

EARTH MANUAL

A WATER
RESOURCES
TECHNICAL
PUBLICATION



A guide to the use of soils as
foundations and as construction materials
for hydraulic structures

SECOND EDITION

1974

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.



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PREFACE TO THE SECOND EDITION

The purposes of the Second Edition remain essentially the same as those which prompted the First Edition, as described in the latter's Preface. Constantly-changing concepts of soil mechanics—as evidenced by new research techniques and ideas, innovations in construction methods and equipment, and computer-generated solutions to previously insurmountable soils-analyses problems—make mandatory this Second Edition. To improve its readability and provide for the new material, the Manual has increased in size as those familiar with the First Edition will recognize.

The contributors to the Manual have held important the need for uniformity in terminology, so that all personnel—field and office alike—speak the same language. Much effort has been expended to achieve consistency of terms in the text and the 39 designations or procedures that comprise the appendix. This may be noted especially in the material on soil classification, and methods of logging and reporting; and types and methods of field explorations and investigations, and the tools and equipment required to obtain the desired information.

Although the Manual is primarily geared to the Reclamation organization, engineers and technicians of other governmental agencies, foreign governments, and private firms can, with modifications, utilize the information as a guide to their individual investigations, control of earth construction, and laboratory testing since emphasis is upon practical applications rather than upon complex theory. Users of the Manual should recognize that certain recommendations and values are the result of experience and cannot always be mathematically proved, nor should one attempt to. The Manual has been written as a guide and aid for the construction of a safe and stable structure with utmost concern for the safety of lives.

New material, not covered in the First Edition, includes material on: stabilized soils (soil-cement and asphaltic concrete), more complete information on field investigations and testing equipment in both chapter 2 and designation E-2, an expanded discussion on pipelines, and a newly developed designation, E-39, titled, "Investigations for Rock Sources for Riprap", which describes investigative and reporting procedures. In addition to the conversion factors in the First Edition, conversion curves are included to facilitate the increased utilization of metric units.

Major revisions center on designation E-16, which has been rewritten

and retitled, "Measurement of Capillary Pressures in Soils", and designation E-17, "Triaxial Shear of Soils", which has been rewritten to conform to advanced developments in the procedure. Introduced in E-17 is the "Triaxial Shear Test with Zero Lateral Strain" referred to in modern soil mechanics texts as the K_0 -test, which now can easily be performed through the use of the electronic computer.

Since the "Rapid Compaction Control" method, designation E-25, is being used extensively in 35 foreign countries as well as the United States, reorientation of the text material has been made for presenting the material in a manner more readily adaptable to both field and office use. More recently (1970), Australia has been granted permission by the Commissioner, Bureau of Reclamation, to incorporate the "Rapid Compaction Control" method in the Australian standards, "Testing Soils for Engineering Purposes". Designation E-12 has similarly been reoriented for ease in performing the relative density test in cohesionless soils.

Designations E-27 through E-35 covering "Instrument Installations" have been revised and updated to reflect changes in equipment and materials, techniques in installation procedures, and to clarify some of the methods of reading and reporting of data. To be commended are those dedicated field personnel who recognize inconsistencies or problems in the field related to "instruments" and who so often resolve the problems on-the-job. Reflected in these designations are many of their recommendations which have been offered unselfishly.

While environmental and ecological problems are major concerns of the Bureau of Reclamation, space and time limitations cause exclusion of discussion of views and policies regarding these highly important design considerations. It still remains the responsibility of each planner, investigator, designer, and constructor to consider these problems in his work.

There are occasional references to proprietary materials or products in this publication. These must not be construed as an endorsement since the Bureau cannot endorse proprietary products or processes of manufacturers or the services of commercial firms for advertising, publicity, sales, or other purposes.

Indicative of the monumental task involved in the preparation of this Second Edition is that some 90 persons—engineers, technicians, and those of other disciplines—from the Bureau of Reclamation in its Engineering and Research Center, Denver, Colo., constructively contributed to the content in some measure. The efforts of these people, some of whom are internationally acknowledged, are greatly appreciated.

