

# KDOT Geotechnical Manual

## 2007 Edition

The KDOT Geotechnical Manual is available two volumes. Both volumes are very large electronic (pdf) files which may take several minutes to download. The table of contents from both volumes is shown below.

[Volume I \(24.5 MB\)](#)

[Volume II \(95.5 MB\)](#)

## Table of Contents

### Volume I

Chapter 1: Geotechnical and Pavement Tasks in Highway Projects.....	1-1
1.1 Introduction .....	1-1
1.2 Planning, Development, and Engineering Phase .....	1-2
1.3 Project Design Phase .....	1-3
1.4 Construction Phase.....	1-4
1.5 Post-Construction Phase.....	1-5
Chapter 2: Subsurface Investigation Procedures .....	2-1
2.1 Introduction .....	2-1
2.2 Review of Project Requirements.....	2-1
2.3 Office Review of Available Data.....	2-1
2.3.1 Topographic Maps .....	2-2
2.3.2 Aerial Photographs .....	2-2
2.3.3 Kansas Geological Survey Maps and Reports.....	2-2
2.3.4 Soil Conservation Service Surveys .....	2-2
2.3.5 Archived KDOT Geotechnical Reports.....	2-3
2.4 Field Reconnaissance .....	2-3
2.5 Field Exploration Methods.....	2-4
2.5.1 Test Pits and Trenches.....	2-4
2.5.2 Boreholes.....	2-4
2.5.3 Auger Borings.....	2-4
2.5.4 Hollow-Stem Auger Borings .....	2-5
2.5.5 Wash Borings.....	2-5
2.5.6 Percussion Drilling .....	2-5
2.5.7 Rotary Drilling.....	2-5

2.5.8 Coring .....	2-6
2.5.9 Soundings.....	2-6
2.5.10 Geophysical methods.....	2-6
2.5.11 Seismic Refraction and Reflection .....	2-6
2.5.12 Resistivity .....	2-7
2.5.13 Ground Penetrating Radar .....	2-7
2.5.14 Soil Sampling.....	2-7
2.5.15 Bag Bulk Samples .....	2-7
2.5.16 Split-Barrel Samplers.....	2-7
2.5.17 Shelby Tube Samplers.....	2-8
2.5.18 Stationary Piston Samplers.....	2-8
2.5.19 Floating Piston Samplers.....	2-8
2.5.20 Retractable Piston Samplers.....	2-9
2.5.21 Hydraulic Piston Samplers (Osterberg) .....	2-9
2.5.22 Rock Core Sampling.....	2-9
2.5.23 Double Tube Core Barrel.....	2-9
2.5.24 Triple Tube Core Barrel .....	2-10
2.6 References.....	2-11
2.7 Specifications and Standards .....	2-12
Chapter 3: Subsurface Investigation Guidelines for Highways and Related Structures.....	3-1
3.1 Introduction .....	3-1
3.2 General Requirements .....	3-2
3.2.1 Preliminary Actions .....	3-3
3.3 Guidelines for Minimum Explorations.....	3-4
3.3.1 Surface Geology and Soil Surveys.....	3-4
3.3.2 Structures .....	3-6
3.3.3 Borrow Areas .....	3-12
3.4 References.....	3-14
3.5 Specifications and Standards .....	3-15
3.6 Appendix.....	3-16
Chapter 4: In-Situ Testing.....	4-1
4.1 Introduction .....	4-1
4.2 Standard Penetration Test (SPT).....	4-1
4.3 Cone Penetrometer Test (CPT) .....	4-2
4.4 Dynamic Cone Penetrometer Test (DCP) .....	4-3
4.5 Pressuremeter Test (PMT) .....	4-4
4.6 Borehole Shear Device (BSD).....	4-4
4.7 Field Vane Test.....	4-5
4.8 Percolation Test.....	4-5
4.9 Infiltration Test .....	4-5
4.10 Permeability Test.....	4-6
4.11 Seepage Tests .....	4-6
4.11.1 Open-End Borehole Test.....	4-6
4.11.2 Exfiltration Test.....	4-6

