Method D 5240.

11.3 Physical property tests available that may help 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*—This test reflects the quality of rock and is important in that it is one of the indicators of the resistance of a rock to wave action **(1)**. The test is run similar to that in Test Method C 127 except for the size of the test specimens.

11.3.2 *Absorption*—This test provides an indicator of the amount of moisture 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. Again, a test procedure similar to Test Method C 127 except for the size of the test specimens has been used.

11.3.3 *Los Angeles Abrasion*—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 test procedure is similar to Test Method C 535 except for the size of the test specimens.

11.3.4 *Splitting Tensile Strength Test* **(14)**—This test determines the tensile strength of disk-like rock core while the disk is undergoing diametral compression. It may be useful for the approximate tensile stress needed to fracture the rock and in determining the velocity of the shock wave required to fragment the rock. Thus, it can be used indirectly to determine what explosive or blasting agent to employ. Also see Test Method D 3967.

11.3.5 *Insoluble residue test*—This test is useful in determining the percent of quartz, clay, or other non-carbonate minerals in a limestone or dolomite. The rock is dissolved in hydrochloric acid and the percent residue is weighed and determined as a percent of the total rock. Carbonate rocks containing large amounts of clay have been shown to be nondurable **(15).**

12. Report

12.1 The report of the field investigations, petrographic examinations, and laboratory tests should summarize the essential data needed to identify the sample as to source and proposed use. It should include a description giving the essential data on composition and properties of the material as revealed by the evaluation program. The report should reference examination procedures and any test procedures employed and give a description of the nature and features of each important constituent of the sample accompanied by such tables and photographs as may be required.

12.2 In descriptions of the lateral and vertical extent or volume of acceptable rock at the source, there should be a statement as to whether or not there is sufficient acceptable rock at the source to complete the work for which it is intended.

12.3 When the rock has been found to possess properties or constituents that are known to have specific unfavorable effects in the rock, those properties or constituents should be described qualitatively and, to the extent practicable, quantitatively. The unfavorable effects that may be expected to ensue in the rock should be mentioned. This includes any performance data of suspect rocks or minerals. When appropriate, it should be stated that a given sample was not found to contain any undesirable features. When such is the case it may also be appropriate, especially if the report is not accompanied by reports of results of physical and chemical tests for which numerical limits may be applicable, to add that the material appears acceptable for use provided the applicable acceptance tests are made and the results are within the appropriate limits. The report should not, however, contain conclusions other than those based upon the findings of the examination unless the additional data to support such conclusions are included in or with the report.

12.4 The report should include recommendations regarding any additional petrographic, chemical, physical, or geological investigations that may be required to evaluate adverse properties that are indicated by the field, laboratory, and petrographic examinations that have been performed. Supplementary petrographic investigations might include qualitative or quantitative analysis of the rock or of selected portions thereof by X-ray diffraction, differential thermal methods, or other procedures that are directed to identification and description of the constituents of the rock.

13. Precision and Bias

13.1 The practice provides information for evaluating the estimated performance of rock for erosion control based on qualitative and quantitative investigations. Since the final decision involves both judgment and experience, no applicable statement on precision and bias is possible or warranted.

14. Keywords

14.1 armor stone; breakwater stone: erosion control; laboratory testing; petrographic analysis; riprap; rock; rock durability; rock mass properties; rock material properties

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