METHODS OF SAMPLING AND TESTING
MT 207-04
CENTERLINE SOIL SURVEY

1 Introduction

1.1 A centerline soil survey is an essential part of preliminary highway engineering. Information on the engineering properties and distribution of soils, rock and groundwater must be obtained before a reasonable and economic highway design can be developed. A soil survey is not intended to take the place of a thorough Geotechnical Foundation investigation.

1.2 The soil survey work depends on many factors which include scope of the proposed project, types and variability of materials found on the project, groundwater conditions, adverse geologic features, etc. Often field conditions found during the soil survey will increase or decrease the amount of work needed to supply the necessary information for design. The soil survey and the geotechnical investigation must be coordinated in order to preclude duplication of effort.

2 Referenced Documents

AASHTO
M 145 Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
T 190 Resistance R-Value and Expansion Pressure of Compacted Soils

MT Materials Manual
MT 210 Moisture-Density Relations of Soils Using a 5.5 lb. Rammer
MT 230 Moisture-Density Relations of Soils Using a 10 lb. Rammer

3 Apparatus

3.1 *Sampling tools*
Hand shovels, picks, etc.
Hand augers, post hole diggers
Power augers and drills, etc.
Backhoes

3.2 *Instruments*
Survey equipment
Nuclear moisture and density testing device
Camera & film

3.3 *Miscellaneous*
Stakes and lath
Sample bags (17"X28" canvas 75 lb. capacity cloth)
Sealed containers (jars or plastic bags)
Field notebooks and forms

4 General Procedure

4.1 *General Procedure*: Following is the general procedure which should be followed in conducting any soil survey. The complexity of the soil survey will depend upon many factors as discussed in Section 1.2 above.

4.2 Reconnaissance of the proposed project should be conducted with pertinent existing information in hand. Additional information available may include but is not limited to the following items:

Maintenance records
Construction records
Topographic & geologic maps
Historic use of the area
U.S. Department of Agriculture Soil Conservation Service
County soil survey reports
Utility company maps & locations

City and county plat maps
City, county and state health department information
Information from landowners and businesses
Aerial photography

4.3 *Preliminary Survey Plan*

4.3.1 A preliminary plan should be determined prior to fieldwork. This should be based upon available information and intended scope. Approximate sample site locations should be determined to enable proper soil profile determination and adequate sampling. This plan will likely change as information is gained during the actual construction of the test sites.

4.3.2 Boring records should be kept in a systematic manner and referred to new centerline stationing and elevations for each project. Such records should include and be recorded on Forms 30 and 111.

Describe each site or area investigated, with each test hole, boring, or test pit clearly located (horizontally and vertically) with reference to some established coordinate system or permanent monument.

Log each test hole, boring, test pit, or cut-surface exposure with the field description and location of each material encountered clearly shown by Montana Department of Highways' symbols and word descriptions used on Form 30.

Note – Color photographs of samples, and exposed strata may be of considerable value to the Department. Each photograph should include a date and an identifying number or symbol.

Identify all soils based on AASHTO M 145 Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purpose.

Record seepage and water-bearing zones and free water-table depth found in each test hole, boring or test pit.

Identify artifacts and items of cultural and historical significance.

Note items concerning environmental hazards or other worthy notes.

4.3.3 Identify vertical and/or horizontal change of original ground where instability problems exist (landslides, subsidence, etc.).

4.4 *Soil Profile Determination and Sampling*

4.4.1 Boring or test pits should be taken for laboratory analysis from all areas which may supply appreciable quantities of earthwork, and known borrow areas. Embankment areas should be tested for areas of swamp conditions or loosely compacted soils that will result in embankment settlements. The spacing of these investigations will depend upon the geologic complexity of the project area and upon the importance of soil and rock parameters to the project design. The depth should be a minimum of five feet below the proposed top of subgrade elevation or to borrow area depth.