4.12 Pumping tests .....	4-6
4.13 Environmental Corrosion Tests.....	4-7
4.14 Grout Plug Pull-out Test .....	4-8
4.15 Osterberg Cell.....	4-8
4.16 References .....	4-9
4.17 Specifications and Standards.....	4-10
Chapter 5: Laboratory Tests .....	5-1
5.1 Introduction .....	5-1
5.2 Soils Tests .....	5-1
5.2.1 Grain Size Analysis .....	5-1
5.2.2 Moisture Content.....	5-2
5.2.3 Atterberg Limits .....	5-2
5.2.4 Specific Gravity of Soils .....	5-3
5.2.5 Strength Tests .....	5-3
5.2.6 Consolidation Test .....	5-5
5.2.7 Organic Content.....	5-6
5.2.8 Swell.....	5-6
5.2.9 Slake Durability Test.....	5-7
5.2.10 Permeability .....	5-7
5.2.11 Compaction Tests.....	5-7
5.2.12 Relative Density Tests .....	5-8
5.3 Rock Cores .....	5-9
5.3.1 Unconfined Compression Test .....	5-9
5.3.2 Splitting Tensile Strength Test .....	5-9
5.3.3 Triaxial Compression Strength.....	5-9
5.3.4 Specific Gravity and Absorption.....	5-10
5.3.5 Unit Weight.....	5-10
5.4 Modulus Tests for Paving Materials.....	5-10
5.4.1 Resilient Modulus Test (Cylindrical-Axial) .....	5-10
5.4.2 Indirect Resilient Modulus Test (Diametral Test) .....	5-10
5.5 References .....	5-11
5.6 Specifications and Standards.....	5-12
Chapter 6: Materials Description, Classification, and Logging .....	6-1
6.1 Introduction .....	6-1
6.2 Materials Description and Classification - Soils .....	6-1
6.2.1 Color.....	6-2
6.2.2 Constituents.....	6-2
6.2.3 Grading.....	6-2
6.2.4 Relative Density or Consistency .....	6-3
6.2.5 Moisture Content.....	6-4
6.2.6 Particle Angularity and Shape.....	6-4
6.2.7 Additional Descriptive Terms .....	6-4
6.2.8 Classification .....	6-4
6.2.9 AASHTO Classification System.....	6-5

6.3 Materials Description and Classification - Rock.....	6-6
6.3.1 Color.....	6-6
6.3.2 Constituents.....	6-7
6.3.3 Weathering.....	6-7
6.3.4 Hardness.....	6-7
6.3.5 Cementation.....	6-7
6.3.6 Stratification and Parting of Shales.....	6-7
6.3.7 Bedding and Splitting.....	6-8
6.3.8 Additional Descriptive Terms.....	6-9
6.4 Logging.....	6-9
6.4.1 Comments on Drilling Procedures and/or Problems.....	6-10
6.4.2 Sampling.....	6-10
6.4.3 Test Results.....	6-11
6.4.4 Rock Core Recovery and Rock Quality Designation.....	6-11
6.5 References.....	6-12
6.6 Specifications and Standards.....	6-13
Chapter 7: Field Instrumentation.....	7-1
7.1 Introduction.....	7-1
7.2 Inclinometers (Slope Indicators).....	7-2
7.2.1 Settlement Indicators.....	7-2
7.2.2 Piezometers.....	7-3
7.2.3 Total Pressure Cells.....	7-4
7.2.4 Tiltmeters.....	7-5
7.2.5 Monitoring Wells.....	7-5
7.2.6 Vibration Monitoring.....	7-5
7.2.7 Special Instrumentation.....	7-6
7.3 References.....	7-7
7.4 Specifications and Standards.....	7-8
Chapter 8: Surface Geology and Soil Surveys.....	8-1
8.1 Introduction.....	8-1
8.2 Geology Survey Reports.....	8-1
8.2.1 Plotting the Field Ground Profile.....	8-1
8.2.2 Project Profile Development.....	8-1
8.2.3 Field Profile.....	8-2
8.2.4 Cross-section Development.....	8-2
8.2.5 Centerline Profile for Cross-Sections.....	8-3
8.2.6 Manually Plotted Cross-Sections.....	8-3
8.2.7 Coded Cross-Sections.....	8-3
8.2.8 Plan Profile Preparation.....	8-8
8.2.9 Preliminary Geology Report.....	8-8
8.2.10 Section I - Generalized Geologic Section.....	8-8
8.2.11 Section II - Geology of the Project.....	8-8
8.2.12 Section III - Geo-Engineering Aspects of the Project.....	8-9
8.2.13 Dividing Project Geology into Sections by Stationing.....	8-9
8.2.15 Groundwater Issues.....	8-10