Special recognition is given to H. J. Gibbs, Chief, Earth Sciences Branch, Division of General Research, and F. J. Davis, Supervisory Civil Engineer, Hydraulic Structures Branch, Division of Design and

Construction, for authoring much of the technical material, for their technical advice, and for their overall guidance. In addition, recognition is made of engineers C. W. Jones, W. Ellis, R. R. Ledzian, G. DeGroot, and P. C. Knodel, and technician R. C. Hatcher, all of the Division of General Research, and engineer W. W. Daehn of the Division of Design and Construction for their major contributions. Because illustrations are invaluable to a publication, recognition must be made to R. E. Glasco and Mrs. H. Fowler for their patience, guidance, and help in obtaining illustrations of the highest quality.

This Second Edition was edited and coordinated, and supplemental technical information and illustrations provided by H. E. Kisselman, general engineer, Technical Services and Publications Branch.

CONTENTS

<i>Section</i>	<i>Page</i>
Preface to the Second Edition -----	iii
Preface to the First Edition -----	vii

CHAPTER I—PROPERTIES OF SOILS

A. IDENTIFICATION AND CLASSIFICATION

1. General -----	1
2. Soil components -----	2
(a) Size -----	2
(b) Gradation (Grain-size distribution) -----	3
(c) Shape -----	4
3. Soil moisture -----	4
4. Characteristics of soil components -----	10
(a) Gravel and sand -----	10
(b) Silt and clay (Fines) -----	11
(c) Organic matter -----	13
5. Classification of soils -----	14
(a) General -----	14
(b) Field classification -----	14
(c) Laboratory classification -----	16
6. Description of soils -----	17
(a) General -----	17
(b) Borrow materials -----	17
(c) Foundations for structures -----	18
7. Properties of soil groups -----	18

B. INDEX PROPERTIES

8. Definition -----	22
9. Gradation -----	23
10. Soil consistency -----	25
11. Porosity and void ratio -----	28
12. Specific gravity -----	29

<i>Section</i>	<i>Page</i>
13. Water content or moisture content -----	32
14. Density or unit weight -----	33
15. Penetration resistance -----	40
16. Unconfined compressive strength -----	42
17. Soluble salts -----	43

C. ENGINEERING PROPERTIES

18. General -----	43
19. Shear strength -----	44
(a) General -----	44
(b) Direct shear -----	45
(c) Triaxial shear -----	46
(d) Pore-water pressure -----	46
(e) Capillary stresses -----	48
(f) Sliding resistance -----	48
20. Compressibility -----	49
(a) General -----	49
(b) Control of compressibility -----	51
(c) Load-compression characteristics -----	53
(d) Load-expansion characteristics -----	53
21. Permeability -----	55
(a) Definition -----	55
(b) Ranges of permeability -----	59
(c) Control of permeability -----	59
(d) Determination of permeability values -----	60
22. Changes in soil properties -----	61
23. Workability -----	62
24. Frost action -----	63

CHAPTER II—INVESTIGATION

A. STAGES OF INVESTIGATION

25. General -----	65
26. Reconnaissance -----	67
(a) Objectives -----	67
(b) Sizes and depths of investigated areas -----	67
27. Feasibility -----	68
(a) Objective -----	68
(b) Organization of the investigation -----	69

<i>Section</i>	<i>Page</i>
28. Specifications -----	71
(a) Scope -----	71
(b) Programing the exploration -----	72
 B. PRINCIPLES OF INVESTIGATIONS	
29. General -----	73
(a) Objectives -----	73
(b) Classification of structure foundations -----	74
30. Sources of map and photo information -----	75
(a) Topographic maps -----	75
(b) Geologic maps -----	77
(c) Agricultural soil maps -----	80
(d) Air photos -----	84
31. Surface exploration -----	87
(a) General -----	87
(b) Fluvial soils -----	88
(c) Glacial deposits -----	92
(d) Eolian deposits -----	94
(e) Residual soils -----	96
32. Subsurface exploration -----	100
(a) General -----	100
(b) Point structures -----	101
(c) Line structures -----	101
(d) Damsites -----	106
(e) Tunnels -----	106
(f) Borrow areas -----	106
(g) Selection of samples -----	108
(h) Field tests -----	111
33. Exploration for materials having specific properties -----	111
(a) General -----	111
(b) Impervious materials -----	112
(c) Pervious materials -----	113
(d) Riprap and rockfill -----	115
34. Materials for stabilized and modified soils -----	119
(a) General -----	119
(b) Compacted soil-cement -----	120
(c) Plastic soil-cement -----	121
(d) Asphaltic concrete -----	121
(e) Modified soil -----	121

