Teaching Aids and Allied Materials in Engineering Geology

Committee on Teaching Aids
Division on Engineering Geology
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INTRODUCTION

THE FIELD of engineering geology is being discussed at an ever increasing rate by many writers —in textbooks, symposia, special papers, reports, periodicals, and popular publications. This accelerated acceptance of engineering geology has focused attention on the academic preparation required of an engineering geologist and the material needed for course work. Several writers in recent years have ventured suggestions on the nature of academic training considered appropriate (Berkey, 1942; Burwell, 1946; Kiersch, 1955; and others), but there have been few recommendations as to teaching materials needed.

This report, based on the assessed opinions of Division members, attempts to clarify the current views on many aspects of teaching engineering geology such as: (1) constitution of the field; (2) preparation needed for professional practice; (3) manner of presenting the formal training; and (4) materials useful in teaching courses.

HISTORY-TEACHING AIDS WORK

In an effort to improve professional understanding and supply needed teaching materials, the Committee on Teaching Aids of the Division on Engineering Geology, Geological Society of America, was formed in 1948. Through the years, the Committee[1] has prepared and distributed many valuable teaching aids to supply engineering geology, currently maturing as a formalized branch of applied geology, with acceptable curricula and "standard" teaching materials. The initial contribution of the Committee was a selected reading list in engineering geology, which was made available in preliminary form in 1949, as a working draft in 1951 and 1952, and subsequently was published as Engineering Geology Reference List (Happ, 1955). An Inventory of Available Core Boring Samples was complied and published by the Committee in 1950, preparation of case histories in engineering geology was initiated in 1951 and subsequently expanded until it required formation of a separate committee of the Division in 1953. A questionnaire on teaching methods, materials, and texts in use for engineering geology was circulated in 1948 and the results were publicized by progress reports in November 1948, March 1950, and August 1950. This initial survey raised the question of sample curricula for engineering geology majors, a subject treated in the present report with suggested courses of study.

Two outside committees whose interests are closely allied to that of the Division should be mentioned: (1) the Sub-Committee on Geological Engineering[2] in the Committee on Education, American Geological Institute (1951); and (2) the Committee on Landslide Investigations[3], Highway Research Board, National Research Council (1951-1957). The American Geological Institute initiated two projects of a "general" character in 1957 that promise the cooperation of Division members: (1) compilation of information and preparation of a manual on teaching aids in the geosciences; and (2) compilation of a list of movies about the geosciences[4].

The outlook for engineering geology is bright and encouraging. However, the more quantitative approach to geologicic problems is a challenge to the profession and necessitates a modified course of training for geologists preparing to enter the field. In an effort to assimilate current thinking and arrive at a better understanding of the Division members' views on course work and allied materials considered appropriate for training engineering geologists, the present Committee on Teaching Aids circulated a 12-item questionnaire in the Spring of 1955 (Appendix A). In drafting the questionnaire, the Committee received helpful ideas from S. S. Philbrick, E. B. Eckel, and others; the parent Geological Society of America financed reproduction and distribution of the questionnaire and of this report. A good response to the questionnaire brought 102 replies. Many individuals appended separate comments, and at least twelve members wrote covering letters explaining their personal views. To all participants, the Committee expresses appreciation for their interest and cooperation; we regret it has been impossible to credit all opinions cited herein. A preliminary analysis of the survey by this Committee was presented at the annual meeting of the Division on Engineering Geology in 1955[5], followed by a progress report in 1956[6]. This report has profited from review and criticism by members of the Executive Committee of the Division for 1955-1957, E. B. Burwell, Jr., A. B. Cleaves, E. Dobrovolny, T.W. Fluhr, S. C. Happ, W. H. Irwin (Chairman, 1956), R. F. Legget, R. H. Nesbitt, S. S. Philbrick (Chairman, 1955), and J. R. Schultz (Chairman, 1957), and members C. P. Holdredge and Parry Reiche.

1. The Committee on Teaching Aids was established under the chairmanship of A. B. Cleaves (1948-1954) with members S. C. Happ (1948-1953) and E. E. Wahlstrom (1948-1950). In 1951, R. M. Foose, R. W. Chapman, and J. H. Mackin were additional members.
2. Sub-Committee on Geological Engineering (1951) composed of A. B. Cleaves (Chairman), S. S. Philbrick, and G. Rittenhouse.
3. Committee on Landslide Investigations (1951-1957), composed of E. B. Eckel (Chairman), R. F. Baker, A. B. Cleaves, S. E. Horner (1951-1955) and J. D. McNeal (1955-1957), Ta Liang, H. Marshall, S. S. Philbrick, A. M. Ritchie, A. W. Root, R. Smith, D. J. Varnes, W. A. Warrick, and E. J. Yoder.
4. GeoTimes, March 1957, v. 1, no. 9, p. 12
5. Interim report: Committee on Teaching Aids and Allied Material, Division of Engineering Geology, Geol. Soc. Am., Nov. 7, 1955, 11 p.
6. Annual report: Committee on Teaching Aids and Allied Material, Division of Engineering Geology, Geol. Soc. Am., Oct. 31, 1956, 4 p.

DEFINITION OF ENGINEERING GEOLOGY

The Committee defined the subject area of engineering geology for the purpose of the questionnaire as "geology in civil engineering and also certain specialized applications in military, agricultural, irrigation, petroleum, and mining engineering." Engineering geology was thus limited to the application of geology to civil engineering and specialized branches thereof. Many institutions currently offer a broad curriculum entitled Geological Engineering as preparation for general practice in applied geology (Cleaves, 1951). The Committee intended that its definition would designate engineering geology as a separate and specialized branch of applied geology. Questionnaire replies indicate a growing distinction between the various branches of applied geology and cite several colleges that now offer a curriculum for engineering geology majors. Among the experienced and practicing engineering geologists, there is strong sentiment for clarifying and formalizing the field.

The Executive Committee[7] of the Division on Engineering Geology for 1952, together with a special committee[8], drafted the following definition of a professional engineering geologist:

> A professional engineering geologist is a person who by reason of his or her special knowledge of the geological sciences and their application to engineering practice, acquired by professional education and practical experience, is qualified to render professional services for the purpose of assuring that the geologic factors affecting the location, design, construction, and operation of engineering works are adequately provided for by the responsible engineer.
>
> A person is qualified as a professional engineering geologist if (a) he, or she, holds a bachelor's degree in geology, engineering geology, geological engineering, or mining engineering from a college or university of recognized standing and if he, or she, shall have been in responsible charge of important engineering geological work for at least 4 years; or (b) if he, or she, is a geologist of recognized standing and has had not less than 12 years of practical experience in the application of geological sciences to engineering practice at least 4 years of which shall have been in responsible charge of engineering geological work.

DEFINITION OF COURSES—OPTION IN ENGINEERING GEOLOGY

Currently the term "Engineering Geology" is loosely applied in college and university curricula, commonly to designate an introductory course for engineering students covering physical geology with some engineering applications. In an attempt to standardize and clarify subject areas, this level course is herein labeled Geology for Engineers. Today some 57 colleges and universities offer this type of course and 1 additional institution plans on initiating such instruction soon (tabulated APPENDIX B). Designed to teach engineering students what constitutes geology, relationship to engineering, and when and how to use an engineering geologist.

A second course in geology designed primarily for the civil engineering student is offered by 15 colleges, and one additional institution plans to offer such a course (APPENDIX C). This type of course, which further acquaints the student with the uses and applications of geology in engineering, is herein labeled Applications of Geology for Engineers (an Advanced Geology for Engineers). The material included varies according to the school; many such courses confine their presentation to applications, while a few are largely restricted to mineralogy for engineers, and one, historical geology for engineers.

For the engineering student, exclusive of the mineral industries major, this course work is probably his only contact with the subject of geology and its engineering applications except for such allied courses as soil mechanics, rock mechanics, and foundation engineering. While offering an insight into the value of using the services of a well-trained geologist, these courses alone are not considered adequate geologic training for a professional engineering geologist. Although frequently the argument arises in practice as to whether an engineering geologist is basically an engineer or a geologist, questionnaire replies expressed a more than six to one preference for defining the engineering geologist as a trained geologist rather than a trained engineer with limited geological background (two or three courses). There is general agreement, then, that the professional engineering geologist is "a trained geologist with a general knowledge of engineering practice and possessing a practical bent" consistent with the definition given previously.

To introduce the trained geologist to the professional practice of engineering geology, 35 colleges indicate they offer course work at the advanced level (senior-graduate), and one institution plans to offer this training in the future (APPENDIX D). This type of course is herein labeled Engineering Geology. Of the 35 colleges, two-thirds offer a formalized upper division or graduate-level lecture course (some include laboratory), while the remainder cover the subject as a seminar. A basic comment about this course by the members was—"Should be taught by an experienced engineering geologist who is familiar with the profession as practiced".

