CHAPTER 1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE

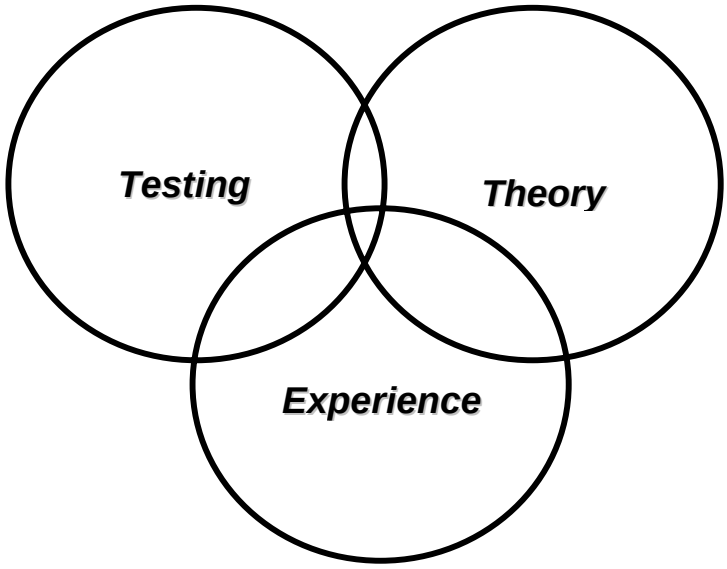
The Soils and Foundations Workshop is a 4-day training course sponsored by National Highway Institute to provide practical knowledge in geotechnical and foundation engineering for both generalists and those planning to take more advanced geotechnical courses in the future. The workshop is designed for bridge and foundation engineers involved in the design and construction aspects of a highway project.

This reference manual is the third edition of the Federal Highway Administration Soils and Foundations Workshop manual. The first edition was prepared in 1988 and a second edition with minor modifications came out in 1993. The manual is geared to the practicing engineer who routinely deals with soils and foundations problems but has little theoretical background in soil mechanics or foundation engineering. The overall goal of this manual is to present a recommended method for safe, cost-effective design and construction of foundations. Coordination between engineers in all project phases is stressed. The reader is encouraged to develop an appreciation of foundation activities in all project phases which influence or are influenced by his work

The manual follows a project oriented approach whereby the soils input to a fictitious bridge project is traced from conception to completion in a serialized illustrative workshop design problem.

1.2 SOILS AND FOUNDATIONS FOR HIGHWAY STRUCTURES

Man's earliest attempts at construction probably involved soil. As civilization developed through many centuries, man learned by trial and error about soil as a foundation material. Since World War I, much understanding of soil behavior has been achieved by applying the principles of physics, mechanics, hydraulics, strength of materials, and structural engineering. This approach to analyzing soils problems is called "soil mechanics." Because soil is a very complex medium, an entirely theoretical solution of most soil problems is not practical. The most practical solution to soil problems can be reached by a combination of the following sources of information.



1. Experience obtained by trial and error in the past; this developed into the empirical or "rule of thumb" procedures for today. The weakness of this approach is not recognizing differences in the engineering properties of soils. What works well at one location may not succeed with the same type of soil at another location.

2. Testing to obtain information on the properties of soils; generally obtained by field explorations and laboratory tests. Subsequent, theoretical analysis results will only be as good as the soils data used as input.

3. Theory based on scientific principles from various fields of engineering and science; used to explain or predict the behavior of soils under various conditions.

Analysis of soil is more complex than the analysis of other construction materials. Steel and concrete are relatively uniform solids which have predictable strength properties within the elastic range of loading. The strength may be "ordered" in the manufacture of steel and in the making of a concrete mix. This strength will be constant under all climatic conditions. Structures can then be built of these materials with confidence in their strength.