<i>Section</i>	<i>Page</i>
C. EXPLORATORY METHODS	
35. General	122
36. Test pits, trenches, and tunnels	123
(a) General	123
(b) Test pits	124
(c) Trenches	125
(d) Tunnels	127
37. Auger borings	129
38. Rotary drilling	136
39. Drive-tube boring	140
40. Miscellaneous methods	142
(a) Nonsampling borings	142
(b) Geophysical methods	142
41. Field tests	143
(a) General	143
(b) Field permeability tests	143
(c) Field vane test	143
(d) Inplace density tests	143

D. RECORDING AND REPORTING OF DATA

42. Maps	144
43. Logging of exploratory holes	146
(a) Location of holes	146
(b) Identification of holes	146
(c) Log forms	147
(d) Description of soils	155
(e) Description of rock cores	155
44. Subsurface sections	157
45. Sampling	158
46. Reports	159

CHAPTER III—CONTROL OF EARTH CONSTRUCTION

A. PRINCIPLES OF CONSTRUCTION CONTROL

47. Importance of control	165
48. Organization	166
49. Specifications	167
50. Inspection	169

<i>Section</i>	<i>Page</i>
51. Field laboratory facilities -----	171
52. Reports -----	174

B. EARTHWORK

53. General -----	176
54. Embankment -----	176
(a) Types of embankment -----	176
(b) Dumped fill -----	176
(c) Selected fill -----	177
(d) Equipment-compacted embankment -----	178
(e) Rolled earthfill -----	178
(f) Tractor-compacted embankment -----	179
(g) Blended earthfill -----	181
(h) Modified soil fill -----	183
(i) Hydraulic fill -----	183
55. Linings and blankets -----	184
(a) General -----	184
(b) Rock blankets -----	186
(c) Sand and gravel or crushed rock blankets -----	187
(d) Impervious blankets and linings -----	189
(e) Topsoil blankets or zones -----	189
56. Backfill -----	190
(a) General -----	190
(b) Compacted backfill -----	191
57. Excavation -----	191

C. FOUNDATIONS

58. General -----	195
59. Bearing capacity -----	195
60. Stability -----	196
61. Settlement and uplift -----	201
62. Deterioration -----	202
63. Permeability -----	202
64. Inadequate foundation conditions -----	205
(a) General -----	205
(b) Topsoil -----	206
(c) Swamp muck -----	206
(d) Silt and sand -----	206
(e) Talus and spoil piles -----	211

<i>Section</i>	<i>Page</i>
(f) Clays -----	211
(g) Soft or saturated materials -----	211
 D. ROLLED EARTH DAMS	
65. Foundation treatment -----	212
(a) Design features -----	212
(b) Specifications provisions -----	218
(c) Control techniques -----	220
66. Compacted earthfill -----	221
(a) Design considerations -----	221
(b) Specifications provisions -----	223
(c) Control techniques -----	225
67. Compacted pervious fill -----	234
(a) Design considerations -----	234
(b) Specifications provisions -----	236
(c) Control techniques -----	237
68. Rockfill and riprap -----	238
69. Miscellaneous fills -----	241
70. Instrument installations -----	243
(a) Instruments -----	243
(b) Installation of earth dam instrumentation -----	243
(c) Inspection -----	244
(d) Observations -----	244
(e) Record tests -----	245
71. Records and reports -----	247
(a) Daily reports -----	247
(b) Periodic progress reports -----	249
(c) Final embankment construction reports -----	250
(d) Earth dam instrumentation reports -----	253
72. Control criteria -----	253
 E. CANALS	
73. Design features -----	260
74. Specifications provisions -----	266
(a) General -----	266
(b) Subgrades and foundations for embankments and compacted earth lining -----	266
(c) Earth embankments and linings -----	267