Increased interest in a course of study or option to train engineering geologists (as distinguished from geological engineers) has resulted in the establishment of an engineering geology major at: University of California (Berkeley), Colorado School of Mines, Michigan College of Mining and Technology, Rensselaer Polytechnic Institute, Syracuse University, and Washington University (St. Louis). (Curricula are briefly described in APPENDIX E). In addition three

7. E. B. Burwell, Jr., (Chairman), E. B. Eckel, and P. D. Trask.
8. S. S. Philbrick (Chairman), B. C. Moneymaker, and S. Paige.

schools offer a combination Geology-Civil Engineering curriculum with dual degrees: Kansas State College (5 years), University of Notre Dame (5 years), and Louisiana State University and Agricultural and Mechanical College (6 years). The University of Illinois encourages a similar combination without the dual degrees. For completeness of this report, those 32 institutions offering the broad geological engineering curriculum or its equivalent are tabulated in APPENDIX F.

Of the schools offering course work in geology for the engineering student as well as Engineering Geology for the trained geologist, it is interesting that most offer additional course work in overlapping fields: nonmetallic mineral deposits by some 28 schools; ground water geology by 22 with four planning to initiate courses; and introductory soil mechanics by 23, with two expecting to initiate courses.

TEXTBOOKS

Replies uniformly agree that the available textbooks for course work in Geology for Engineers and Engineering Applications of Geology are quite satisfactory. Wide use is made of such texts as Legget (1939), Trefethen (1949), and Schultz and Cleaves (1955), which have been adopted in about equal proportions. Many instructors use standard physical geology texts, such as Gilluly, Waters, and Woodford (1951), and Longwell and Flint (1955), as supplemental sources, along with an occasional reference to specialized papers in Paige (1950), Trask (1950), and Van Tuyl and Kuhn (1950). The glossary of geologic terms by Stokes and Varnes (1955) has proved very helpful to engineers. In the second course for engineering students, Applications of Geology for Engineers, the emphasis is on case histories and, although the texts mentioned above are all used, Legget (1939) and Paige (1950) are most popular because of their diversity and case approach.

Generally the replies express some dissatisfaction with the texts available for Engineering Geology. Almost every one indicates that several texts are used in combination, along with various reports, symposia, and other special papers. The Berkey Volume (Paige, 1950) is in use by all instructors, with Applied Sedimentation (Trask, 1950) and Applied Geology (Van Tuyl and Kuhn, 1950) being used by half the schools. Instructors indicate that as valuable supplementary materials they use the texts by Legget, Trefethen, and Schultz and Cleaves along with numerous recent symposia and special reports published by the following organizations: American Society for Testing Materials (symposia on Surface and Subsurface Reconnaissance, Identification and Classification of Soils, Aggregate and Concrete, and others); American Society of Civil Engineers; Highway Research Board; agencies of the Federal Government such as the Geological Survey (folios and special geologic maps), Corps of Engineers, Bureau of Reclamation, and Tennessee Valley Authority; and certain State Geological Surveys. Also useful are textbooks and symposia in overlapping and supporting fields such as ground water, soil and rock mechanics, geophysics, and seismology. The Engineering Geology Reference List (Happ, 1955) and the historical review and subject outline in Engineering Geology (Kiersch, 1955) are reported helpful in teaching this course.

The consensus of Division members regarding Engineering Geology is that a more complete text is warranted; as expressed by many, "we need a text covering the field as it is practiced." The majority feeling seems to be that a well-rounded Engineering Geology text should include the pertinent geologic processes and phenomena of particular importance to engineering geology, the techniques and tools of this field, and a liberal number of appropriate case histories. Together with these aspects should be blended the fundamental principles of engineering design and the nomenclature of engineering structures and construction procedures. This, then, interweaves design requirements and the geologic setting with their effects as substantiated by case histories (the current practice in teaching the other branches of applied geology).

A number of new textbooks are appearing or are in preparation that reflect the general feeling regarding Engineering Geology. They include the following:

Krynine, P. D., and Judd, W. R., 1957, Principles of engineering geology and geotechnics: N. Y., McGraw-Hill Book Co., 730 p. (Undoubtedly prove very useful text in Engineering Geology)

Dapples, E. C., and Osterberg, J. O., in prep., Geology for civil engineers: N. Y., John Wiley and Sons.

Legget, R. F., in prep., Geology and engineering (revised edition): N. Y., McGraw-Hill Book Co.

Terzaghi, Karl, in publ., Civil engineering geology: N. Y., John Wiley and Sons (emphasis on case histories).

Trask, P. D., and Kiersch, G. A., in prep., Engineering geology: N. Y., Prentice-Hall Inc.

The Division formed a Committee on Review Articles[9] in 1957 as an outgrowth of action by the parent Society's Review Article Committee. Periodic volumes of review papers are planned for publication by the Division's Committee that will encompass all branches and aspects of engineering geology.

TREATISES OR REPORTS
(New or in Preparation)

Some 22 reports on research studies covering numerous phases of engineering geology were in preparation by Division members as of 1955. Nearly half deal with landslides; perhaps the most ambitious is

9. T. W. Fluhr (Chairman), Alice Allen, E. B. Burwell, Jr., S. C. Happ, W. H. Irwin, G. A. Kiersch, R. M. Leggette, and G. A. Muilenberg, and the Executive Committee officers (ex-officio).

the forthcoming publication on "Landslides and Engineering Practice," sponsored by the Highway Research Board and edited by E.B. Eckel. Probably the second largest number of forthcoming publications will be in the field of Arctic construction, permafrost, and related problems under study by the U.S. Corps of Engineers and Geological Survey, and private investigators. Other fields include the following: geology and engineering properties of loess; beach erosion and harbor installations; engineering properties of bedrock weathering products; exploration techniques; case histories of engineering structures, e.g. dams, tunnels, highways, and bridges; theory of pressure grouting; and significance of properties of concrete.

This summary does not include the many case histories being completed by geologists on "as constructed" engineering projects or the research programs of such groups as the U.S. Bureau of Reclamation, Corps of Engineers, Geological Survey (especially Engineering Geology, Military Geology, and Alaskan Geology Branches), and Beach Erosion Board, various State Geological Surveys, American Society of Civil Engineers, American Society for Testing Materials, and other organizations.

COMMITTEES COMPILING DATA

Two noteworthy outside committees already have been mentioned, the Sub-Committee on Geological Engineering, and the Committee on Landslide Investigations. Of interest to all Division members is the joint Geological Society of America-American Society of Civil Engineers Committee on Engineering Geology[10], which has four task committees currently active: (1) Committee on Products of Weathering of Bedrock and their Engineering Properties[11] presented a symposium of five papers at the 1955 GSA national meeting, New Orleans, and a symposium of three papers at the 1957 ASCE regional meeting, Jackson, Mississippi; (2) Committee on Influence of Geological Factors on Tunnel Construction[12], presented a symposium of four papers at the 1955 ASCE meeting, St. Louis, that is being published in the ASCE Proceedings (1957) and in addition is collecting case histories demonstrating the effective application of geology to tunnel design and construction; (3) Committee on Nomenclature and Engineering Properties of Shale,[13] is compiling a bibliography and establishing a classification emphasizing properties of shales; and (4) Committee on Nomenclature and Engineering Properties of Rock[14] (other than shale), is formulating a classification of rocks based on engineering properties rather than on rock genesis.

Additional committees that have the interest and participation of some Division members include: Committees of the Highway Research Board covering a wide range of subject areas closely allied to geology; the American Society for Testing Materials Committee D-18 on Soil for Engineering Purposes and Committee C-18 on Natural Building Stone; the American Society of Civil Engineers Committee on Grouting; and committees of the American Concrete Institute, the American Society for Testing Materials, and affiliated organizations on petrographic properties of aggregates and concrete constituents.

CASE HISTORIES

Division members are nearly unanimous in their agreement that case histories are useful in teaching and in professional practice. The Division has an active committee under chairman P. D. Trask (1953-1957) compiling case histories that follow a general format and are issued as bound booklets (8 1/2 by 11 inches). The following nine case histories are available as a package of some 65 pages for a price of one dollar. Remittances and requests should be sent to the Secretary, Geological Society of America, 419 West 117 St., New York 27, N.Y.

Fluhr, T. W., Geology of the Queens Midtown Tunnel, New York.

Fluhr, T. W., Geologic Engineering Features of the West Delaware Tunnel, New York.

Fox, P. P., Geology Exploration and Drainage of the Serra Slide, Santos, Brazil.

Holdredge, C. P., Geologic Reports on Damsites in the John Day Basin, Oregon.

Monahan, C. G., Geologic Features at McNary Dam, Oregon.

Staples, L. W., Landslide at North Abutment of Lookout Point Dam, Oregon.

Supp, C. W. A., Engineering Geology of the Chesapeake Bay Bridge.

