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_o-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.

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