<i>Section</i>	<i>Page</i>
(d) Riprap, protective blankets, gravel fills, and gravel subbase -----	269
75. Control techniques -----	274
(a) General -----	274
(b) Subgrades and embankment foundations -----	274
(c) Earth embankments and linings -----	278
F. PIPELINES	
76. Design features -----	282
77. Specifications provisions -----	283
(a) General -----	283
(b) Pipeline excavation -----	283
(c) Backfill in pipe trenches -----	283
(d) Compacting backfill in pipe trenches -----	286
(e) Compacted backfill for bedding -----	286
G. MISCELLANEOUS CONSTRUCTION FEATURES	
78. Highways and railroads -----	288
(a) General -----	288
(b) Design features -----	288
(c) Earthwork specifications provisions -----	289
(d) Control techniques -----	293
79. Miscellaneous structures -----	294
(a) General -----	294
(b) Structure foundations on soil or rock -----	294
(c) Pile and caisson foundations -----	300
(d) Transmission tower footings -----	303
(e) Backfill -----	304
(f) Filters -----	305
H. STABILIZED SOILS	
80. General -----	309
81. Compacted soil-cement -----	310
(a) Design considerations -----	310
(b) Construction provisions -----	310
(c) Control techniques -----	315
(d) Control testing -----	316

<i>Section</i>	<i>Page</i>
82. Plastic soil-cement -----	318
83. Asphaltic concrete -----	322
(a) General -----	322
(b) Design considerations -----	322
(c) Construction provisions -----	324
(d) Control testing -----	325
84. Modified soil -----	326

APPENDIX

Procedures for Sampling, Classification, and Testing of Soils and Installation of Instruments

SAMPLING

<i>Designation</i>	<i>Page</i>
E-1 Disturbed sampling of soils -----	327
E-2 Undisturbed sampling of soils -----	341

CLASSIFICATION

E-3 Visual and laboratory methods for identification and classification of soils -----	387
E-4 Lists of laboratory equipment -----	408

LABORATORY TESTS

E-5 Preparation of soil samples for testing -----	419
E-6 Gradation analysis of soils -----	424
E-7 Soil consistency tests -----	435
E-8 Soluble salts determination of soils -----	448
E-9 Moisture determination of soils -----	450
E-10 Specific gravity of soils, aggregate, and density of irregu- lar blocks of soil -----	453
E-11 Proctor compaction test (moisture-density relations of soil) -----	466
E-12 Relative density of cohesionless soils -----	479
E-13 Permeability and settlement of soils -----	491
E-14 Permeability and settlement of soil containing gravel --	505
E-15 One-dimensional consolidation of soils -----	509
E-16 Measurement of capillary pressures in soils -----	521
E-17 Triaxial shear of soils -----	545

APPENDIX—Continued

<i>Designation</i>	<i>Page</i>
FIELD TESTS	
E-18 Field permeability tests in boreholes	573
E-19 Field permeability test (well permeameter method) ..	578
E-20 Inplace vane shear test	593
E-21 Field penetration test with split-tube sampler	603
E-22 Needle-moisture determination of soils	610
E-23 Field density of dry, gravel-free soils	610
E-24 Field density test procedure	613
E-25 Rapid compaction control	621
E-26 Vertical load-settlement relationship for individual piles	642
INSTRUMENT INSTALLATIONS	
E-27 Instructions for installing and reading hydraulic-type twin-tube piezometers in earth dams	650
E-28 Instructions for installing and reading porous-tube pie- zometers	686
E-29 Instructions for installing and reading internal vertical movement devices	699
E-30 Instructions for installing and reading internal horizontal movement devices	719
E-31 Instructions for installing and reading foundation settle- ment apparatus	730
E-32 Instructions for installing and reading measurement points—embankment	733
E-33 Instructions for installing and reading measurement points—concrete structures—outlet works conduits —conduit-type spillways	738
E-34 Instructions for installing and reading measurement points—concrete structures—chute and stilling basin of outlet works—chute-type spillways	741
E-35 Recording earthquake vibrations	745
ADDITIONAL FIELD AND LABORATORY TESTS	
E-36 Field permeability test (shallow-well permeameter method)	747

