VERMONT
VTrans

Materials & Research Engineering Instructions **MREI 12-01**

Distribution: Structures, Director PDD, Assistant Director PDD, PDD Section Managers, Chief of Contract Admin., Director Ops., Assistant Director Ops., Consultants.

Approved: ______________________ **Date:** 12-27-2012

for William E. Ahearn, Materials and Research Engineer

Subject: Geotechnical Guidelines to Standardize VTrans' Sample Handling, Testing and Data Reporting Procedures

Administrative Information:

Effective Date: This Materials & Research Engineering Instruction (MREI) shall be considered effective from the date of approval.

Superseded MREI: None

Disposition of MREI Content: The content of this MREI will be incorporated into a future VTrans Soils & Foundations Engineering Manual.

1. PURPOSE:

The purpose of this MREI is to standardize Geotechnical sample handling, testing and data reporting procedures performed at the Vermont Agency of Transportation, Materials & Research Laboratory.

2. TECHNICAL INFORMATION:

In general, guidance outlined in Sections 9.0 and 10.0 of AASHTO Manual of Subsurface Investigations, 1988 and Section 4.12.2 of FHWA's Geotechnical Engineering Circular No. 5, *GEC No. 5* shall be followed. Any specific guidance presented in this MREI that differs from these references shall take precedence.

3. OVERVIEW:

Handling of geotechnical samples from field to laboratory can be critical to the integrity of the material to be tested. Proper handling methods are addressed to assure the material to be tested yields meaningful and representative data. The means of identifying and tracking materials to be tested are identified allowing for a traceable record for each sample. Once at the laboratory and entered into the laboratory sample tracking system, individual tests are performed and testing results are then reported and used in design. Once the sample material has been tested and reported, the disposition of any remaining material must be determined. Disposition may require holding on to the material for a period of time or specific disposal options.

4. DEVELOPING THE TESTING PROGRAM:

Upon receipt of the Geotechnical Services Request Form, the VTrans Soils and Foundations Engineer will assign the project to an in-house Engineer, Geologist or Geotechnical consulting firm. The lead Engineer, Geologist or Consultant will develop a sampling plan as part of the Field Work Order based upon the geotechnical parameters needed for design. Following field sampling, the Engineer will identify the various soil and rock types to be tested, which tests are necessary, and any other guidance related to the handling and testing of the samples. Guidance on choosing the most appropriate test to be performed for the type of investigation requested is contained in the following guidance documents:

AASHTO Manual of Subsurface Investigations, 1988
NHI Soils & Foundations Reference Manual No. 132012 Volumes 1 and 2
FHWA Geotechnical Engineering Circular No. 5

The amount of laboratory testing required for a project will vary depending on availability of preexisting data, the character of the soils and the requirements of the project. Laboratory tests should be selected to provide the desired and necessary data as economically as possible. Laboratory testing should be performed on both representative and critical test specimens obtained from geologic layers across the site. Critical areas correspond to locations where the results of the laboratory tests could result in a significant change in the proposed design. In general, a few carefully conducted tests on samples selected to cover the range of soil properties with the results correlated by classification and index tests is the most efficient use of resources. The following should be considered when developing a testing program:

- Project type (bridge, embankment, rehabilitation, buildings, etc.)
- Size of the project
- Loads to be imposed on the foundation soils
- Types of loads (i.e., static, dynamic, etc.)
- Whether long-term conditions or short-term conditions are in view
- Critical tolerances for the project (e.g., settlement limitations)

• Vertical and horizontal variations in the soil profile as determined from boring logs and visual identification of soil types in the laboratory
• Known or suspected peculiarities of soils at the project location (i.e., swelling soils, collapsible soils, organics, etc.)
• Presence of visually observed intrusions, slickensides, fissures, concretions, etc in sample – how will it affect results
• Project schedules and budgets

Soil samples collected from most VTrans projects undergo testing necessary to classify the soils according to AASHTO M 145 (Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes). The index tests performed consist of AASHTO T 265 (Moisture Content of Soils) and AASHTO T 88 (Particle Size Analysis of Soils). If soils appear to have some clay content, further tests such as AASHTO T 89 (Liquid Limit of Soils) and AASHTO T 90 (Plastic Limit and Plasticity Index) are performed.

VTrans has developed a VTrans Geotechnical Laboratory Test Request Form to be used for requesting specific tests. This form shall be used internally to request testing other than the standard series of index tests typically performed at the lab and for all testing requested by outside entities.

It is important that soil and rock samples used for design are not averaged across multiple strata (samples with differing properties should not be commingled). Therefore, when there is a significant change in strata, the retrieved sample should be segregated into two separate lab samples for testing.

5. SAMPLE HANDLING:

All samples shall be collected using care to preserve sample integrity. Care should be used to avoid subjecting the sample to conditions which might alter the properties of the material such as impact, vibration, freezing, excessive heating or contamination. Improperly handled samples can lead to poor test data that does not reflect actual geotechnical conditions.