Soils deposits are composed of a mixture of three dissimilar materials; soil, water, and air. The soils' properties will be influenced by the action of each of these materials in the soil mass. Some of the factors influencing the strength of soil are:

1. Size, shape, and distribution of soil particles,

2. Degree of packing of soil particles,

3. Amount of water in soil, and

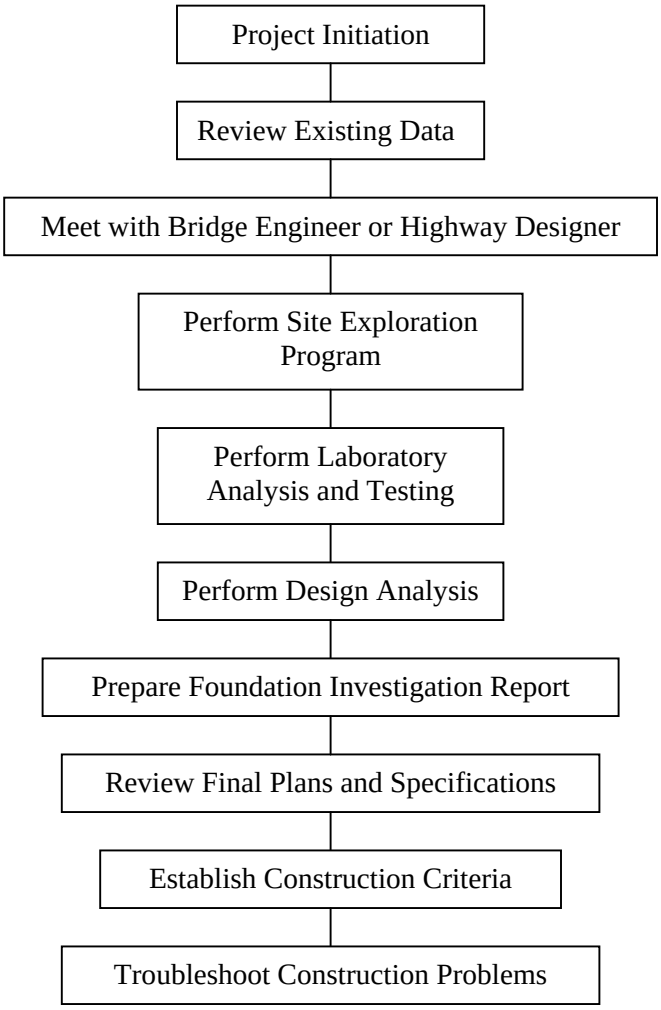
4. Climatic variations

Engineers should understand the fundamental properties of soils to use them as construction materials.

The success or failure of a foundation design is often decided in the early stages of a project. To assure success, the input of an experienced geotechnical engineer should begin at project inception and continue until completion of construction. The early interaction of the geotechnical engineer with other engineers will prevent establishment of a project alignment or grade which may require expensive foundation treatment later in design. It is imperative that good communication and interaction exist between the geotechnical engineer, structural engineer, and construction engineer, throughout the design and construction process to insure cost-effective design and to minimize design and construction problems. The importance of this communication and interaction will be stressed throughout this manual and cannot be overemphasized.

The following flow chart of geotechnical activities generally describes this involvement. A more specific listing of these activities for structure foundations is shown in Table 1, Geotechnical Involvement in Project Phases.

Flow Chart



1.3 ORGANIZATION OF MANUAL

The manual content follows a project-oriented approach whereby the design is traced from preparation of the boring request through design computation of settlement, allowable footing pressure, etc., to the construction of approach embankments, pile driving operations, etc. Recommendations are presented on how to layout borings efficiently, how to minimize approach embankment settlement and eliminate the bump at the end of-the bridge, how to design the most cost-effective pile foundation, and how to transmit design information properly to construction through plans, specifications, or contact with the project engineer.