Supp, C. W. A., Obear, G. H., and Whikeheart, R. E., Occurrence, Investigations and Treatment of an Embankment Foundation Failure, on Ohio Turnpike Project No. 1

10. The Administrative Committee consisted of the following in 1956: Karl Terzaghi (Chairman), E. B. Burwell, Jr., and E. B. Eckel (GSA), R.W. Spencer, H.O. Ireland, and W. R. Judd (ASCE). GSA representatives in 1957 are A. B. Cleaves and P. D. Trask.
11. T. H. Thornburn (Chairman), W. V. Conn, D. U. Deere, P. P. Fox, R. E. Grim, J. W. Hilf, K. B. Hirashima, C. P. Holdredge, G. A. Kiersch, D. G. Moye, F. R. Olmstead, A. W. Root, J. R. Schultz, and G. F. Sowers.
12. A. B. Cleaves (Chairman), C. Rankin, A. B. Reeves, E. B. Waggoner, T. W. Fluhr, A. H. Nicol, and R. H. Carpenter, with additional members in 1957, B. C. Moneymaker and A. von Moos.
13. S. S. Philbrick (Chairman, 1956), J. W. Early, H. Forbes, M. E. King (1954), K. S. Lane, R. H. Merrill, J. A. Trantina, and Vladimir Wolkodoff.
14. R. C. Mielenz (Chairman), E. A. Abdun-nur, N. E. Grosvenor, J. A. Handin, R. W. Lemke, L. A. Obert, H. B. Stuart, A. Van Valkenburg, Jr., and D. O. Wolff.

Sidrer, Paul. Engineers' problems in estimating quantity of bedrock to be removed in estimating cost of highway-construction jobs.

A second group of case histories is currently being published. Because of the widespread interest in the data supplied by a good history, investigators having appropriate material in their files are urged to contact the Chairman, Case History Committee of the Division and arrange to submit a report for publication.

RESEARCH PROJECTS

Research at large in engineering geology up to 1948 was reviewed by Paige and Rhoades (1948). Because research is an integral part of any active college program in engineering geology, the questionnaire inquired into the current status of research in institutions offering course work and also in the profession generally. Fifteen institutions or organizations state that they are performing research in engineering geology; while an additional 14 institutions or organizations indicate an interest in performing research. Replies, as a rule, favor research basic to engineering geology; lack of financial support continues to be the principal "road block."

A wide range of specialized studies is underway by Federal agencies, colleges, and private organizations, along with a few projects by individuals under terms of research grants. The Geological Society of America made its first project grant in engineering geology in 1954 (significance of rock weathering on the engineering and physical properties of rock and soil).

The following selected list of projects[15] underway in 1957 by the Engineering Geology Branch of the U. S. Geological Survey gives an insight into some of the research problems currently being investigated: studies of sea-cliff erosion in New England to determine the rate and pattern of cliff recession, factors responsible, mechanics and prediction of erosion, and recommendations for control; studies of landslides in the Fort Randall Reservoir area, South Dakota, to determine the short and long range effects of a reservoir on the ground water regime and slope stability of the Pierre shale; preparation of a Manual of Highway Geology to illustrate and explain the principles and practices of geologic applications in highway construction; study of Osceola Mudflow, Washington, to develop criteria for distinguishing volcanic mudflow deposits from other unsorted sediments; review of literature on subsidence to find "gaps" in geologic knowledge as a guide to programming future research studies; research on loess to determine the chemical, mineral, and physical properties as related to behavior in engineering use; summary studies of landslides; and research on rock deformation which applies modern theories of rock mechanics, plasticity, and elasticity to the analysis of geologic structures and field problems.

15. L. P. Buck, Personal Communication, March 12, 1957.

Additional problems, such as of particular interest to a construction agency, are illustrated by research in progress by the U. S. Bureau of Reclamation:[16] the use of geophysical (seismic) techniques to determine the modulus of elasticity of dam site foundation and abutment rock "in situ" as a supplement to modulus data secured by laboratory testing of individual rock samples; measurement of natural electrical currents (generated in earth materials by moving water) for possible use in canal seepage investigations; correlation of engineering laboratory test data (unconfined and triaxial compressive strength, modulus of elasticity, et al.) with petrographic and geologic characteristics of various rock types.

MOTION PICTURES AND OTHER AUDIO-VISUAL AIDS

Although a variety of motion pictures outlining geologic principles is stocked by most college film libraries, little attention has been given to collecting a representative group of motion pictures and other audio-visual aids that deal specifically with the application of geology to civil engineering. APPENDIX G of this report contains a preliminary and very incomplete listing of 16 mm. motion pictures probably appropriate for use in engineering geology courses. The list can be greatly improved and expanded if persons using such materials will provide the Committee with additional information about the films listed and full references to other films that should be included. For each film it is desirable that the brief description, some recommendations for class use (type of course, category of subject matter, etc.), and a rating (e.g., excellent, good, fair) be based on actual viewing. The release date of the film should be indicated if known. Information on audio-visual aids should be sent to Dr. John T. McGill, U. S. Geological Survey, Department of Geology, University of California, Los Angeles 24, California, for processing by the Sub-Committee on Visual Aids.

For a general guide to audio-visual aids dealing with geology and related subjects, the reader is referred to the directory published by the A.A.P.G.,[17] which contains the addresses of college and university film libraries and other producers and distributors in addition to an extensive classified film catalogue.

Several members of the Division have expressed a willingness to submit personal libraries of 2" x 2" color slides for copying and distribution to interested parties. Series of annotated slides showing the construction histories of various types of major engineering projects are desired. Especially valuable would be slides illustrating the engineering geology

16. W. H. Irwin, Personal communication, July 22, 1957.
17. American Association of Petroleum Geologists, Committee on Applications of Geology, 1951, Directory of films and slides of possible interest to geologists, 2nd edition: Am. Assoc. Petroleum Geologists, Box 979, Tulsa 1, Oklahoma, 39 p., 50 cents.

case histories being prepared under the sponsorship of the Case Histories Committee of the Division. Information on any pertinent and available 2" x 2" slides, 35 mm. filmstrips, and 3 1/2" x 4" lantern slides is welcome and will be compiled for listings in subsequent reports.

The Committee feels that the judicious but widespread use of audio-visual aids will go far towards "advertising" the engineering geology profession at the student level where there is a critical need for convincing "salestalks."

BIBLIOGRAPHIC MATERIAL

More published abstracts, particularly covering the foreign publications, were invariably requested by the members. A sincere interest was expressed in furthering some form of annotated bibliography of engineering geology; all agree, however, that current bibliographies should not be duplicated. Because much basic information is published in foreign literature generally unavailable to the American worker, members suggest that the Division support a more liberal distribution of abstracts of foreign-language as well as English publications. A partial solution is to encourage the authors of engineering geology papers to publish in the more readily available journals. Two suggestions for handling and distributing a larger volume of bibliographic material on engineering geology are:

(1) An associate editor on the staff of the Geological Abstracts (American Geological Institute) could coordinate and publish engineering geology material from sources not currently covered. This would include reports and symposia of somewhat limited circulation.

(2) The engineering geology section of Annotated Bibliography of Economic Geology could be broadened to include both foreign and English materials not currently covered. This would be financed by supporting funds from the Division or other sources.

Partial or complete bibliographies on the geology and foundation conditions of many urban areas have been compiled and can fill numerous teaching needs. Material on the following cities can be consulted through arrangement with the Engineering Geology Branch, U. S. Geological Survey, Federal Center, Denver, Colorado:

Boston, Mass.; Washington, D.C.; Denver, Colo.; Knoxville, Tenn.; Seattle, Wash.; Great Falls, Montana; New Orleans, La.; Chicago, Ill.; New York City, N.Y.; San Francisco and Los Angeles, Calif.; and Mexico City, Mexico.

Also, data on Boston is available from the Subsoil Committee of the Boston Society of Civil Engineers. Material on San Juan, Puerto Rico can be procured from D. U. Deere, University of Illinois, Urbana.

FIELD AND LABORATORY EXERCISES

Comments from the members in the questionnaire overwhelmingly endorsed the advisability of having field trips in conjunction with the engineering geology courses. The only criticism raised was that field exercises are too dependent on local conditions. It was strongly recommended that the students be taken to nearby projects such as excavations, exploratory drilling, dam sites, highway and road cuts, tunnels, aggregate processing plants and to more permanent activities such as quarries, mines, and laboratories. Special attention should be given to the methods used and the equipment employed. Interest in such construction projects should be developed outside of the course activities; one suggestion urged that the students become "sidewalk superintendents" (presumably this was not to be overdone). It was felt that the greatest value on trips to construction projects would come from a guided tour by the resident geologist. Several suggested longer trips—three days to a week —so that the regional geologic setting could be studied and significant features of the geomorphology, structure, and stratigraphy could be related to proposed engineering structures and engineering geology problems.

The student should be required to prepare a report on his trip describing the salient features of the project, and the engineering problems that are related to the geology. Trips should be taken to sites that demonstrate both good and poor planning (geologically) to illustrate geologic reasoning and application. Trips to undeveloped sites for engineering projects could begin by a laboratory plotting of the site on available topographic and geologic maps. Subsequently for the senior-graduate level students, a "team" of two, engineering geologist and engineer in the same stage of training, could be assigned to develop this site jointly through the planning, design, and construction stages; they would report the problems involved as they visualize them and recommend a solution.