8.2.16 Springs, Ponds, and Oil Wells .....	8-10
8.2.17 Final Design Geology Report.....	8-10
8.2.18 Presplitting.....	8-10
8.2.19 Overbreakage.....	8-10
8.2.20 Underdrains.....	8-10
8.2.21 Wells .....	8-10
8.2.22 Ground Water.....	8-11
8.2.23 Subgrading.....	8-11
8.3 Soil Surveys .....	8-11
8.3.1 Report Preparation .....	8-12
8.3.2 Reduction and Grouping of Laboratory Data .....	8-12
8.4 Volume Multiplication Factors.....	8-13
8.4.1 Earthwork Quantities for Initial Consolidation and Settlement.....	8-13
8.4.2 E' Value for CMP Backfill.....	8-13
8.4.3 Development of Soil Characteristics Table .....	8-14
8.4.4 Soil Survey Report .....	8-14
8.4.5 Introduction.....	8-14
8.4.6 Soil Characterisitics.....	8-14
8.4.7 Soil Selection .....	8-15
8.4.8 Stabilization Requirements.....	8-17
8.4.9 Compaction Requirements.....	8-17
8.4.10 Rock Excavation.....	8-18
8.4.11 Overbreakage.....	8-18
8.4.12 Slope Topping for Exposed Rock .....	8-19
8.4.13 Slope Stability.....	8-19
8.4.14 Embankment Slopes (Large Fills) .....	8-19
8.4.15 Cut Slopes.....	8-19
8.4.16 Potential Problems.....	8-19
8.4.17 Earthwork Adjustments .....	8-19
8.4.18 Conclusion.....	8-20
8.4.19 Report Appendices .....	8-20
8.5 Geology Report Figures .....	8-21
8.5.1 DrillLogs.....	8-21
8.5.2 Standard Geology Symbols .....	8-23
8.5.3 Centerline Profile.....	8-25
8.5.4 ICES Codes.....	8-26
8.5.5 Examples of ICES Coding.....	8-35
8.5.6 Example of Geology Coding – Word Format.....	8-38
8.5.7 Example of Geology Coding – Excel Format.....	8-39
8.5.8 Example Geologic section.....	8-40
8.5.9 Example of Underdrain Design .....	8-41
8.5.10 Examples of Backslope Design .....	8-42
8.6 Soil Survey Figures.....	8-44
8.6.1 Soil Probe Notes .....	8-44
8.6.2 Soil Routine Test Results .....	8-45
8.6.3 Soil Compaction Test Results.....	8-46

8.6.4 Soil Swell Test Results .....	8-47
8.6.5 Soil Fertility Test Results .....	8-48
8.6.6 Volume Multiplication Factor Computations.....	8-49
8.6.7 Qs and Qic Computations and Tables .....	8-52
8.6.8 Table 1 .....	8-66
 Chapter 9: Allowable Strength Analysis and Design – Soil.....	 9-1
9.1 Roadway Embankment Materials .....	9-1
9.1.1 Limits of Unsuitable Materials .....	9-2
9.1.2 Corrosivity .....	9-2
9.1.3 Drainage .....	9-2
9.1.4 Other Considerations .....	9-2
9.2 Foundation Systems .....	9-2
9.2.1 Spread Footings.....	9-4
9.2.2 Driven Piles – Friction and End-Bearing .....	9-4
9.2.3 Drilled Shafts .....	9-6
9.3 Auger-Cast-Piles .....	9-7
9.3.1 Design Procedure .....	9-7
9.3.2 Settlement of Auger Cast Pile Groups .....	9-10
9.3.3 Auger Cast Pile Specifications .....	9-12
9.4 Micro Piles .....	9-21
9.4.1 Design Procedure .....	9-21
9.5 Additional Considerations in Foundation Analysis.....	9-21
9.5.1 Lateral Loads.....	9-21
9.5.2 Scour.....	9-21
9.5.3 Downdrag .....	9-21
9.5.4 Construction Requirements.....	9-22
9.6 Embankment Settlement/ Stability .....	9-22
9.6.1 Settlement .....	9-22
9.6.2 Stability .....	9-23
9.6.3 Design Procedure - Lateral Squeeze .....	9-24
9.7 Retaining Wall Design.....	9-24
9.7.1 Design Procedure.....	9-25
9.7.2 Consideration .....	9-25
9.8 Steepened Slopes.....	9-25
9.8.1 Design Procedure .....	9-25
9.9 Light Tower Foundation Design .....	9-25
9.10 ASD Analysis Method Tables .....	9-29
9.11 Computer Programs used in KDOT .....	9-33
9.12 ASD Design Tables.....	9-39
9.13 References .....	9-40
9.14 Figures .....	9-43
 Chapter 10: Load and Resistance Factor Design for Soils.....	 10-1
10.1 Limit States for Design .....	10-1
10.1.1 Strength Limit States .....	10-1