TABLE 1
GEOTECHNICAL INVOLVEMENT IN PROJECT PHASES

Phase	Function
Planning	1. Study existing data. (a) Topographic sheet. (b) Agricultural soil map. (c) Ground water bulletin. (d) Air photos. 2. Field reconnaissance with bridge engineer. (a.) Inspect nearby structures for settlement, scour, etc. (b) Assess site conditions. 3. Prepare terrain reconnaissance report for planning engineer. Include: (a) Anticipated soil, rock and water conditions. (b) Major problems or cost which will hinder or preclude structure construction. (c) Right-of-way required for possible special foundation treatment. (d) Beneficial shifts in alignment.
Alternate Design	1. Assess structure locations with regard to major soil problems. 2. Provide input for Bridge Scour. 3. Implement subsurface program after design approval.
Advanced Detail Plans	1. Review subsurface information. 2. Provide input for Bridge Engineer. 3. Submit soils investigation report to Bridge Engineer. Include: (a) Coordination with roadway construction. (b) Alternate foundation design. (c) Subsurface profile. (d) Special notes and specifications.
Construction	1. Submit wave equations to Bridge Engineer. (a) Hammer approval. (b) Stress analysis. (c) Required blow count. (d) Special effects. 2. Attend preconstruction meeting with engineer-in-charge and pile inspector. Explain: (a) General soil profile. (b) Design basis. (c) Wave analysis. (d) Possible soil problems. 3. Troubleshoot soils-related problems as required. 4. Assist with pile load tests as required.
Post Construction	1. Review actual pile results versus predicted. (a) Blow count. (b) Length. (c) Field problems. (d) Load test capacity. 2. Participate in court of claims action.

The concepts presented in each chapter are concise and specifically directed at a particular operation in the foundation design process. Basic example problems are included in several sections for hands-on knowledge. Continuity between chapters is achieved by sequencing the information in the normal progression of a foundation design study. In addition , the manual contains a complete geotechnical design, in a serialized format, for a highway project involving a bridge and approach embankment over soft ground. In each phase of the fictitious project the soil concepts are developed into specific foundation designs or recommendations for that segment of the workshop design problem. The organization of the manual is presented below.

- Chapter 2 presents basic information on site investigation procedures, including terrain reconnaissance, subsurface investigation methods, standard penetration test procedures, undisturbed soil sampling, and guidelines for minimum programs in investigation of both roadway and structure sites.

- Chapter 3 discusses the basic engineering properties of the main soil groups, procedures for describing and classifying soils, and development of a soil profile.

- Chapter 4 presents effective stress principles, uses of classification test data, basic consolidation and strength testing concepts, guidelines for laboratory testing on a typical highway project, and a procedure for summarizing and choosing design values from lab tests.

- Chapter 5 and 6 present the general design procedures for stability and settlement analyses for embankments. Basic analyses are shown and explained with emphasis on practical application of analysis results to highway embankments. Remedial methods are discussed for both stability and settlement problems.

- Chapter 7 presents the foundation design procedure for shallow foundations. The analysis of both bearing capacity and settlement are discussed as well as application of results.

- Chapter 8 discusses basic concepts in the selection and design of deep foundations with emphasis on driven pile foundations. Analyses for skin friction end bearing for are covered for both cohesive and cohesionless soils. Foundation installation effects on design are discussed as well as negative skin friction and pile settlement.

- Chapter 9 provides construction control procedures for both embankments and foundations with the emphasis on control of driven pile foundations. The components of pile driving equipment, the soil properties and the use of design analysis results are related to the use of wave equation analysis in construction control. Generic information is presented on preparation of deep foundation specifications and the use of load testing.

- Chapter 10 presents a basic outline for a foundation investigation report and includes suggestions for how to incorporate geotechnical information into contract documents.

1.4 PRIMARY REFERENCES

A detailed list of references is provided in Chapter 11. However, certain basic references were used to develop materials for many sections in this document. In addition, FHWA has either developed or is in the process of developing detailed guidance in the topic areas covered in this document. Most of those documents are reference manuals for geotechnical courses developed for the National Highway Institute. Both the basic and detailed references are listed below. Finally, the reader is directed to the web site for the FHWA Geotechnical Group, *www.fhwa.dot.gov/bridge/geo.htm*, to obtain information on all geotechnical publications and software which have been developed by FHWA.