Much less enthusiasm was expressed for laboratory exercises, the general consensus being that the time could be better spent on field trips. Those favoring laboratory exercises do so perhaps because of conditions over which they have no control. Usually the course includes a certain time for laboratory, possibly one afternoon each week. That single afternoon may be too short a time to visit a project, or perhaps the weather for part of the year may not permit such trips. The instructor must resort to laboratory exercises to utilize this time effectively. While not ideal, these exercises can be made practical and informative.

Following are some specific suggestions as to laboratory materials and problems:

1. Prepare exercises from geologic maps, especially from the U. S. Geological Survey Hollidaysburg special folio, and from the New England surficial geology maps in the U.S.G.S. Geologic Quadrangle Map series.

2. Using aerial photographs (as well as geologic maps) have students locate potential sites for dams, water wells, fill material, aggregate, underground installations, highway and tunnel alignments, et al.
3. Supply the students with outlines describing what to look for and how to describe their observations when faced with a specific problem; for example, how to map and describe a gravel deposit in a way that will be most useful to a geologist or engineer in the future.
4. Have students study published reports by Federal and State agencies and private companies showing results of subsurface exploration. Require them to complete an alternate interpretation of the data for sake of instruction; discuss merits, how to check in field.
5. Have students plan layout of exploratory holes which will give maximum data while minimizing drilling and report writing.
6. Set up laboratory equipment demonstrating various phenomena, such as flow of water through permeable media.
7. Have laboratory excercises stress the basic subjects such as structure and sedimentation.
8. Perform some of the routine physical property tests on construction materials and relate results to both the megascopic and microscopic geologic features.
9. Utilize models of typical engineering structures to demonstrate the relation of such structures and their operation to possible sites and geologic conditions.

If the engineering geology course is to include both laboratory and field trips (as probably most will), an effective approach would be to design some laboratory exercises as preparation for the field trips. Time never seems to be adequate on field trips, and the students seem to benefit most if they have previously and more leisurely become steeped in the methods to be followed and the features to be observed.

A SUGGESTED COURSE OF STUDY

As previously mentioned, the members overwhelmingly agree that the engineering geologist should be a trained geologist with a general knowledge of engineering practice and possessing a practical bent. Fundamentally, then, the lower division academic training would include a general foundation in chemistry, mathematics, physics, engineering and descriptive drawing, surveying (including plane table), English, and allied subjects.

The student would concurrently or, in some instances, afterwards complete the "building-block" courses of geological science with physical and historical geology, mineralogy, petrology, structural geology, optical mineralogy and petrography, field geology, and possibly paleontology and principles of mineral deposits.

To this framework, whether taken in a Liberal Arts College or a Technical College curriculum, the members strongly recommend adding as many as possible of the following advanced courses (senior-graduate) in geology, listed in order of member preference: Engineering Geology, ground water geology, sedimentation, geomorphology, advanced structural geology, stratigraphy, aerial photo and map interpretation, sedimentary petrology, nonmetallic mineral deposits, and seismology. Fewer replies suggest such general courses as advanced physical geology, surficial geology, advanced petrology-petrography, and regional geomorphology. For the student who wishes to specialize, courses in hydrology, ground-water hydrology, oceanography, or glacial geology are suggested.

In addition to appropriate advanced courses in geology, certain allied subjects are recommended by the members as follows (listed in order of preference): introductory soil mechanics, geophysical methods, report writing, strength of materials, mining and excavation methods, rock mechanics, hydraulics, engineering economics, and engineering design fundamentals. For those wishing to specialize further, such courses as advanced soil mechanics, concrete technology, or foundation engineering may be appropriate.

It is doubtful that an adequate curriculum as advocated by the members can be completed by a student in less than five years. This seems apparent, regardless of whether he (1) completes his basic courses at a Liberal Arts College and then transfers to a Technical College for specialized courses during the fifth year, or (2) completes an undergraduate curriculum at a Technical College with the emphasis on basic courses and allied subjects and then devotes the fifth year largely to advanced geology courses. Suggested outlines of desirable courses under both "approaches" to prepare for Engineering Geology practice are given in APPENDIX H.

One difficulty commonly experienced by the student completing a Liberal Arts curriculum is the matter of prerequisites for enrollment in some of the desirable engineering courses. At many schools, particularly the Universities, prerequisites virtually require that the student be an engineering major. In such instances, what appears needed are courses by the engineering department, such as Introductory Soil Mechanics for Geologists and Strength of Materials for Geologists, analogous to the existing courses in Geology for Engineers. Prerequisites for these special-service courses could be lower division physics and mathematics.

A few members believe that the engineering geologist should have a basic degree in civil engineering with additional training in geology. This view, although understandable, tends to place an overemphasis on engineering at the expense of geology. Under such a plan, engineering geology would be separated from its sister professions in applied geology, a distinction that does not seem warranted. For example, the mining geologist is expected to posses a general knowledge of mining engineering but is not necessar-

ily a mining engineer with graduate training in geology. He is a well-trained geologist with a general background in mining engineering and a practical tendency. The general consensus of replies indicates that a similar balance best fits the needs of the engineering geologist; he is a well-trained geologist and in addition possesses enough engineering training and experience to work intelligently with the practicing engineer. However, if the student initially trained in civil engineering can see fit to spend at least two additional years in intensified study of geology and allied subjects, his training would then largely fulfill the basic geologic requirements.

A basic degree in geology followed by a fifth year of graduate training in civil engineering would meet a majority of the suggested needs; however, this is generally impractical or impossible for the average geology major because of the prerequisites for graduate status in engineering. It goes without saying that much of the geologist's important engineering training necessarily must be acquired through working with engineering problems and construction.

A new approach to the whole field of earth science is currently being offered to the third year civil and agricultural engineering students at the University of Melbourne, Australia[18]. This full-year integrated course presents fundamentals of geology and engineering geology, soil chemistry, soil mechanics, and soil physics to students who have preferably had a prerequisite of physical geology. A syllabus of the course is given in APPENDIX I.

EMPLOYMENT OPPORTUNITIES IN ENGINEERING GEOLOGY

No longer are the large governmental agencies that specialize in dam construction the principal employers of engineering geologists. Rather, the trend is toward the employment of these specialists in private architect-engineer organizations, contracting firms, municipalities, utility companies, Atomic Energy Commission, World Bank, local irrigation districts, local bridge and highway authorities and departments, large land companies with active agricultural interests, railroads, and a host of other organizations that practice specialized engineering. A partial list of organizations employing engineering geologists in the United States (part-or full-time) is given in APPENDIX J to aid in advising students. The instructor-advisor with engineering geology experience should counsel the student candidate by recommending phases of the profession for which he is best suited.

GUEST SPEAKERS

Guest lectures by practicing engineering geologists of the region are extremely desirable and most welcome additions to the course work. A roster of potential guest speakers residing in the United States who have agreed to participate is given in APPENDIX K.

CONCLUSIONS

Today the colleges have an unusual opportunity to strengthen and enhance the field of engineering geology by offering well-rounded curricula; such action will automatically further the recognition of engineering geology as a separate and mature branch of applied geology.

A portion of the teaching material in this report will become out of date in a short time because of the rapid advance and expansion of this growing field. Additions and new data are solicited from recipients of this report for inclusion in reports by subsequent Committees[19]. In particular it is hoped that later reports will be expanded to include coverage of sources and curricula for Canada and other areas outside the United States.

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APPENDICES

APPENDIX A

COMMITTEE ON TEACHING AIDS QUESTIONNAIRE ON TEACHING AIDS AND ALLIED MATERIALS, 1955

QUESTIONNAIRE OF _____

COMPLETED BY _____ (Organization or Individual)

Note: Engineering geology as herein used covers geology in civil engineering and also certain specialized applications in military, agricultural, irrigation, petroleum and mining engineering.

I. TEXTBOOKS (including other publications used as texts)

Do you offer course work in:

A._____ Geology for Engineers (physical geology with applications)?
B._____ Applications of Geology for Engineers (for engineers with physical geology prerequisite)?
C._____ Engineering Geology (senior-graduate level geology for trained geologists)?

Of the following, what text have you found most appropriate for the course or courses given? Indicate as Course, A, B, or C above.

_____ Blyth "Geology for Engineers"
_____ Legget "Geology and Engineering"
_____ Trefethen "Geology for Engineers"
_____ Schultz and Cleaves "Geology in Engineering"
_____ Berkey Volume "Appl. Geology to Engineering Practice" GSA
_____ Applied Sedimentation - Trask editor
_____ Applied Geology (Colo. Sch. Mines, Quarterly)
_____ Others (give title)

What supplementary texts, symposia, or other publications do you use in teaching, exclusive of case histories? (e.g., USGS Translations, map interpretation folio, et al.)

_____ Are any of these texts ideal from your standpoint? If not, describe your ideal briefly.

_____ Are you currently planning to prepare a textbook or specialized publication in the field of engineering geology? If so, what is its title and instructional level (engineers or trained geologists), publisher, anticipated date?