10.1.2 Service Limit States .....	10-1
10.2 Load Factors.....	10-1
10.2.1 Dead Loads .....	10-1
10.2.2 Transient Loads (or Live Loads) .....	10-2
10.2.3 Load Factors and Load Combinations .....	10-4
10.2.4 Load Factors for Foundations and Retaining Walls .....	10-5
10.2.5 Load factors for Culverts and Buried Structures.....	10-6
10.3 Design Parameter Selection .....	10-7
10.3.1 Resistance Factor Development for Design Parameters.....	10-7
10.4 Spread Footing Design .....	10-7
10.4.1 Limit States .....	10-7
10.4.2 Resistance Factors .....	10-7
10.4.3 Design Procedure .....	10-7
10.5 Driven Pile Design .....	10-9
10.5.1 Limit States.....	10-9
10.5.2 Resistance Factors.....	10-9
10.5.3 Design Procedure .....	10-9
10.6 Drilled Shaft Design.....	10-12
10.6.1 Limit States .....	10-12
10.6.2 Resistance Factors.....	10-12
10.6.3 Design Procedure .....	10-12
10.7 Conventional Retaining Wall and Abutment Design .....	10-14
10.7.1 Limit States .....	10-14
10.7.2 Resistance Factors.....	10-14
10.7.3 Design Procedure .....	10-15
10.8 Modular Wall Design .....	10-16
10.8.1 Limit States .....	10-16
10.8.2 Resistance Factors.....	10-16
10.8.3 Design Procedure .....	10-17
10.9 Anchored Wall Design .....	10-18
10.9.1 Limit States .....	10-18
10.9.2 Resistance Factors.....	10-18
10.9.3 Design Procedure .....	10-18
10.10 Mechanically Stabilized Earth (MSE) Wall Design .....	10-20
10.10.1 Limit States.....	10-20
10.10.2 Resistance Factors.....	10-20
10.10.3 Design Procedure .....	10-20
10.11LRFD Tables .....	10-23
10.12 References .....	10-36
 Chapter 11: Allowable Strength Analysis and Design - Rock.....	 11-1
11.1 Foundation Systems for Rock .....	11-1
11.1.1 Spread Footings.....	11-2
11.1.2 Driven Piles-End-Bearing.....	11-5
11.1.3 Drilled Shafts.....	11-7
11.1.4 Micro Piles.....	11-9