1.4.1 Basic References

AASHTO. (latest year of issue), Standard Specifications for Highway Bridges, American Association of State Highway and Transportation Officials, Washington, D.C.

AASHTO. (1988), Manual on Foundations Investigations, Standard Specifications for Highway Bridges, 15th Edition, American Association of State Highway and Transportation Officials, Washington, D.C.

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FHWA. (1986). Spread Footings for Highway Bridges, FHWA RD-86-185.

FHWA. (1988), Checklists and Guidelines for Review of Geotechnical Reports and Preliminary Plans and Specifications, FHWA ED-88-053.

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FHWA (1996), Design and Construction of Driven Pile Foundations, FHWA HI-97-014.

FHWA (1999), Drilled Shafts: Construction Procedures and Design. FHWA HI-99-025.

FHWA (latest year of issuance) Geotechnical Engineering Notebook, Issuances GT1 –GT16.

NAVFAC. (1982), Design Manuals 7.01 Soil Mechanics & 7.02 Foundations and Earth Structures, Dept. of the Navy, www.ccb.org/searchfrm.asp

1.4.2 Detailed Technical References

Module 1: Arman, A., Samtani, N., Castelli, R., and Munfakh, G. (1997), "Geotechnical and Foundation Engineering, Module 1 – Subsurface Investigations", Principal Investigator: George Munfakh, U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, Virginia, *National Highway Institute Course No. 13231- Publication No. FHWA HI-97-021*, 305 p.

Module 3: (in progress) Lee, W.S., Walkinshaw, J., Collin, J., and Hung, J.C. (2000), "Geotechnical and Foundation Engineering, Module 3 – Soil Slopes and Embankments," Principal Investigator: George Munfakh, Under Preparation, NHI Course No. 13233, U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, Virginia.

Module 5: Wyllie, D. and Mah, C.W. (1998), "Geotechnical and Foundation Engineering, Module 5 – Rock Slopes," Principal Investigator: George Munfakh, U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, Virginia, *National Highway Institute Course No. 13235- Publication No. FHWA HI-99-007*, 393 p.

Module 6: Munfakh, G., Samtani, N.C., Castelli, R.J., and Wang, J. (1999), "Geotechnical and Foundation Engineering, Module 6 – Earth Retaining Structures," Principal Investigator: George Munfakh, U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, Virginia, *National Highway Institute Course No. 13236- Publication No. FHWA NHI-99-025*, 444 p.

Module 7: (in progress) Arman, A., Collin, J., Brouillette, R.P., and Hung, J.C. (2000), "Geotechnical and Foundation Engineering, Module 7 – Shallow Foundations," U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, Virginia.

Module 9: Kavazanjian, E., Matasovic, N., Hadj-Hamou, T., and Wang, J. (1999), "Geotechnical and Foundation Engineering, Module 9 – Geotechnical Earthquake Engineering," Principal Investigator: George Munfakh, U.S. Department of Transportation, Federal Highway Administration, National Highway Institute, Arlington, Virginia, *National Highway Institute Course No. 13239- Publication No. FHWA HI-99-012*, 392 p.

Module 11: Dunnicliff, J. (1998), "Geotechnical and Foundation Engineering, Module 11 – Geotechnical Instrumentation," Principal Investigator: George Munfakh, U.S. Department of Transportation,

Federal Highway Administration, National Highway Institute, Arlington, Virginia, *National Highway Institute Course No. 13241- Publication No. FHWA HI-98-034*, 238 p.

TRB. (1996), Special Report 247, Landslides: Investigation and Mitigation. Transportation Research Board, 2102 Constitution Ave. Washington DC 20418.