Auger & Split-barrel samples should be collected and stored in air tight plastic bags (we use 10"X14", 4 mil plastic bags with twist ties. Zip lock bags are unacceptable). The intent is to transport samples in durable bags that are as water tight as possible to maintain in-situ moisture content. A sufficient amount of sample should be collected to meet sample size testing requirements in the lab (each AASHTO and ASTM test method contains guidance on the amount of sample necessary to perform the test). In practice, sample size is usually dictated by the method of sampling and the actual sample recovery. For SPT samples, sample size depends upon SPT recovery. Although there may not be enough for testing, it is helpful for the engineer to see what was recovered. In the case of sampling off of the auger flights, for most soils one full bag (allowing for tightly closing the top of the bag) would surf ice. If the material is boney (contains a lot of large size particles) two bags may be necessary. It should point out that if there is a change in lithology within the sampling interval, each material needs to be collected in separate bags.

Typically, more than one test is performed per sample. If there is not enough sample to perform the requested tests, the soils technician will notify the geotechnical project engineer for direction on which tests to perform.

Samples should be transported to the Soils laboratory before changes in sample qualities can occur but no more than 4 days after sampling. . A sample tag must be attached to the outside of any sample to be tested. The sampling tag must indicate the tests requested and if necessary, a Laboratory Test Request Form should be filled out and submitted to the soils technician.

Rock cores should be stored in sturdy wooden core boxes. Boxes should be provided with hinged lids, with the hinges on the upper side of the box and a latch to secure the lid in a closed position. Cores should be placed in the boxes from upper left to right bottom. When the upper compartment of the box is filled, the next lower compartment (and so on until the box is filled) should be filled, beginning in each case at the left-hand end. The boring number and run number should be written on the box at the box edge immediately above the rock core runs. A rock core tag should be filled out and affixed to the inside of the core box cover in the order which the cores were loaded into the box. Spacers should be placed in the core box to immobilize the core and to keep the core in the correct position. Specific requirements can be found in Appendix A.

Cores should be handled carefully during transfer from barrel to box. Cores should freely come out of the core barrel tube. Excessive hammering of the core barrel for core extraction should be avoided. Deliberate breaking of core runs is allowed in order to fit the core into the core box. Intentional breaks for this purpose should be clearly marked. These locations shall be marked on the core. The filled rock core box should be handled with care not to cause unnecessary breakage of the cores.

6. SAMPLE DELIVERY:

When the soils technician receives the samples, he/she will assign a unique laboratory ID number and log each sample in a log book for proof of delivery, tracking and future use. All soils laboratory numbers are prefaced by the letter "E", followed by a two digit number representing the year the sample was received followed by a three digit number representing the sequential order in which samples were received for that particular year. As an example, sample E110202 signifies the 202nd sample received during the year 2011. The sample tag stays with its sample during all testing procedures until testing for that sample is complete. Upon testing completion, sample tags are filed at the Materials & Research laboratory and kept for seven years.

Split-barrel samples should be delivered in sealed durable plastic bags (See Section 5.0) with each sample having a sample card attached to the outside of the sample bag. Arrangements for sample delivery shall be coordinated with the Soils Lab Technician. If there are any special instructions, the soils technician should be notified prior to logging the samples in. Samples that are sent by mail delivery need extra care so that moisture doesn't leak out and sample tags stay attached and dry. This can be accomplished by placing sealed sample bags upright in clean plastic containers with secure lids similar to 5-gallon spackle buckets although any size container could be used depending upon the volume of samples shipped. Samples should not be sent in cardboard or paper packages.

Shelby Tube samples shall be properly sealed and transported to the lab within 3 days of sampling in an upright position and protected from vibration, shock, and extreme temperatures. As noted in FHWA Geotechnical Engineering Circular No. 5, the goal of high-quality undisturbed sampling is to minimize the potential for alteration of the soil structure, changes in moisture content or void ratio and changes in chemical composition of the soil. Tube samples shall have a sample tag that is inserted in a sealed plastic bag and attached to the side of the tube showing all the information that is required for that Shelby tube. The tube shall be delivered directly to the soils technician. In the event that the technician is not available, samples shall be delivered to the laboratory supervisor or the Soils and Foundations Engineer.

Grab samples shall be placed in large air tight plastic bags to prevent moisture loss and leakage of fine material from the bag. If the moisture content of the soil sample is not required, and the sample is in a dry condition, the sample can be transported in a cloth bag.

Samples with a damaged container will be examined by the soils technician and then a determination of what tests, if any, should be performed for that sample. The soil report will note in the comments about the damage and the decision made for this soil sample.

Rock core boxes should be delivered to the Materials & Research laboratory. The VTrans geotechnical soil lab will label the ends of the boxes with a unique number identifying the year, the project sequence during the year and the box number for that project (as an example, core box number 11-06-03 would indicate the cores were taken in the year 2011 and it was the sixth project drilled during the year and the third core box for that project). An Excel spreadsheet is kept in the Soils & Foundations G: drive folder that lists the core box number, Project Name and Number, Project Coordinates, Boring Number and Run Numbers, Project Status, Date Drilled, Date Project Constructed, Core Size, Disposition Status and Project Manager. This spreadsheet is updated after each core box is logged and periodically referenced to facilitate disposition.