11.2 Additional Considerations in Rock Foundation Analysis.....	11-9
11.2.1 Lateral Loads .....	11-9
11.2.2 Scour.....	11-9
11.2.3 Downdrag .....	11-9
11.2.4 Construction Requirements .....	11-10
11.3 Rock Slope Design and Stability.....	11-10
11.3.1 Design Procedure .....	11-10
11.3.2 Considerations .....	11-10
11.3.3 ASD Analysis Method Tables .....	11-11
11.5 Computer Programs used in KDOT .....	11-12
11.6 References .....	11-14
11.7 Figures .....	11-16
Chapter 12: Analysis and Design of Pavements .....	12-1
12.1 Design Preliminaries .....	12-1
12.1.1 Project Data .....	12-2
12.1.2 Special Provisions .....	12-6
12.1.3 Geometries.....	12-7
12.1.4 Subgrade Data .....	12-7
12.1.5 Base Courses.....	12-13
12.1.6 Existing Pavement Data.....	12-16
12.1.7 Traffic.....	12-16
12.2 Rigid Pavement Design .....	12-18
12.2.1 AASHTO Method.....	12-19
12.2.2 PCA Method.....	12-22
12.3 Flexible Pavement Design .....	12-23
12.3.1 AASHTO Method.....	12-23
12.3.2 Asphalt Institute Method.....	12-26
12.3.3 Layered Elastic Analysis-Fatigue Assessment.....	12-26
12.4 Shoulder Surfacing.....	12-27
12.5 Life Cycle Costing.....	12-29
12.6 Pavement Reports.....	12-29
12.6.1 Report of Pavement Investigation.....	12-29
12.6.2 Form 1141- Response Form .....	12-29
12.6.3 Form 1142- Recommended Surfacing Alternates.....	12-30
12.6.4 Report of Pavement Investigation.....	12-30
12.6.5 Surfacing Recommendations for Bridge Replacements.....	12-34
12.7 References.....	12-38
12.8 Example Maps and Tables .....	12-39



## Volume II

Chapter 13: Bridge Deck Condition Surveys	13-1
13.1 Initiating the Survey	13-1
13.2 Visual Inspection	13-1
13.3 Delamination Evaluation	13-1
13.4 Corrosion Potential	13-2
13.5 Salt Content	13-2
13.6 Coring	13-2
13.7 Bridge Deck Evaluation Report	13-3
13.7 Report Distribution	13-3
Chapter 14: Example Geotechnical Documents	14-1
14.1 Geology Report	14-1
14.2 Geology Report Addendum	14-60
14.3 Final Design Geology Report	14-73
14.4 Final Design Geology Report Addendum	14-86
14.5 Soil Survey	14-93
14.6 Report of Borrow Investigation	14-109
14.7 Report of Borrow Area Investigation	14-123
14.8 Report of Retaining Wall Investigation	14-139
14.9 Slope Stability and Settlement Investigation	14-166
14.10 Report of Slope Failure Investigation	14-187
14.11 Report of Stabilization Pond Investigation	14-204
14.12 Report of Wash Bay Foundation Investigation	14-220
14.13 Report of Wetland Mitigation Investigation	14-233
14.14 Report of Light Tower Investigation	14-245
14.15 Report of Pavement Investigation - New Construction	14-255
14.16 Report of Pavement Investigation - Rehabilitation	14-271
14.17 Report of Pavement Investigation - Failure Investigation	14-286
14.18 Bridge Replacement Surfacing Recommendation Documents	14-300
14.19 Bridge Deck Condition Report	14-305
14.20 Bridge Foundation Geology Report	14-319
14.21 Test Pile Special - PDA Report	14-349
14.22 Test Pile Special - PDA Report Addendum	14-396
Chapter 15: Construction and Post-Construction	15-1
15.1 Construction and Post-Construction	15-1
15.2 Dynamic Pile Driving Analysis	15-1
15.3 Dynamic Monitoring of Pile Driving	15-2
15.4 Load Tests	15-2
15.4.1 Static Load Tests	15-2
15.4.2 Dynamic Load Tests	15-3
15.4.3 Osterberg Cell Load Tests	15-3
15.5 Pile/Drilled Shaft Damage Assessment	15-4
15.5.1 Pile Integrity Testing	15-4
15.5.2 Crosshole Sonic Logging	15-4

15.6 Drilled Shaft Construction ..... 15-4  
    15.6.1 Shaft Inspection Device (SID) ..... 15-5  
15.7 Field Instrumentation Monitoring..... 15-5  
15.8 Falling Weight Deflectometer ..... 15-6  
15.9 Pavement Condition Survey ..... 15-6  
15.10 Troubleshooting ..... 15-6  
15.11 Records ..... 15-6  
15.12 Figures ..... 15-8  
15.13 References..... 15-12  
15.14 Specifications and Standards..... 15-13

[Volume I \(24.5 MB\)](#)

[Volume II \(95.5 MB\)](#)