4.5 *Sampling*

4.5.1 Accurately identify each sample with the project identification, location, date, test site number and depth below reference ground surface from which it was taken. Place identification inside the container, securely close the container, protect it to withstand rough handling, and mark it with proper identification on the outside of the container. Keep samples for natural moisture determination in sealed containers to prevent moisture loss. When drying of samples may affect classification or engineering properties, protect them to minimize moisture loss.

4.5.2 Soil and water samples should be taken from the probable, proposed, or existing centerline of pipe, channel bottom and bridge locations as well as probable borrow areas, to determine pH, resistivity and sulfate (SO4) content of the soil and water. In areas of bad soils (resistivity less than 500), additional samples should be taken.

Sample Size not less than 5 lbs. (2.3 Kg.)

Sample Size, Water 1 quart.

4.5.3 Evaluate performance of existing installations in the immediate vicinity of the proposed site, relative to their historical performance and environmental impact. Photos of relevant installations properly labeled are helpful.

4.5.4 Representative disturbed samples for laboratory classification tests of soil, rock, and local construction material should be supplemented by undisturbed specimens.

4.5.5 Standard traffic control is required while working on the PTW.

4.6 *Testing*

4.6.1 Testing analysis should be performed on all samples for the following items and recorded on Form 111.

Soil class by AASHTO M 145
Liquid limit
Plastic limit
Percent of material passing the 10 mesh, 40 mesh, and 200 mesh sieve size.
Maximum dry density and optimum moisture content by MT 230 for A-1 soils, MT 210 for all other soils
In-place density and moisture content
"R" value by AASHTO T 190, all soils except A-6 and A-7's.
Depth to water table

5 Field Procedure

5.1 *Overlay, New and Reconstruction Projects*

Survey data required for all projects is as follows:

The PTW should be cored at least 5' into the subgrade and sampled in the driving lanes (not the shoulder) as frequently as necessary.

Typical sampling frequency is one per 1/2 mile, more or less as conditions dictate.

Note and log the mat thickness.

Note and log base thickness and subgrade. Sample and determine moisture content, record soil class (AASHTO M 145), moisture, density and "R" value (AASHTO T 190).

Perform a culvert inspection; take chemical corrosion samples where necessary. Take photos at locations of bad pipe.

Review the existing project and record its past performance. A narrative summary should be provided with the soil survey.

Problem areas must be shown and recommendations for sub-excavation and the proposed depth of sub-excavation should be noted.

Anticipated borrow material should be sampled and tested for R values and corrosion.

Projects, where the intent is to overlay the existing plant mix, should be cored and the cores submitted to the Materials Bureau for evaluation. A typical sampling frequency is one (1) core per lane mile with a minimum of five (5) cores per project. The frequency can and should be adjusted as conditions warrant. The cores will be evaluated to determine the in-place condition of the PMS and a report issued to Surfacing Design.

5.2 *New and Reconstruction Projects Only*

Additional survey data for new and reconstruction projects only are as follows:

Review planning reports and anticipate alignment and grades.

Test holes in the field should be located to provide engineering soil properties where appreciable quantities of excavation will occur. Depth will be determined by the new grade line with holes extending about five feet below the proposed subgrade line. Typical sampling frequency is one per 1/2 mile, more or less as conditions dictate.

Tests should include samples of each soil strata encountered and the in place moisture, the chemical-corrosive properties, soil class (AASHTO M 145), "R" value (AASHTO T 190), and the specific gravity for each strata.

Determine in place densities for shrink and swell determinations if frozen conditions do not exist.

A log of the test holes should be kept and the test holes plotted on a profile sheet.

Data obtained should be reviewed to determine if additional test sites (i.e., areas of refusal, inadequate depth, or of questionable frequencies) are required.

Topsoil depth and availability should be noted.

Any anticipated borrow material should be sampled for "R" value, chemical-corrosive properties, and moisture density purposes.

If centerline is following close to the PTW and material in present embankment will be used, additional R-values and chemical-corrosive properties should be taken beneath the PTW driving lanes.

Potential borrow areas that have better quality soils (A-4(0) or better) should be investigated to determine their use in the top 2' of the subgrade especially in areas where surfacing materials are scarce.