7. SAMPLE PREPARATION AND TRACKING:

Soil Samples

Upon receipt and logging of samples, the soils technician will prepare test specimens according to procedures appropriate for the tests to be performed. These preparation procedures can be dry, wet or chemical preparation techniques.

The technician will organize samples according to boring number and sample interval. (B-101, B-102, B-103, etc.) Each group of samples are placed in order by the depths that they were collected for that boring hole. (B-103: (0' to 2', 2'to 4', etc.). Samples are then logged in by stamping each sample card with a Materials & Research sample log number. These log numbers are entered into a log book. An example of a log book entry is shown below:

Lab Numbers	Date Received	Quant.	Project	Hole #	Start Depth	End Depth	Sample Type	Date Sampled	Driller
E11202 – E11207	**01/09/11**	**6**	**Addison BRF 0215(4)**	**B-103**	**0.0'**	**16.0'**	**Split Spoon**	**01/08/11**	**Smith**

All soil samples undergo preparation using test method AASHTO R-58 Dry Preparation of Disturbed Soil and Soil-Aggregate Samples. The Moisture Content of the sample should be measured (AASHTO T-265 Moisture Content of Soils) as soon as possible after it arrives in the lab.

Rock Samples

Rock cores are prepared for testing Unconfined Compressive Strength (UCS) by selecting representative core lengths that will allow for trimmed samples of 4 to 4.5-inch in length to be tested. Only NX size (2.16" diameter) rock cores will be used for UCS testing. The geologist will determine the depths and number of samples to be tested. Samples should be marked with an identification label using an indelible marker.

The first part of the label is the boring number, the second part of the label represents the run within that boring and the third part represents the sequential piece of core from that boring and run that was chosen for testing. As an example, the third sample from the first run of boring B-101 would be labeled B-101 R1 S3.

The label should be in the following form:

Boring Number	Run #	Sequence #
B-101	R1	S3

Each sample also needs to be labeled with the depth of the mid-point of the sample. Samples are prepared for testing by grinding the ends of the sample so that the ends are perpendicular with the long axis of the sample. This is accomplished with a special V-block jig and a rotary grinding apparatus. Each sample will then be wrapped in cellophane so that after breaking, the sample will retain enough of its original shape so that the sample can be returned to the core box.

8. LABORATORY TESTING:

Testing will be performed using calibrated/verified equipment at all times. Testing at the lab is conducted consistent with AASHTO or when necessary ASTM Testing methods. Testing of soil samples shall be conducted in a timely manner. This is necessary not only for project schedule requirements, but also because some of the properties of the soil are sensitive to physical and chemical changes over time. This will depend on priority requests and the workload at the time of delivery. The tests that can be performed within the Materials & Research Laboratory are as follows:

- **AASHTO R 58** Dry Preparation of Disturbed Soil and Soil-Aggregate Samples
- **AASHTO T 88** Particle Size Analysis of Soils
- **AASHTO T 89** Determining the Liquid Limit of Soils, Method: B
- **AASHTO T 90** Determining the Plastic Limit and Plasticity Index of Soils
- **AASHTO T 99** Moisture-Density Relations of Soils using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
- **AASHTO T 100** Specific Gravity of Soils
- **AASHTO T 180** Moisture-Density Relations of Soils using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- **AASHTO T 193** The California Bearing Ratio
- **AASHTO T 208** Unconfined Compressive Strength of Cohesive Soil
- **AASHTO T 216** One-Dimensional Consolidation Properties of Soils
- **AASHTO T 236** Direct Shear Test of Soils under Consolidated Drained Conditions
- **AASHTO T 265** Laboratory Determination of Moisture Content of Soils
- **AASHTO T 267** Determination of Organic Content in Soils by Loss on Ignition
- **AASHTO T 288** Determining Minimum Laboratory Soil Resistivity
- **AASHTO T 289** Determining pH of Soil for Use in Corrosion Testing
- **AASHTO T 290** Determining Water-Soluble Sulfate Ion Content in Soil
- **AASHTO T 291** Determining Water-Soluble Chloride Ion Content in Soil
- **AASHTO T 296** Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression
- **AASHTO T 297** Consolidated, Undrained Triaxial Compression Test on Cohesive Soils
- **ASTM D 1140** Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-µm) Sieve
- **ASTM D 7012** Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

The types of soil testing methods used at the lab can be classified as Index Properties, Strength Tests, Chemical Tests and Visual Classification Tests. Brief discussions of each testing method are presented below.

8.1. Index Properties:

Specific Gravity of Soils AASHTO T 100

The specific gravity of solids (G_s) is a measure of solid particle density and is referenced to an equivalent volume of water. Specific gravity of solids is defined as $G_s = M_s/(V_s \times \gamma_w)$ where M_s is the mass of the soil solids and V_s is the volume of the soil solids. It is common to assume a reasonable G_s value, although laboratory testing by AASHTO T100 can be used to verify and confirm the G_s value.

Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-µm) Sieve ASTM D 1140

This method involves weighing the sample, washing the sample to remove silt and clay sized particles, re-weighing and comparing the mass percent of the original sample to the washed sample.

Dry Preparation of Disturbed Soil and Soil-Aggregate Samples AASHTO R-58

This method involves the dry preparation of soil and soil-aggregate that is used to prepare samples received from the field for mechanical analysis, physical tests, or moisture-density relation tests.

Particle Size Analysis of Soils AASHTO T 88

Particle size distribution by mechanical sieve and hydrometer are useful for soil classification purposes. Testing is accomplished by placing air-dried material on a series of screens of known opening size.

Each successive screen has a smaller opening to capture progressively smaller particles. Testing of the finer grained particles is accomplished by suspending the chemically dispersed particles in water column and periodically measuring the specific gravity of the liquid with a 152H hydrometer as the particles fall from suspension.

Representative samples with fines (particles with diameter less than 0.075 mm or the U.S. No. 200 sieve) should be air dried or oven dried to a temperature no greater than 60° C prior to testing because some particles may cement together leading to a calculated lower fines content from mechanical sieve analyses than is actually present.

If the clay content is an important parameter, hydrometer analyses need to be performed. It should be noted that the hydrometer test provides approximate analysis results due to oversimplified assumptions, but the obtained results can be used as a general index of silt and clay content.

A standard wash gradation analysis (following AASHTO T-88, but omitting the hydrometer portion) can be performed with results in a soil report showing the percent of material passing on the 1½", ¾", 3/8", No.4, No.10, No.20, No.40, No.60, No.100 & No.200 sieves.

Determining the Liquid Limit of Soils, Method: B AASHTO T 89

The liquid limit is the water content at which a soil changes from plastic to liquid behavior. The liquid limit is determined by ascertaining the moisture content at which two halves of a soil cake will flow together for a distance of 0.5 inch (13 mm) along the bottom of the groove separating the halves, when the bowl they are in is dropped 22 to 28 times for a distance of 0.4 inches (10 mm) at the rate of 2 drops/second.

Determining the Plastic Limit and Plasticity Index of Soils AASHTO T 90

The plastic limit of a soil is the lowest water content at which the soil remains plastic. It is the moisture content at which the soil is in a plastic state. The plastic limit is determined by rolling the ellipsoidal shaped mass into threads 0.125 inches (3.2 mm) in diameter without crumbling, remolded, and continuing the process until the material crumbles before reaching 0.125 inches (3.2 mm) in diameter. The plasticity index of a soil is the numerical difference between the liquid limit and the plastic limit.

Moisture-Density Relations of Soils using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop AASHTO T 99 and Moisture-Density Relations of Soils using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop AASHTO T 180

The moisture-density relationship test is also called the Proctor test. This test method determines the relationship between the moisture content and the density of soils compacted in a mold. Two different standards of moisture-density relationships are presently in use by VTrans. AASHTO method T-99 uses three layers of soils, a compaction rammer weight of 5.5 lbs. and a distance drop of 12". AASHTO T-180 uses five layers of soils, a compaction rammer weight of 10.0 lbs. and a distance drop of 18".

The objective of this procedure is to determine the maximum dry density and optimum moisture content for a particular soil.

Based on the results obtained from conducting consecutive Proctor tests with changes in moisture, plot each test result on the cross-ruled area on the form with the moisture content plotted on the abscissa (x) and the density on the ordinate (y). After all the results are plotted, draw a smooth flowing curve through or close to the plotted points. From the peak of the curve, determine the maximum dry density and optimum moisture.

Laboratory Determination of Moisture Content of Soils AASHTO T 265

The moisture content, w, is defined as the ratio of the weight of water in a sample to the weight of solids. The wet sample is weighed, and then oven-dried to a constant weight at a temperature of about 230° F (110° C). The weight after drying is the weight of solids. The change in weight, which has occurred during drying, is equivalent to the weight of water. For organic soils, a reduced drying temperature of approximately 140° F (60° C) is sometimes recommended. The moisture content is valuable in determining the properties of soils and can be correlated with other parameters.

8.2. Strength Tests:

The California Bearing Ratio AASHTO T 193

This test method is used to evaluate the potential strength and load-bearing capacity of subgrade, subbase and base course material used in roadway construction.

Unconfined Compressive Strength of Cohesive Soil AASHTO T 208

Unconfined Compressive Strength (UCS) testing is used to obtain an approximate estimation of undrained shear strength of cohesive soils. Unlike the triaxial test, UCS testing does not apply a confining pressure during testing and although this test can be performed rapidly the results generally are conservative. In this test, the maximum stress at failure, $q_{u,}$ is equal to two times the undrained strength, (s_u).

One-Dimensional Consolidation Properties of Soils AASHTO T 216

This test is used to measure the magnitude and rate of consolidation of a soil when it is restrained laterally and drained axially while subjected to incrementally applied controlled-stress loading. During consolidation, measurements are made of the change of sample height. The results of this test can be used to assess the rate of consolidation, creep characteristics, stress history and swell potential of soil. Although this test is typically performed on undisturbed samples, it can be run on re-compacted material to assess settlement of compacted fills. The determination of the rate and magnitude of consolidation of soil when it is subjected to controlled-strain loading is covered by ASTM D4186.