APPENDIX—Continued

<i>Designation</i>	<i>Page</i>
E-37 Method for calibrating mechanical laboratory soil compactors -----	755
E-38 Compaction test for soil containing gravel (moisture-density relations) -----	760
E-39 Investigations for rock sources for riprap -----	775
Conversion Factors	
Some conversion factors commonly used in earth construction _	782
Conversion Curves	
Conversion curves to convert inches to centimeters and feet to meters -----	786
Conversion curves to convert gallons to liters and acre-feet to cubic meters -----	787
Conversion curves to convert square feet to square meters and acres to hectares -----	788
Conversion curves to convert second-feet to cubic meters per second and miles to kilometers -----	789

LIST OF FIGURES—Continued

<i>Figure</i>	<i>Page</i>
44 Exploration for embankment materials—Location map and section for a typical damsite	109
45 Results of a major blast in a riprap quarry	117
46 Blast test in igneous rock investigated as a source for riprap	117
47 Talus slope of igneous rock proposed for riprap	118
48 Test pit cribbing	125
49 Excavation of hand-dug test pit in borrow area	126
50 Equipment-excavated test pit showing location of samples	127
51 Trenching, a low-cost method of obtaining soil samples	128
52 Shallow test trench excavated by bulldozer	128
53 Trench in steep abutment area excavated by bulldozer and backhoe	129
54 Exploring a borrow area with a hand auger	130
55 Types of hand augers (2-inch helical, 2- and 6-inch Iwan, and 6-inch Fenn (adjustable))	131
56 Illustration of the helical, disc, and barrel types of machine-driven augers showing basic differences	132
57 Undisturbed sampling with a double-tube helical auger and description of equipment	133
58 Disc auger used to explore borrow areas of fine-grained soils	134
59 Bucket auger used in exploration of a borrow area containing gravel particles	135
60 Enclosed auger	135
61 Diamond drill rig used in foundation exploration	137
62 Core barrels used for obtaining samples of rock	138
63 Arrangement of cores in a core box to insure proper identification of samples	139
64 Geologic log of a drill hole	148
65 Log of a hand-dug test pit—For foundation investigation	149
66 Log of a test pit excavated by backhoe—For both borrow and foundation materials investigations	150
67 Log of an auger hole—For borrow materials investigation	151
68 Penetration resistance and drill hole data for subsurface exploration	152
69 Gradation and plasticity data for loessial soils in the Kansas-Nebraska area	156
70 Summary of field and laboratory tests for embankment materials report—Impermeable-type materials	163

LIST OF FIGURES—Continued

<i>Figure</i>	<i>Page</i>
71 Summary of field and laboratory tests for embankment materials report—Permeable-type materials -----	164
72 Examples of floor plans for field control laboratories ---	172
73 Typical field laboratories -----	173
74 Large-scale permeability apparatus in a field laboratory--	182
75 Sluiced backfill in cut-and-cover section of a power tunnel_	185
76 Placing a 3-foot blanket of riprap over an 18-inch cobble blanket in the tailrace of a powerplant -----	187
77 Vibratory consolidation of sand and gravel beneath a spillway slab -----	192
78 Consolidating backfill about a conduit by means of internal vibrators -----	193
79 A deposit of impervious material which overlies a deposit of pervious material -----	194
80 An example of an arc failure of a natural slope (landslide) resulting from excessive moisture entering the material -----	198
81 View of cutoff trench at Davis Dam, Arizona-Nevada --	199
82 View of cutoff trench at Twin Buttes Dam, Texas -----	200
83 View of a typical sinkhole (pothole) -----	203
84 Portable grout machine used to force a mixture of cement and water into holes drilled in the foundation -----	204
85 Cracking and settling of canal bank in dry, low-density silt -----	208
86 Ponding dry foundation of Trenton Dam, Nebraska, to facilitate consolidation -----	209
87 Criterion for treatment of relatively dry fine-grained foundations -----	210
88 Curtain grouting in right abutment of Granby Dam, Colorado -----	216
89 Temporary diversion channel through Bonny Dam, Colorado -----	218
90 Foundation preparation by washing to remove detrimental air-slaked and loose material at Twin Buttes Dam, Texas -----	220
91 Power tamping of earthfill at contact with irregular rock abutment -----	222
92 Separation plant at Meeks Cabin Dam, Wyoming, where impervious material containing oversize was screened into fractions above and below 5 inches -----	224