II. TREATISES OR REPORTS IN PREPARATION ON SPECIFIC SUBJECT AREAS

_____ Are you currently working on the completion of a treatise or special report within the scope of engineering geology, e.g., landslides, highway geology, tunnel geology, et al? If so, what subject area will be covered, publisher, and anticipated date?

III. COMMITTEES COMPILING DATA COVERING SPECIFIC SUBJECT AREAS

The GSA-ASCE four-task committees cover: (a) bedrock weathering products; (b) physical properties of rocks, exclusive of shale; (c) physical properties of shale; and (d) geological factors influencing tunnel construction

_____ Are you aware of or associated with other committees for similar purposes? If so, please state subject area, members, organization, anticipated publication date and medium.

IV. CASE HISTORIES

A committee of the Division is compiling pertinent case histories for teaching purposes under Parker Trask.

_____ Are you aware of or associated with any other effort to compile case histories and present them in published form? If so, please state pertinent facts.

Do you find case histories useful in teaching engineering geology (_____); in professional work (_____)?

V. RESEARCH PROJECTS

_____ Is your organization (a) performing, (b) interested in performing research in the field of engineering geology?

_____ If performing research, please state short description of scope, program and anticipated significance for application.

_____ If interested in performing research, what subject area, how financed?

VI. MOTION PICTURES AND OTHER AUDIO-VISUAL AIDS

Please give the following information for all motion pictures and other audio-visual aid material which you consider appropriate for engineering geology course work: name, source, brief description, recommended use, availability, cost, length, sound, et al.

_____ Are you aware of any such audio-visual aids contemplated or in preparation? If so, please give pertinent details.

VII. TEACHING AIDS YOU CONSIDER TO BE NEEDED

The Division has published an Engineering Geology Bibliography, a task completed by the Teaching Aids Committee under Stafford Happ.

_____ Are you aware of visual aids material, catalogs, brochures, samples, demonstration material that is available? If so, give pertinent details as under section VI.

_____ Do you have any suggestions for laboratory exercises in engineering geology (based on published material)? If so, give pertinent details.

_____ Do you have any suggestions for field exercises, type of field trips?

_____ Do you feel the need for and would you support some kind of periodical "Annotated Bibliography of Engineering Geology"?

_____ The foreign literature has much to offer engineering geology that is missed by most American workers. What suggestions do you have for making it more available?

Please give the type and nature of any other teaching aid which you consider currently needed for use in presenting engineering geology course work.

VIII. DOES YOUR INSTITUTION (A) OFFER OR (B) PLAN TO OFFER COURSE WORK IN:

_____ Introductory course of Geology for Engineers?
_____ Applications of Geology for Engineers (second course for engineers)?
_____ A course in Engineering Geology (senior-graduate level for the trained geologists)?
_____ Do you offer courses in overlapping phases: _____ ground water; _____ nonmetallic mineral deposits; _____ introduction to soil mechanics?

IX. AN "IDEAL" COURSE OF STUDY TO TRAIN ENGINEERING GEOLOGISTS

_____ Is the engineering geologist to be: (a) trained geologist with a general knowledge of engineering practice and possessing a practical bent; or (b) a well-trained engineer with some knowledge of geology (1-3 courses)?

If you agree that the engineering geologists must be (a) above : having a basic foundation in chemistry, mathematics, physics, English, surveying, drawing and allied subjects along with the "building block" courses of geology, i.e., physical, historical, mineralogy, petrology-petrography, structure, and possibly paleontology and mineral deposits ---

What advanced courses in geology do you consider appropriate? Give the lecture and/or laboratory hours, total credit units for each:

Engineering geology _____
Ground water geology _____
Hydrology _____
Ground water hydrology _____
Nonmetallic mineral deposits _____
Geomorphology _____
Aerial photo and map interpretation _____
Stratigraphy _____
Sedimentation _____
Sedimentary petrology _____
Adv. structural geology _____
Seismology _____
Oceanography _____
OTHERS: _____ _____ _____
_____ _____ _____

What courses in allied subjects do you consider appropriate? Give the lecture and/or laboratory hours, total credit units for each.

Geophysical methods _____
Mining and Excavation methods _____
Introduction soil mechanics _____
Adv. soil mechanics _____
Strength of materials _____
Hydraulics _____
Engineering design _____
Rock mechanics - testing _____
Report writing _____
Engineering economics _____
OTHERS: _____ _____ _____
_____ _____ _____

Do you consider it necessary for the engineering geologist to have some graduate level training? If so, what courses (those above and others) should be included in his graduate training program? If possible, enclose an outline of course of study for majors in engineering geology.

If you agree the geological work can be adequately handled by a man prepared as (b) above, please outline the type of training you consider appropriate, particularly course work in geology.

X. ENGINEERING GEOLOGY OPPORTUNITIES

_____Would you favor a continuing effort by the Division or some other group to evaluate the opportunities for engineering geologists? This would not be an employment service, but might serve to help students decide on their careers.

XI. ROSTER - POTENTIAL GUEST SPEAKERS

Guest speakers drawn from practicing engineering geologists of the region are desirable and most welcome additions to the lecture course work. Would you be willing to give occasional guest lectures? If so, please state:

Name_____Address_____

Business and/or academic affiliation_____

Field of engr. geol. specialization_____

XII. SPECIAL BIBLIOGRAPHICAL MATERIAL

_____ Have you had occasion to compile a bibliography on the geology and foundation materials of urban areas? If so, can you supply references under the headings of:

Topic	Region

APPENDIX B

COLLEGES AND UNIVERSITIES (UNITED STATES) OFFERING OR PLANNING TO OFFER A COURSE IN GEOLOGY FOR ENGINEERS[20]

(Beginning Course for Engineering Students)

University of Alabama
Alfred University
University of Arizona
University of Arkansas
Brigham Young University
Brown University
California Institute of Technology
University of California, Berkeley
University of Cincinnati, College of Engineering
Columbia University, School of Engineering
Cornell University
Dartmouth College
*Dickinson College
University of Florida
University of Illinois
State University of Iowa
University of Kansas
University of Kentucky
Lamar State College of Technology
Lehigh University
University of Maine
University of Massachusetts
Massachusetts Institute of Technology
University of Michigan
University of Minnesota
Mississippi State College
University of Nebraska
University of New Mexico
Northwestern University
University of Notre Dame
Ohio State University
Ohio University
Oklahoma Agric. and Mech. College
University of Oklahoma
Oregon State College
Pennsylvania State University
University of Pittsburgh
Rensselaer Polytechnic Institute
University of Rhode Island
Rutgers University
St. Louis University, Inst. of Tech.
University of South Carolina
Southern Methodist University
Stanford University
Syracuse University
University of Tennessee
Agric. and Mech. College of Texas
Texas Technological College
University of Texas
Tulane University
Union College
University of Vermont
State College of Washington
University of Washington
Washington University (St. Louis)
Wayne State University
University of Wisconsin
University of Wyoming

20. Based on Teaching Aids Committee Questionnaire 1955, with additions from Am. Geol. Inst. Report 11, 1956-1957 edition.
* Plans to offer course.

APPENDIX C

COLLEGES AND UNIVERSITIES (UNITED STATES) OFFERING OR PLANNING TO OFFER A COURSE IN APPLICATIONS OF GEOLOGY FOR ENGINEERS[21]

(Second Course for Engineering Students)

University of Alabama (M)

University of California, College of Engineering, Berkeley

University of Cincinnati, College of Engineering

Columbia University, College of Engineering (M)

Dickinson College

*University of Idaho, School of Mines

University of Illinois

University of Maine

Massachusetts Institute of Technology

Ohio State University (H)

Rensselaer Polytechnic Institute

St. Louis University, Institute of Technology

Syracuse University

Agricultural and Mechanical College of Texas

Virginia Polytechnic Institute

Washington University (St. Louis), School of Engineering

21. Based on Teaching Aids Committee Questionnaire, 1955, with additions from Am. Geol. Inst. Report 11, 1956-1957 edition.
EXPLANATION: Title and context of course differ according to school; several offer as Advanced Geology for Engineers, two as (M) Mineralogy for Engineers, one as (H) Historical Geology for Engineers.
* Plans to offer course.

APPENDIX D

COLLEGES AND UNIVERSITIES (UNITED STATES) OFFERING OR PLANNING TO OFFER A COURSE IN ENGINEERING GEOLOGY[22]

(Course for Trained Geologist)

University of Alaska, School of Mines (Frozen Ground) - LL
M

*University of Arkansas - LL

University of Arizona - L
G M

Boston University
G

Brigham Young University
G M

University of California, College of Engineering, Berkeley - SL
M

Colorado School of Mines - LL
G M

Colorado State University - LL
G

Columbia University - L
M

Emory University - L
M

Franklin and Marshall College

Fresno State College

University of Illinois - S
G M

University of Kentucky

Louisiana State University and Agricultural and Mechanical College

Michigan College of Mining and Technology - L
G M

Michigan State University
G

Millsaps College

Montana School of Mines - L
M

New York University

North Carolina State College of Agriculture and Engineering
M

University of Notre Dame - L

University of Oregon - S

Ohio State University - L
G

Princeton University

Rensselaer Polytechnic Institute - LL
G

South Dakota School of Mines and Technology - L
G M

University of Southern California - L
G

Stanford University - LL
G M

Syracuse University (Part other courses, see APPENDIX E)

Agricultural and Mechanical College of Texas - L
G M

Utah State University
G

University of Utah
G M

Virginia Polytechnic Institute - L

University of Washington - LL
G

Washington University (St. Louis) School of Engineering - LL
G

22. Based on Teaching Aids Committee Questionnaire 1955, with additions from Am. Geol. Inst. Report 11, 1956-1957 edition.