Direct Shear Test of Soils under Consolidated Drained Conditions AASHTO T 236

Direct Shear testing is used to determine the consolidated drained shear strength of a soil material in direct shear. Direct shear tests can be performed on a variety of soils ranging from dense sands to soft cohesive soils. The circular or square specimen can be either an undisturbed or remolded sample. This test is applicable to field situations where complete consolidation has occurred under the existing overburden and failure is reached slowly so that excess pore pressures are dissipated. Generally, three specimens are tested at different effective consolidation stresses to define a strength envelope. By reversing the shear force and re-shearing the specimen repeatedly, the residual shear strength parameters of the specimen can be obtained. Residual parameters may be required for landslide analysis where a significant amount of ground movement in the soil has already experienced.

Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression AASHTO T 296

Unconsolidated-Undrained (UU) Compressive Strength testing is used to determine the unconsolidated strength and stress-strain relationships for a cylindrical specimen of either an undisturbed or remolded cohesive soil sheared undrained in compression at a constant rate of axial deformation. The strength in this test is measured under undrained conditions and is applicable to field conditions where soils are subject to a change in stress without time for consolidation to take place, and the field stress conditions are similar to those in the tests. The undrained shear strength to the soil, S_u, is measured in this test.

Consolidated, Undrained Triaxial Compression Test on Cohesive Soils AASHTO T 297

Consolidated, Undrained (CU) Triaxial Compression testing is used to determine the strength and stress-strain relationships for a cylindrical specimen of either an undisturbed or remolded saturated cohesive soil when it is isotropically consolidated and sheared undrained in compression at a constant rate of axial deformation. The strength in the test is measured under undrained conditions and is applicable to field conditions where soils have been fully consolidated under one set of stresses and are subjected to a change in stress without time for further consolidation to take place, and the field stress conditions are similar to those in the test. Shearing is conducted with the drainage lines closed so that during shearing, there is continued pore water pressure development. Pore pressures are measured during the tests so that both total stress (c and ϕ) and effective stress (c' and ϕ') strength parameters are obtained. Generally, three specimens are tested at different effective consolidation stresses to define a strength envelope.

Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures ASTM D 7012

VTrans conducts Uniaxial Compressive Strength (UCS) testing of rock in accordance with an in-house practice (State of Vermont, Agency of Transportation Materials & Research Section, VT-AOT-MRD 58-12) that generally follows ASTM D 7012 Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures and ASTM D4543 - 08 Standard Practices for Preparing Rock Core as Cylindrical Test Specimens and Verifying Conformance to Dimensional and Shape Tolerances. The VTrans practice does not require the degree of tolerance measurement required in ASTM D4543-08. Experience has shown that careful visual inspection of the sample would be sufficient in identifying if a sample were out of tolerance.

Representative samples are cut and prepared for testing using rock cutting and grinding equipment to assure a properly sized and dimensionally correct sample. The core sample is then loaded incrementally while the load and axial displacement are measured. The sample is usually loaded to failure, although if it is expected that the sample is of very high strength, the sample will be loaded to the point where a stable slope of stress/strain is developed, at which point the load is released, the strain measuring equipment removed from the core and the load applied again to failure.

8.3. Organic and Chemical Tests:

Determination of Organic Content in Soils by Loss on Ignition AASHTO T 267

This test approximates the percent organic content of a sample based on the loss of mass after subjecting it to temperatures sufficient to ignite and burn off organic matter.

Electro-Chemical Tests

Electro-chemical tests provide quantitative information related to the aggressiveness of the subsurface environment, the surface water environment, and the potential for deterioration of foundation materials. Electro-chemical testing includes pH, resistivity, sulfate, and chloride contents. These tests are performed by the Materials & Research Chemist. Soil samples are delivered to the soils lab, where they are dried and sieved. The chemistry lab takes a portion of the prepared sample for electrochemical testing. The amount of damage that an aggressive soil is capable of causing depends upon its specific properties and moisture conditions at the site.

Determining pH of Soil for Use in Corrosion Testing AASHTO T 289

pH testing is used to determine the acidity or alkalinity of subsurface soils. Acidic or alkaline environments have the potential for being aggressive on structures placed within these environments. Soil samples collected during the normal course of a subsurface exploration for structures that may contain buried metal elements should undergo pH testing. Low soil pH can be destructive to concrete and steel. High pH is generally only a problem with zinc and aluminum.

Determining Minimum Laboratory Soil Resistivity AASHTO T 288

Resistivity testing is used to determine the electric conduction potential of the subsurface environment. The ability of soil to conduct electricity can have a significant impact on the corrosion of steel piling, MSE wall metallic reinforcing strips or other metal geotechnical components. Highly conductive soils can accelerate the damaging effects of other undesirable soil properties. Conduction in all soils is highly dependent on the amount of moisture present.