6 Interpretation of Results

6.1 Interpret the results of an investigation only in terms of actual findings and make every effort to collect and include all field and laboratory data from previous investigations in the same areas. Extrapolation of data into local areas not surveyed and tested can be done only where geologically uniform subsurface conditions of soil and rock are known to exist. Engineering properties of the soils and rocks encountered on important projects should not be predicted wholly on field identifications or classification but should be checked by laboratory and field tests made on samples collected.

6.2 The recommendations for design parameters can be made only by professionals who have specialized in the field of soils and foundations or highway engineering, and who are familiar with the problems for which the study is being made.

7 Report

7.1 A soil survey investigation report should:

7.1.1 Locate the area investigated in terms pertinent to the project. This may include sketch maps or aerial photos on which the test holes, pits, and sample areas are located, as well as topographic items relevant to the determination of the various soil and rock types, such as contours, streambeds, sink holes, cliffs, etc. Where feasible, include a geologic map of the area investigated in the report.

7.1.2 Include copies of all borings, test-hole logs and laboratory test results.

7.1.3 Describe and relate the findings obtained by following the format of Section 4, General Procedure.

7.1.4 Provide preliminary shrink/swell recommendations. Shrink/swell information obtained from adjacent projects in the area should be included.

7.1.5 Provide recommendations relative to availability of better quality soils (A-4(0) or better) that could be used in the top 2' of the subgrade to reduce more costly surfacing material and to improve drainage.

Provide recommendations for additional testing required by core drill, seismic, etc., for materials inaccessible because of depth, topography, etc.

7.1.6 Each soil survey shall be submitted and distributed as follows:

1 copy to Preconstruction Bureau
1 copy to Geotechnical & Materials Bureau
1 copy to Surfacing Design - Materials Bureau
2 copies to be retained by the District

DRAINAGE EVALUATION FORM
MT 207

This form should be submitted with each soil survey. Each area of concern on the project should be noted.

Project No. _____ Designation: _____

Date _____ Submitted by: _____

Station(s) _____

Are the ditch lines clear of standing water? _____

_____

Are the ditch lines and pavement edges free from weed growth that may indicate a moisture concentration? _____

_____

After a rain,

a) Is there moisture standing in the joints or cracks? _____

b) Is there any evidence of pumping? _____

c) Is there water standing at the outer edge of the shoulder? _____

d) Is there evidence that the water may pond on the shoulder? _____

Are joint sealants or crack sealants in good condition and preventing water from entering the pavement? _____

Are the cross drainage conduits closed by debris? _____

AC Pavements

Is there moisture related distress evident such as; Stripping, Rutting, Cracking in Wheelpath, Shoulder Dropoff/Heave, Pumping, Water Bleeding, Swelling?

_____

_____

_____

_____

PCC Pavements

Is there moisture related distress evident such as; Pumping, Faulting, Corner Break, D-Cracking, Edge Joint Opening, Shoulder Dropoff/Heave, Punchout (CRCP only), Swelling, Slab Cracking?

_____

_____

_____

_____

Is there evidence of springs and excessively wet areas?

Are there slides or slumps noted along the alignment?

Specific surface/subsurface drainage recommendations

MT 207

LOG OF BORING

MONTANA DEPARTMENT OF TRANSPORTATION

Geotechnical Section

Project Name: EXAMPLE - ENGLISH			Project Number: BR 549(0)
Borehole Location: STA. 13+95, 20.8 ft. Lt. PTW Centerline		Borehole Number: EXAMPLE	Sheet 1 of 1
Drilling Equipment: CME 550	Hammer Type: Automatic	Driller: A. Driller	Logger: A. Logger
Drilling Fluid: Water	Borehole Diameter (in): 8	Date Started: 1/1/98	Date Finished: 1/1/98
Elevation and Datum: Ground: 3739.80	Casing:	Notes: Legal Description - 01S18E32DAC. Elevation and Station provided by District Survey.	