EXPLANATION: Type of course indicated by: L-lecture only; LL-lecture and laboratory; S-seminar only; SL-seminar and laboratory.

* Plans to offer course Overlapping courses in applied geology offered: G-ground water geology; M-mining geology.

APPENDIX E

COLLEGES AND UNIVERSITIES (UNITED STATES) OFFERING A MAJOR IN ENGINEERING GEOLOGY[23]

(Integrated Study at Undergraduate and Graduate Level for Training Engineering Geologists)

University of California, College of Engineering, Berkeley - E (1955) M
Training in Engineering Geology for both geologists and engineers.
Undergraduate training of engineering students with 3 required courses in geology and 7 optional courses in geology or related fields (22 units) recommended for B.S. degree according to inclination of student for a specialty. Graduate training in Engineering Geology and allied fields beginning 1957.

Colorado School of Mines - E (1955)
Basic Geological Engineering curriculum with an Engineering Geology option that includes 46 sem. hrs. of Geology and 33 sem. hrs. of Civil Engineering. Plan on initiating a graduate program in Engineering Geology in near future.

University of Illinois - B
Training in Engineering Geology for both geologists and engineers. Large offering in Soils Engineering and Ground Water.

Kansas State College -
Training in Engineering Geology for both geologists and engineers.
Dual degree programs in Engineering and Geology can be achieved in 5 years; includes 30 sem. hrs. of Geology.

Louisiana State University and Agricultural and Mechanical College -
Training in Engineering Geology for both geologists and engineers.
Dual degree program in Engineering and Geology can be achieved in 6 years.

Michigan College of Mining and Technology - E (1956)
Basic Geological Engineering curriculum with an Engineering Geology option completed by 18 credits of designated electives; includes 62 credits of Geology and 38 credits of Civil Engineering (quarter system). Plan on initiating a graduate program in Engineering Geology in near future.

University of Notre Dame - B (1957)
In process of revision to Geology-Civil Engineering combination 5-year program; B.S. in Geological Science (4 yrs.); B.S. in Civil Engineering (5 yrs.).

Rensselaer Polytechnic Institute - E
Basic Geological Engineering curriculum with an Engineering Geology option that includes basic courses in Geology and Civil Engineering. Emphasis on foundation engineering.

Syracuse University - * (1955)
Masters degree program only in combined fields of Engineering Geology and Soil Engineering with prerequisites of: basic undergraduate engineering subjects, 4 courses in Geology and 3 courses in Civil Engineering. Graduate program of 24 sem. hrs. requires 3 designated courses in Geology and 3 in Civil Engineering, with remainder electives either field, plus thesis.

Washington University (St. Louis) - E (1948) M D
Basic Geological Engineering curriculum includes some courses in Engineering Geology and undergraduate training equivalent to Engineering Geology option; includes 45 sem. hrs. of Geology and 10 sem. hrs. of Civil Engineering plus associated physical sciences. Graduate program in either Geological Engineering (Engineering School) or Graduate School with many advanced courses in Engineering Geology offered, as well as allied subjects.

23. Based on Teaching Aids Committee Questionnaire 1955, with additions from Am. Geol. Inst. Report 11, 1956-1957 edition.
EXPLANATION: E-Engineering Geology option in Geological Engineering curriculum; B-Engineering Geology option in Bachelor of Science in Geology curriculum.
Year initiated in parenthesis.
* Masters degree in Engineering Geology - Soils Engineering, graduate curriculum only.
Schools offering graduate Engineering Geology programs indicated by: M-Master's degree; D-Doctor's degree.

APPENDIX F

COLLEGES AND UNIVERSITIES (UNITED STATES) OFFERING A GEOLOGICAL ENGINEERING CURRICULUM OR EQUIVALENT[24]

University of Alaska, School of Mines

University of Arizona, College of Mines* (1950)

California Institute of Technology (6 yrs.)

University of California, College of Engineering, Berkeley

Colorado School of Mines *M D

University of Idaho, School of Mines *M (1950)

University of Kansas, The School of Engineering and Architecture

Lehigh University *M D

Louisiana Polytechnic Institute School of Engineering

Michigan College of Mining and Technology *M (1951)

University of Minnesota, Institute of Technology *M D (1950)

University of Mississippi

University of Missouri, School of Mines and Metallurgy M

Montana School of Mines *M

University of Nevada, Mackay School of Mines

New Mexico Institute of Mining and Technology

North Carolina State College of Agriculture and Engineering

University of North Dakota

University of Oklahoma, School of Geological Engineering* (1953)

Pennsylvania State University M D

University of Pittsburgh, School of Engineering and Mines *M (1950)

Princeton University, School of Engineering* (1949)

Rensselaer Polytechnic Institute

St. Louis University, Institute of Technology* (1951)

South Dakota School of Mines and Technology *M (1950)

Southwestern Louisiana Institute

Agricultural and Mechanical College of Texas, Sch. of Engineering* (1949)

University of Tulsa, College of Petroleum Science and Engineering

University of Utah, Department of Mining and Geological Engineering* (1952)

Virginia Polytechnic Institute

Washington University (St. Louis), School of Engineering *M D (1948)

West Virginia University, School of Mines M

24. Modified after Cleaves, A. B. (Chairman), 1951, Geological Engineering in Colleges and Universities of United States: Sub-Committee on Geological Engineering, Education Committee, Am. Geol. Inst., Oct. 5, 1951, 12 p., with additions from Am. Geol. Inst. Report 11, 1956-1957 edition.
EXPLANATION: * indicates National Professional Accreditation as of Sept. 30, 1955; year accredited in parenthesis.
Graduate geological engineering program indicated by: M-Master's degree and D-Doctor's degree.
For a classification based on chemistry, physics, and mathematics requirements, see listing by Cleaves (1951) p. 3-5.

APPENDIX G

16 MM MOTION PICTURES PROBABLY APPROPRIATE FOR USE IN ENGINEERING GEOLOGY COURSES

(Note: For films obtained without rental charges, the borrower normally pays for return transportation via registered mail. The cost of film rental from college and university libraries is usually quoted for one-day's use, exclusive of shipping, and the user normally pays transportation charges both ways).

CONSTRUCTION MATERIALS AND METHODS

1. The Army's Corps of Engineers. Sound. Black and white. 15 min.

   Producer: Corps of Engineers.
   Description: The Army Engineers in combat in both World Wars and since, and engaged in civil works and military construction.
   Distributor: Chief of Engineers, U.S. Army, Washington 25, D.C.
   Charge: No charge.
   Source of information: Military Engineer, Sept.-Oct. 1955.

2. Brick and Stone Mason. Sound. 10 min.

   Producer: Vocational Guidance.
   Description: Masons at work laying various kinds of materials.
   Distributor: College and university film libraries.
   Charge: $1.50 (Univ. Calif. for use in western states only).
   Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #3623

3. Cavalcade of Marble. Sound. Color. Two versions: 27 and 40 min.

   Producer: Vermont Marble Co.
   Description: Story of the marble industry, including all production processess and pictures of structures built of marble throughout the country.
   Distributor: Vermont Marble Company, Proctor, Vermont.
   Charge: No charge.
   Source of information: A.A.P.G. Directory of films, 2nd ed., 1951.

4. Concrete Quality Control Tests. Sound. Color. 15 min.

   Producer: Educational Film Sales, Univ. Calif. Extension, Los Angeles (1955).
   Description: Testing and control of large batch mixes of concrete at construction sites and in the laboratory.
   Distributor: (1) Univ. Calif. Extension, film no. 2755, for use in western states only.
   (2) Other college and university film libraries?
   Charge: $5.00 (Univ. Calif.).
   Source of information: Univ. Calif. Extension film catalogue for 1956-58.

5. The Drama of Portland Cement. Sound. Color. 30 min.

   Producer: Portland Cement Association.
   Description: Steps in the manufacture of Portland cement from quarrying or dredging raw material to the packing operation. Examples of notable concrete structures.
   Distributor: Portland Cement Association, 33 West Grand Ave., Chicago 10, Illinois.
   Charge: No charge.
   Source of information: Military Engineer, Nov.-Dec. 1949.

6. Earth Movers. Sound.

   Producer: Corps of Engineers.
   Description: Types of engineering work done by the Corps of Engineers in World War II.
   Distributor: Chief of Engineers, U.S. Army, Washington 25, D.C.
   Charge: No charge.
   Source of information: Military Engineer, Sept.-Oct. 1950.