Determining Water-Soluble Chloride Ion Content in Soil AASHTO T 291

Subsurface soils should be tested for chloride if the presence of chlorides is suspected. Chloride is damaging to all metals (even stainless steels to some extent) and concrete.

Determining Water-Soluble Sulfate Ion Content in Soil AASHTO T290

Subsurface soils should be tested for sulfate. Sulfate attacks concrete directly and can indirectly contribute to metal corrosion by increasing the electrical conductivity of the soil.

9. SOIL CLASSIFICATION:

Upon completion of testing, the soils technician will classify the soils consistent with ASTM M-145, Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. Samples that do not undergo testing are described visually utilizing ASTM D-2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) methods. The AASHTO method classifies soil into seven distinct groups designated A-1 through A-7. These groups are classified by results of load carrying capacity and service.

10. ROCK CLASSIFICATION:

The geologist will visually classify rock cores. The geologist will generate a core log noting core run depths, core recoveries, Rock Quality Designation (RQD), dip of strata, Rock Mass Rating (RMR) and a detailed geologic description of the rock encountered. A thorough description of rock core classification procedures is contained in Appendix E.6 of AASHTO Manual of Subsurface Investigations, 1988. RMR guidelines are provided in ASTM D5878 - 08 Standard Guides for Using Rock-Mass Classification Systems for Engineering Purposes. ASTM D6032 - 08 Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core details the procedure for calculating RQD.

11. DATA MANAGEMENT AND REPORTING:

11.1. Worksheets:

Each soil sample will have a worksheet that will be used to enter testing information and data while tests are being performed. An example copy of the form used by VTrans is present below in Figure 1.

VERMONT AGENCY OF TRANSPORTATION – SOILS LABORATORY TEST DATA SHEET	LABORATORY NUMBER: E 12 -	OF	

PROJECT NAME & NUMBER ______________________ DATE SAMPLED: ____/____/ 12 DATE TESTED: ____/____/ 12

STATION: ____+____ OFFSET: ________ HOLE: ________ DEPTH: ________ ft / m TO ________ ft / m FIELD DESCRIPTION: ________

SUBMITTED BY: ________ TESTED BY: ________ SAMPLED FROM (CIRCLE ONE) AUGER, SPLIT BARREL, TUBE, HAND, OTHER EXAMINED FOR: ________

AASHTO T87 /ASTM D1140 PARTICLE SIZE DETERMINATION

RETAINED ON	MASS	RETAINED ON	MASS
75 mm (3 in.)		850µm (No.20)	
37.5 mm (1 1/2in.)		425µm (No.40)	
19mm (3/4 in.)		250µm (No.60)	
9.5 mm (3/8 in.)		150µm (No.100)	
4.75 mm (No.4)		75µm (No.200)	
Reduced 4.75 mm		< 75µm (No.200)	
2.00mm (No.10)		TOTAL (g) =	
Reduced 2.00mm			

AASHTO: ATTERBURG LIMITS:	T89 LIQUID	T90 PLASTIC	T265 FIELD %MOISTURE	HYDRO. %MOISTURE
1. CAN NUMBER				
2. MASS CAN & WET SOIL				
3. MASS CAN & DRY SOIL				
4. MASS CAN				
5. NUMBER OF BLOWS				

AASHTO T100 SPECIFIC GRAVITY - No.10	
PYCNOMETER NUMBER	#
1. MASS OF PYCNOMETER	
2. MASS OF PYC. & SOIL	
3. MASS OF PYC., SOIL, & WATER	
4. WATER TEMPERATURE	
5. MASS OF PYC. & WATER (book)	
6. "K" FACTOR (CHART IN BOOK)	

AASHTO T-88 HYDROMETER ANALISIS
HYDROMETER #

	TIME	TEMP.	READING	CORRECTED
START:				
2 MIN.				
5 MIN.				
15 MIN.				
30 MIN.				
60 MIN.				
250 MIN				
1 DAY				

COMPACTION CONTROL CURVE AASHTO T-99 OR T-180 METHOD A B C D

1. DETERMINATION NUMBER	1	2	3	4	5	6	7
2. MASS OF MOLD & SOIL							
3. MASS OF MOLD							
4. CAN NUMBER							
5. MASS OF CAN & WET SOIL							
6. MASS OF CAN & DRY SOIL							
7. MASS OF CAN							

NOTES:

F: Boring Forms / Lab testing worksheet.doc

Figure 1 Example of Soils Laboratory Test Data Sheet

Worksheets will be filled out with all the provided field information about the sample. VTrans has developed a test data worksheet for soil index properties that allows for the recording of results from the following test procedures:

AASHTO T 87/ASTM D 1140
AASHTO T 89

AASHTO T 90
AASHTO T 265
AASHTO T 100
AASHTO T 88
AASHTO T 99
AASHTO T 180

Worksheets for strength testing data have been developed and are kept in a green 3-ring binder in the soils lab. Worksheets for sample information, saturation, consolidation and shear phases of testing are contained in the workbook.