DEPTH (feet)	DRILL: OPERATION	DRILL: PRESSURE (psi)	DRILL: RATE (fph)	CORE PERCENT RECOVERY	ROCK QUALITY DESIGNATION (ROD)	SAMPLE	RECOVERY (%)	STANDARD PENETRATION TEST SPT	DRY DENSITY (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (feet)	REMARKS
5							100	5-10-5		15		NP		Sandy GRAVEL, coarse, subangular, damp, tan, medium dense.	9.0	Hollow stem auger with bullet bits.
10							100		100	30	53	18		CLAY, moist, gray, medium stiff, high plasticity, medium dry strength, slow dilatency, medium toughness.		qu = 250 psf @ 10 ft.
15							95	3-4-3		27					15.0	
20		500	15	100	85		100	37-50/0.4 ft.						SHALE, moderately fissile, slightly weathered, hard field hardness, black, horizontal bedding.		Switched to NW triple tube core barrel with surface set bit @ 16 ft.
25		700	20	100	88										25.0	

Bottom of Hole Elevation = 3714.80 ft.

GPJ MTDOT.GDT 3/25/98

LOG_OF_BORIN

Operation Types: Auger; Casing Advancer; Core Barrel; Drive Casing

Sampler Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Penetrometer; Vane Shear; Special Samplers; Testpit

WATER LEVEL OBSERVATIONS

While Drilling ▽ 12.1 ft Upon Completion of Drilling ▽ 9.8 ft

Time After Drilling

Depth To Water (feet)

Remarks: Water table at 9.8 ft.

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LOG OF BORING

MONTANA DEPARTMENT OF TRANSPORTATION

Geotechnical Section

Project Name: SAMPLE - Metric			Project Number:
Borehole Location:		Borehole Number: -	Sheet 1 of 1
Drilling Equipment:	Hammer: Type:	Driller:	Logger:
Drilling Fluid:	Borehole Diameter (mm):	Date Started:	Date Finished:
Elevation and Datum: Ground:	Casing:	Notes:	

DEPTH (m)	DRILL: OPERATION	DRILL: PRESSURE (MPa)	DRILL: RATE (mph)	CORE: PERCENT RECOVERY	CORE: ROCK QUALITY DESIGNATION (RQD)	SAMPLE	RECOVERY (%)	STANDARD PENETRATION TEST: SPT	DRY DENSITY (kN/m³)	MOISTURE CONTENT (%)	LIQUID LIMIT: LL	PLASTIC LIMIT: PL	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (m)	REMARKS
2																
4																
6																
8																
10																

Operation Types: Auger; Casing Advancer; Core Barrel; Drive Casing

Sampler Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Penetrometer; Vane Shear; Special Samplers; Testpit

WATER LEVEL OBSERVATIONS

While Drilling ▽ ____ m Upon Completion of Drilling ▽ ____ m

Time After Drilling

Depth To Water (m)

Remarks:

LOG_OF_BORING BLANK-M.GPJ MTDOT.GDT 1/13/98

Montana Department of Transportation
Preconstruction Soil Survey Data
and Special Recommendations Relative to Subgrade and Road Surface Design

Project Number _____ Project Name _____ Length _____ County _____ Date _____

UPN _____ Contract No. _____ _____ _____

Submitted by _____ Title _____ District Materials Supervisor Dist. Preconstruction Engineer

Hole Number	Sample Number	Date	Reference to Centerline – Location of Boring	Depth	Representing Stationing	Soil Class (MT214)	LL	PI	10 Mesh (2.00 mm)	40 Mesh (.425 mm)	200 Mesh (.075 mm)	In Place Density	Specific Gravity	Density Maximum Dry	Moisture Percent Natural	Moisture Percent Optimum	Water Table Depth to	(AASHTO T190) "R" Value

Remarks:

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Distribution: Preconstruction Bureau; Geotech, Materials Bureau; Surfacing Design, Materials Bureau; District Lab; Area Lab, _____, _____
NDT Data Collection