7. Flexibility Underground. Sound. Color. 25 min.

   Producer: Armco Drainage & Metal Products, Inc.
   Description: Design and performance characteristics and theory of flexible metal pipe. Actual scenes and animated diagrams demonstrating load-bearing principles of lightweight corrugated metal pipe.
   Distributor: Armco Drainage & Metal Products, Inc., Middletown, Ohio.
   Charge: No charge.
   Source of information: Military Engineer, Jan.-Feb. 1952, and the distributor (4/16/57).

8. The Inside Story of Concrete. Sound. Color. 14 min.

   Producer: Waterways Experiment Station, Corps of Engineers.
   Description: (None available).
   Distributor: Waterways Experiment Station,

Corps of Engineers, Vicksburg, Mississippi.
Charge: ?
Source of information: Reply to 1955 questionnaire.

9. Labrador Railroad Airlift. Sound. Color. 25 min.

Producer: Armco Drainage & Metal Products, Inc.
Description: Construction of a 360-mile railroad (for iron ore mining in northeastern Canada) between Seven Islands on the Gulf of St. Lawrence and Knob Lake in Labrador. All materials required were flown in by the largest civilian airlift in history.
Distributor: Armco Drainage & Metal Products, Inc., Middletown, Ohio.
Charge: No charge.
Source of information: Military Engineer, Jan.-Feb. 1952, and the distributor (4/16/57).

10. The Last Mile. Sound. Color. 19 min.

Producer: Caterpillar Tractor Company.
Description: The dangers involved when construction crews start to turn an old road into a safe modern highway.
Distributor: Caterpillar Tractor Company, Peoria, Illinois, or its local representative.
Charge: No charge.
Source of information: Military Engineer, Jan.-Feb. 1956.

11. The Long Street. Sound. Color.

Producer: Ingersoll-Rand Co.
Description: Modern super-highway construction with emphasis on rock removal by compressed air equipment.
Distributor: Ingersoll-Rand Co. (Film Service Dept.), Phillipsburg, New Jersey.
Charge: No charge.
Source of information: Excavating Engineer, Nov. 1955.

12. Mountain to Main Street. Sound. Color.

Producer: New York Trap Rock Corp.
Description: Production and use of crushed stone. Quarrying, processing, shipping and uses of stone on major construction projects in the New York area.
Distributor: New York Trap Rock Corp., 230 Park Ave., New York 17, New York.
Charge: No charge.
Source of information: Excavating Engineer, Feb. 1957.

13. The Nation's Building Stone. Sound. 20 min.

Producer: Indiana Limestone Institute.
Description: Modern machines quarrying, cutting, and polishing Indiana limestone for building uses. Examples of the ways in which limestone is used. Advantages of limestone as a building material.
Distributor: (1) Indiana Limestone Institute, Bedford, Indiana.
(2) College and university film libraries.
Charge: No charge.
Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #3798.

14. New Sewers for Old. Sound. Color. 14 min.

Producer: Armco Drainage & Metal Products, Inc.
Description: Construction of a new sewer system as an Ohio city installs corrugated metal pipe to replace its outgrown sewer system.
Distributor: Armco Drainage & Metal Products, Inc., Middletown, Ohio.
Charge: No charge.
Source of information: Distributor (4/16/57).

15. Operation Blue Jay. Sound. 25 min.

Producer: Corps of Engineers.
Description: Story of the construction of the giant air base at Thule, Greenland, 900 miles north of the Arctic circle.
Distributor: Chief of Engineers, U.S. Army, Washington 25, D.C. or Signal Officer of nearest Army area.
Charge: No charge.
Source of information: Military Engineer, July-Aug. 1953.

16. Reinforced Concrete Construction. Sound. 30 min.

Producer: Univ. Extension, Univ. of Calif., for the Div. of Civil Engineering, Berkeley.
Description: Story of the construction of a reinforced concrete building from foundation excavation to the roof.
Distributor: Univ. Calif. Extension, film #2689, for use in western states only.
Charge: $5.00
Source of Information: Univ. Calif. Extension supplementary film catalogue for 1956-57.

17. Soil Cement for Low-Cost Paving. Sound. Color. 21 min.

Producer: Portland Cement Association.
Description: Examples of soil-cement roads, streets, airports, and parking areas.
Distributor: Portland Cement Association, 33 West Grand Ave., Chicago 10, Illinois.
Charge: No charge.
Source of information: Military Engineer, Nov.-Dec. 1955.

18. Standardization for the Long Haul. Sound. Color. 30 min.

Producer: Barber-Greene Company.
Description: Employment of belt conveyors in construction and in aggregate production. Projects shown include Folsom Dam, Barnhart Island Power Plant of St. Lawrence Seaway

Project, mammoth underground parking structure in Chicago, and readymix installation of Cleveland Builders Supply Company.
Distributor: Barber-Greene Company, Aurora, Illinois, or its local representative.
Charge: No charge.
Source of information: Military Engineer, March-April 1957.

19. Story of River Sand and Gravel. Sound. Color. 10 min.

Producer: Dravo Corporation.
Description: Digging, transportation, and distribution of river sand and gravel.
Distributor: Dravo Corp., Fifth & Liberty Avenues, Pittsburgh, Penna.
Charge: No charge.
Source of information: A.A.P.G. Directory of films, 2nd ed., 1951.

20. We're Blasting Near You. Sound Color. 25 min.

Producer: Atlas Powder Company.
Description: Modern techniques of controlled blasting. Precautions taken for prevention of accidents and protection of public and private property.
Distributor: Explosives Development Section, Atlas Powder Co., Wilmington 99, Delaware.
Charge: No charge.
Source of information: Excavating Engineer, Jan. 1957.

21. Zonolite, the Wonder Mineral. Sound. 18 min.

Producer: The Zonolite Company.
Description: History and applications of this lightweight building material. Advances in construction brought about by development of vermiculite as insulation and plaster and concrete aggregate.
Distributor: The Zonolite Co., Film Section, 135 So. La Salle St., Chicago 3, Illinois.
Charge: No charge.
Source of information: A.A.P.G. Directory of films, 2nd ed., 1951.

GEOLOGIC PROCESSES

(For general listings see A.A.P.G. Directory and college and university film library catalogues).

1. Earthquakes. Sound. 20 min.

Producer: Association Films, Inc. and/or Ideal Pictures Corp.?
Description: Use of seismological instruments in study of cause, effects, and prevention of damage by earthquakes.
Distributor: (1) Association Films, Inc.:
35 W. 45th St., New York 19, N.Y.
206 S. Michigan Ave., Chicago 3, Ill.
351 Turk St., San Francisco 2, Calif.
3012 Maple St., Dallas 4, Texas.
(2) Ideal Pictures Corp., 65 E. South Water St., Chicago 1, Ill. (Branches in 24 cities).
Charge: ?
Source of information: A.A.P.G. Directory of films, 2nd ed., 1951.

RIVER ENGINEERING

1. Challenge of the North Santiam. Sound. Color. 29 min.

Producer: Portland District, Corps of Engineers.
Description: Construction of Detroit Dam on the North Santiam River in Oregon. Also the Big Cliff regulating dam, which is part of the same project and 2 1/2 miles downstream from the Detroit Dam.
Distributor: Film Library, Division Engineer, North Pacific Division, Corps of Engineers, 210 Custom House, Portland 9, Oregon. For use in Pacific Northwest only.
Charge: No charge.
Source of information: Excavating Engineer, April 1956.

2. Dalles Dam. Sound. Color. 28 min.

Producer: Portland District, Corps of Engineers.
Description: Construction of the multi-purpose Dalles Dam on the Columbia River, 88 miles east of Portland, Oregon.
Distributor: Film Library, Division Engineer, North Pacific Division, Corps of Engineers, 210 Custom House, Portland 9, Oregon. For use in Pacific Northwest only.
Charge: No charge.
Source of information: Excavating Engineer, August 1956.

3. The Eighth Sea. Sound. Color. 28 1/2 min.

Producer: Caterpillar Tractor Company.
Description: Story of the planning and development of the St. Lawrence Seaway. (Narrated by Walter Cronkite).
Distributor: Advertising Division, Caterpillar Tractor Co., Peoria, Illinois, or local Caterpillar dealers.
Charge: No charge.
Source of information: Excavating Engineer.

4. From the Mountains to the Sea. Sound. Two editions: Color, and Black and White. 18 min.

Producer: Los Angeles District, Corps of Engineers. 1955.
Description: Flood problems of the Los Angeles County drainage area. Remedial and control measures undertaken by corps of Engineers

in cooperation with Los Angeles County Flood Control District.
Distributor: Chief, Technical Liaison Branch, Los Angeles District, Corps of Engineers, Room 209, 751 South Figueroa St., Los Angeles 17, California.
Charge: No charge
Source of information: Distributor (3/25/57).

5. Hoover Dam. Sound. Black and White. 35 min.

Producer: Bureau of Reclamation.
Description: Construction history of Hoover Dam.
Distributor: Bureau of Reclamation?
Charge: ?
Source of information: Los Angeles Dept. of Water and Power pamphlet of motion picture programs, Nov. 1956.