Testing data from these worksheets are input into testing data reports and/or gINT® boring logs. At the end of each year all sample worksheets and sample tags are filed in marked boxes that are saved for seven years.

11.2. Sample Test Reports:

When sample testing has been completed, the data from the sample worksheet is entered into the soils laboratory Microsoft® Access® database. A step by step procedures manual for data entry has been developed and is located in the soils laboratory.

Based on the data input, a soils report is generated that lists the sample data and the results of the tests performed on that sample. The report will also show the soil classification of that material by using the percentages from T-88 and limits from T-89 and T-90, if they were performed. Classification is reported according to AASHTO M-145 Classification of Soils and Aggregate Mixtures for Highway Construction Purposes and ASTM D-2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) methods.

Soil Test Reports can be sent by E-mail, FAX, or mailed as a hard copy. If there are multiple sample reports to be sent out, a group of hard copies will be sent to the client by mail. All test results will be reviewed by the Soils Laboratory Supervisor prior to releasing this information to the project Engineer.

11.3. Boring Logs (gINT®):

Using information from the field boring log and the generated information from the soil test reports a boring log report is created. Boring Logs are created using gINT® software that resides on the soils laboratory computer. Input is made by the soils technician. A step by step manual has been created for data entry procedures and is available within the soils lab. For consultant performed projects, VTrans will provide a gINT® boring log template developed specifically for VTrans projects. VTrans will also supply gINT® library and seed files. Percentages of gravel, sand and fines measured during testing are entered in appropriate columns on the gINT® logs and laboratory classifications are noted. Boring Logs can be sent by Email (as a PDF file), FAX, or Mail (as a hard copy) to the client. All gINT® generated boring logs shall be reviewed by the geotechnical project engineer prior to being made final. Upon completion of borings for a project, the soils technician places MicroStation (.dgn) files, gINT® files and Adobe® Acrobat® pdf files for each boring in the Materials & Research subfolder of the subject project folder on the VTrans National Life M: drive.

12. SAMPLE RETENTION:

Remaining soil sample material after testing is normally discarded after all tests have been performed. If requested, the remaining sample can be stored in a labeled & sealed plastic bag for a short period of time. This is dependent upon the amount of sample that was delivered to the soils lab and how much material was needed for testing. Also, if requested, the remaining sample can be returned in a labeled & sealed plastic bag to the deliverer/client. Again, this is dependent upon the amount of sample that was delivered to the soils lab and how much material was needed for testing. Sample retention may be desirable in order to substantiate soil properties for potential future claims, allow additional sample testing in the future or to allow for visual review by engineers and designers.

Rock core boxes that have been logged by VTrans or delivered by consultants are retained by the Material & Research laboratory and are stored on racks in the VTrans Materials & Research Cold Storage building on premises. Cores are retained for one year following construction unless claims are filed that involve subsurface conditions.

REFERENCES:

AASHTO (2010 Edition) Standard Specifications for Transportation and Methods of Sampling and Testing, 30th Edition, American Association State Highway Transportation Officials, Washington, D.C.

AASHTO (1988) Manual on Subsurface Investigations, American Association of State Highway Transportation Officials, Washington, D.C.

FHWA (2002a) Geotechnical Engineering Circular No. 5 (GEC5) Evaluation of Soil and Rock Properties. Report No. FHWA-IF-02-034. Authors: Sabatini, P.J., Bachus, R.C., Mayne, P.W., Schneider, J.A., Zettler, T.E., Federal Highway Administration, U.S. Department of Transportation.

NHI Soils & Foundations Reference Manual No. 132012 Volumes 1 and 2.

Vermont Agency of Transportation (2010) MREI 11-01, Geotechnical Guidelines to Standardize VTrans' Subsurface Investigation Process

Implementation:

The content of this MREI will be implemented immediately for all soil testing requests.

Transmitted/Enclosed Materials:

