VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

MEMORANDUM

GENERAL SUBJECT: **Manual of Instructions Chapter III – Geotechnical Engineering**	**NUMBER:** **MD 456-23**
SPECIFIC SUBJECT: **Section 305.03 Revisions to stipulate allowable methods for estimating settlement and conducting slope stability analyses**	**DATE: August 22, 2023** **SUPERSEDES:** **n/a**
APPROVED: Babish Charles dax24016 Digitally signed by Babish Charles dax24016 Date: 2023.08.23 10:45:10 -04'00'	**Charles A. Babish, PE** **State Materials Engineer**

EFFECTIVE DATE

- This memorandum is effective September 1, 2023.

PURPOSE

- This Memorandum notifies the users of the VDOT's Materials Division Manual of Instructions that Chapter III has been revised to clarify allowable methods and requirements for estimating settlements and conducting slope stability analyses. The revisions are colored in blue below.

PROCEDURES

SECTION 305.03 Geotechnical Design for Embankments and Cut Slopes (soil)
Embankments and certain aspects of retaining wall design are not addressed by LRFD. As such when addressing slope angles for finished grades, settlement of natural soils, lateral earth pressures and global stability, the geotechnical engineering study shall provide design values for friction angle (peak, fully-softened, or residual as appropriate), undrained shear strength, soil modulus, one-dimensional consolidation parameters (including the coefficient of secondary compression), lateral earth pressure coefficients, unit densities, the position of the ground water table and stratigraphy as simplified for the geotechnical design. It is not sufficient to state, "Total settlements are expected to be less than one IN" if the data are not provided to corroborate such a statement.

Total embankment settlements, including immediate (elastic), primary consolidation and secondary consolidation settlement, shall be estimated in accordance with the current AASHTO LRFD Section 10.6.2.4 methodology. When settlement analyses are performed in the final design, the following conditions shall be considered along with LRFD:

- Published correlations shall never be substituted for project-specific laboratory and in-situ testing for critical slopes;
- Primary and secondary consolidation settlements shall be estimated using the consolidation parameters based on one-dimensional consolidation test (ASTM D2435 or D4186). Any assumptions related to the consolidation parameters in the preliminary design shall be verified by laboratory testing in the final design; and
- Correlations used to establish settlement parameters shall be subject to approval of the DME.

Engineering design of stable soils slopes (cut slopes and embankment slopes) shall include an evaluation of stability for interim construction stages, for the end of construction condition, and for design-life conditions. Cut and fill slopes shall be no steeper than 2H:1V unless supported by engineering analyses based on site-specific field investigation and site-specific laboratory strength testing. Slopes steeper than 2H:1V must be approved by VDOT. Cut slopes in Potomac formation clays and silts shall be designed using residual strength values as determined by laboratory testing, neglecting any cohesion. The long-term design of ~~highly plastic~~ embankment slopes consisting of cohesive soils with liquid limit greater than 40 and plasticity index greater than 20 shall be based on fully-softened shear strength. To analyze failure surfaces deeper than 10 feet, the fully-softened shear strength parameters shall be used for the first 10 feet below the face of the embankments while the peak strength parameters may be used for the deeper depth (Castellanos et al. 2015). The use of non-zero cohesion intercept, c', for long-term analyses in natural materials must be carefully assessed. With continued displacements, it is likely that the cohesion intercept value will decrease to zero for long-term conditions, especially for highly plastic soils (LRFD 10.4.6.2.3).

The effective cohesion for coarse-grained non-plastic soils shall be considered zero and maximum allowable value of effective cohesion for coarse-grained plastic soils and fine-grained soils shall be determined by the DME in each District based upon the local soil properties.

The factors of safety tabulated below shall be used with limit equilibrium methods of analysis for representative sections of slope greater than 10 LF in height, for critical slopes, or for slopes in problem soils as defined below. The factors of safety are valid for subsurface investigations performed in accordance with this MOI or for site-specific investigation plans approved by the DME. Approval of site-specific investigation plans with reduced boring frequency may require higher factors of safety.

~~Failure surfaces shall be analyzed by methods such as the Modified Bishop, Simplified Janbu, Spencer, Infinite Slope, or other methods as pre-approved by VDOT.~~ Circular failure surfaces shall be analyzed by methods such as the Modified Bishop, Morgenstern and Price, or Spencer methods (Soil Strength and Slope Stability, Duncan et al. 2014). In addition, block (i.e., wedge failure) and non-circular failure surface analyses may be required to verify the minimum factor of safety. When using a computer program, the software manufacturer recommendations shall be followed. Modified Bishop method is not applicable for non-circular failure surface analyses. A minimum of two methods shall be used for the stability analyses and the lowest value of factor of safety shall be reported. Both drained and undrained strengths shall be considered. All slope stability analyses shall consider the effects of groundwater, external loads, tension cracks, and other pertinent factors as applicable.

TABLE 3-7 – MINIMUM FACTORS OF SAFETY FOR SOIL SLOPES		
Basis for Soil Parameters	**Factor of Safety**	
	Critical Slope[1]	**Non-Critical Slope**
Site specific in-situ or laboratory strength tests of soils[2,3]	1.5	1.3
No site specific in-situ or laboratory strength tests of soils[4]	N/A	1.5

NOTES:

1. A critical slope is defined as any slope that is greater than 25 LF in height, affects or supports a structure (i.e., irrespective of height), impounds water, or where failure would result in significant cost for repair, or damage to private property.
2. Site-specific in-situ testing for critical slopes shall include the use of CPT and/or DMT tests. Correlation to SPT N-values may be used as in-situ testing for non-critical slopes. Where design is governed by peak strength, appropriate laboratory tests shall include CU-bar or DDS testing of undisturbed or remolded samples. Where design is governed by fully-softened strength (i.e., highly plastic silts and clays), appropriate laboratory tests shall include DDS or CU-bar testing of normally-consolidated, reconstituted samples. Where design is governed by residual strength (i.e., slickensided, stiff-fissured clays, and silts), appropriate laboratory tests shall include residual-strength DDS testing of undisturbed or remolded samples in accordance with US Army Corps of Engineers test method EM-1110-2-1906.
3. Embankment borrow soils are not typically known at the time of design. Design assumptions such as minimum CBR value, soil types and parameters, slope ratio, undercutting must be reasonable and shall be included as a required minimum specification in construction plans.
4. When approved by the DME (and recognizing the requirement for reliability assessment) the strength of cut slopes in coarse-grained soil or coarse-grained subgrades supporting embankments may be based on published correlations to SPT N-value. Coarse-grained soil is defined by ASTM D2488 and D2487.

NOTES

REFERENCES

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