VTrans Geotechnical Laboratory Test Request Form

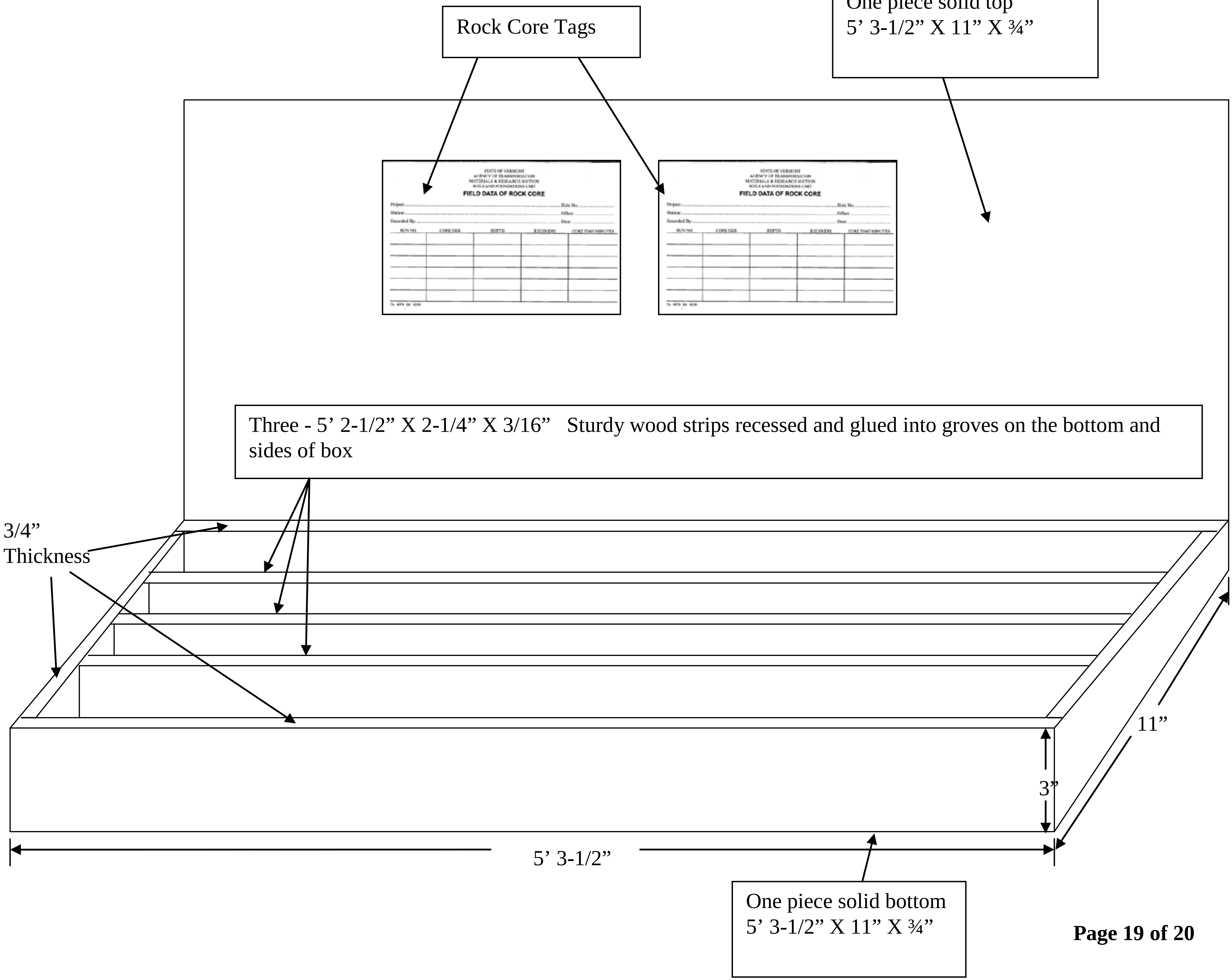
Appendix A Rock Core Handling and Labeling

Rock core from geotechnical explorations should be stored in structurally sound core boxes made of wood. Wooden boxes should be provided with hinged lids, with the hinges on the upper side of the box and a latch to secure the lid in a closed position. Core boxes shall be constructed so that one full 5-foot run can be laid out in one complete section of the core box (one box contains four sections). An example of the core box dimensions used by VTrans is provided.

Cores should be placed in the boxes from left to right, top to bottom. The core should read like a book left to right. When the upper compartment of the box is filled, the next lower compartment (and so on until the box is filled) should be filled, beginning in each case at the left-hand end. The depths of the top and bottom of each core run should be marked by a clearly labeled wooden spacer block. Spacers should be placed in the core box to immobilize the core and to keep the core in the correct position. Spacers should also be inserted in intervals where drilling breaks. The spacers should be labeled and in the case of core loss the spacer should be placed at the depth of the core loss if known or at the end of the run if not known. Spacers should be wooden blocks with dimensions that will assure a secure fit within the run openings. Core box labels and spacer labels should be completed using indelible black marking pens.

Cores should be handled carefully during transfer from barrel to box. Cores should freely come out of the core barrel tube. In no case should the core barrel be allowed to be beaten on or thumped against a wooden block. Deliberate breaks of the core are allowed in order to fit the core into the core box. These induced breaks need to be clearly marked.

A rock core tag for each boring within the box should be prepared. An example tag is provided. Each tag needs to be attached to the inside of the lid in the order core samples are laid out in the box.



One piece solid top
5’ 3-1/2” X 11” X ¾”
Rock Core Tags
FIELD DATA OF ROCK CORE
FIELD DATA OF ROCK CORE
Three - 5’ 2-1/2” X 2-1/4” X 3/16” Sturdy wood strips recessed and glued into groves on the bottom and sides of box
3/4”
Thickness
11”
3”
5’ 3-1/2”
One piece solid bottom
5’ 3-1/2” X 11” X ¾”

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH SECTION
SOILS AND FOUNDATIONS UNIT

FIELD DATA OF ROCK CORE

Project: .... Hole No. ....

Station: .... Offset: ....

Recorded By: .... Date: ....

RUN NO.	CORE SIZE	DEPTH	RECOVERY	CORE TIME MINUTES

TA 407B IM 02/09