6. The Illinois Waterway - The Connecting Link. Sound. Color.

Producer: Chicago District, Corps of Engineers.
Description: The mechanical achievements that make possible the movement of millions of tons of essential freight from the Great Lakes to the Mississippi River through the Illinois Waterway.
Distributor: District Engineer, Chicago District, Corps of Engineers, 520 Merchandise Mart, Chicago 54, Illinois.
Charge: No charge
Source of information: Military Engineer, July-Aug., 1951.

7. Key to the Emerald Empire. Sound. Color. 28 min.

Producer: Portland District, Corps of Engineers.
Description: Construction of Lookout Point Dam on the Middle Fork Willamette River in Oregon. Also Dexter Dam regulating unit, three miles downstream.
Distributor: Technical Liaison Branch, North Pacific Division, Corps of Engineers, 210 Custom House, Portland 9, Oregon.
Charge: No charge
Source of information: Excavating Engineer, May 1957.

8. Mississippi River - Lower River. Sound. Color. 14 min.

Producer: Academy Films.
Description: Man's control and use of the mighty waterway from the mouth of the Ohio River to the Gulf of Mexico. Disastrous floods and their effects on cities and farms. Flood control effected through levee construction, sandbagging, etc.
Distributor: College and university film libraries.
Charge: $5.00 (Univ. of Calif. For use in western states only)
Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #3088.

9. Mississippi River - Upper River. Sound. Color. 14 min.

Producer: Academy Films.
Description: The Mississippi River from source to central section near St. Louis. Use for power generation and transportation. Control by dams and locks.
Distributor: College and university film libraries.
Charge: $5.00 (Univ. of Calif. For use in western states only).
Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #3089.

10. Problem at Port Washington. Sound. 10 min.

Producer: Waterways Experiment Station, Corps of Engineers.
Description: Model studies conducted by Waterways Experiment Station for various Corps of Engineers Districts throughout the United States.
Distributor: Director, Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi.
Charge: No charge.
Source of information: Military Engineer, Nov.-Dec. 1951.

11. The River. Sound. 28 min.

Producer: United World.
Description: Floods and flood control. TVA?
Distributor: College and university film libraries.
Charge: $1.50 (Univ. Calif. For use in Western States only).
Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #3623.

12. Rivers in Miniature. Sound. Color. 13 min.

Producer: Waterways Experiment Station, Corps of Engineers.
Description: The Mississippi Basin Model and the part it will play in the Army Engineer program for the development and control of water resources in the mid-continent region.
Distributor: Director, Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi.
Charge: No charge.
Source of information: Military Engineer, Sept.-Oct. 1955.

13. Shackles for the Giant. Sound. 25 min.

Producer: Corps of Engineers.
Description: Flood control work of the Corps of Engineers in the lower valley of the Mississippi River.
Distributor: Mississippi River Commission,

P.O. Box 80, Vicksburg, Mississippi.
Charge: No charge.
Source of information: Military Engineer, July-Aug. 1951.

14. Valley of the Giant. Sound.

Producer: Corps of Engineers?
Description: Flood control, navigation, and other engineering work on the lower Mississippi River.
Distributor: Mississippi River Commission, P.O. Box 80, Vicksburg, Mississippi.
Charge: No charge.
Source of information: Military Engineer, Sept-Oct. 1950.

WATER SUPPLY

1. City Water Supply. Sound. 10 min.

Producer: Encyclopaedia Britannica Films.
Description: Animated drawings illustrate sources of city water supply, methods of distribution, etc. Other photography includes water tunnels and aqueducts.
Distributor: College and university film libraries.
Charge: $1.50 (Univ. of Calif. For use in western states only).
Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #3017.

2. The Dixie Pipeline. Sound. Color. 15 min.

Producer: Armco Drainage & Metal Products, Inc.
Description: Construction of a water supply line for a Georgia defense plant which obtained needed water from a source 11 miles away.
Distributor: Armco Drainage & Metal Products, Inc., Middletown, Ohio.
Charge: No charge.
Source of information: Distributor (4/16/57).

3. Pipeline to the Clouds. Sound. Color. 25 min.

Producer: General Electric Company.
Description: Story of water supply in the American community of today. The water cycle and sources of water. Reasons for water shortages and how they can be met. Operation of water works.
Distributor: (1) General Electric Company?
(2) College and university film libraries.
Charge: $5.00 (Univ. Calif. For use in western states only).
Source of information: Univ. Calif. Extension film catalogue for 1956-58, film #5387.

4. They Saw Tomorrow. Sound. Color. 25 min.

Producer: Metropolitan Water District of Southern California.
Description: Planning and construction of the great aqueduct supplying the Los Angeles area. Route of the aqueduct from the Colorado River to the thirteen cities it supplies. Pumping stations, canals, tunnels, reservoirs, and filtration stations.
Distributor: Univ. of California Extension, Los Angeles only, film #3409, for use in Southern California, Arizona, and New Mexico only.
Charge: $1.00
Source of information: Univ. Calif. Extension film catalogue for 1956-58.

5. Thirteen Golden Cities. Sound. 20 min.

Producer: Metropolitan Water District of Southern California.
Description: Story of the Metropolitan Water District and the Colorado River aqueduct. Construction work at Parker Dam and Cajalco Reservoir. Specific types of engineering detail: tunneling through solid granite mountain, bridging chasm, building canal through desert. Aqueduct includes 108 miles of hard rock tunnels.
Distributor: Univ. of Calif. Extension, film #2852, for use in western states only.
Charge: $1.00.
Source of information: Univ. Calif. Extension film catalogue for 1956-58.

6. The Twin Titans. Sound. Color. 30 min.

Producer: Dept. of Water & Power, City of Los Angeles.
Description: Story of bringing water and power to Los Angeles. Treated as historical drama with professional cast.
Distributor: (1) Public Relations Div., Dept. of Water & Power, Room 402, 207 S. Broadway, Los Angeles 12, California.
(2) Univ. of California Extension, Los Angeles only, film #5381, for use in Southern California, Arizona, and New Mexico only.
Charge: (1) No charge.
(2) $1.00.
Source of information: Los Angeles Dept. of Water & Power pamphlet of motion picture programs, Nov. 1956: Univ. Calif. Extension film catalogue for 1956-58.

7. Water for Millions. Sound. Color. 34 min.

Producer: Dept. of Water & Power, City of Los Angeles.
Description: Traces the path of a drop of water from a snowflake on the slopes of the High Sierras to the faucet in a city home in Los Angeles.
Distributor: (1) Public Relations Div., Dept. of Water & Power, Room 402, 207 S. Broadway, Los Angeles 12, Calif.

(2) Univ. of Calif. Extension, film #4162, for use in western states only.
Charge: (1) No charge.
(2) $1.00.
Source of information: Los Angeles Dept. of Water & Power pamphlet of motion picture programs, Nov. 1956-58.

8. Water Supply. Sound. Color. 10 min.

Producer: Academy Films.
Description: Sources of water supply in wells, springs, lakes. The water table. Water for the city of Los Angeles from the Colorado River and Owens Valley.
Distributor: College and University Film libraries.
Charge: $2.50 (Univ. Calif. - For use in western states only).
Source of information: Univ. of Calif. Extension film catalogue for 1956-58, film #3861.

HYDROELECTRIC POWER SUPPLY

1. Kilowatt Builders. Sound. Color. 30 min.

Producer: Pacific Gas & Electric Company.
Description: P.G. & E's post-war construction program of hydro-electric and steam generating plants. Dynamiting, tunneling, dredging, concrete work, and road building in the High Sierra.
Distributor: Univ. Calif. Extension, Berkeley only, film #3196, for use in northern and central counties of California only.
Charge: No charge.
Source of information: Univ. Calif. Extension film catalogue for 1956-58.

2. The Kitimat Story. Sound. Color. 20 min.

Producer: Aluminium Limited, Inc.
Description: The Kitimat Power Project, Canada.
Distributor: Aluminium Limited, Incorporated, New York 20, N.Y.
Charge: No charge.
Source of information: Military Engineer, Jan.-Feb. 1956.

3. Man with a Thousand Hands. Sound. Color. 57 min.

Producer: International Harvester Company.
Description: Story of the Kitimat Power Project, Canada.
Distributor: International Harvester Company, Chicago 1, Illinois, or its local representative.
Charge: No charge.
Source of information: Military Engineer, Jan.-Feb. 1956.

4. More Power to You. Sound. Color. 27 min.

Producer: Dept. of Water & Power, City of Los Angeles.
Description: Development of electric power for Los Angeles, including installations on the Colorado River and Los Angeles aqueduct and at Owens Gorge.
Distributor: (1) Public Relations Div., Dept. of Water & Power, Room 402, 207 S. Broadway, Los Angeles 12, Calif.
(2) Univ. of Calif. Extension, film #4036, for use in western states only.
Charge: (1) No charge.
(2) $1.00
Source of information: Los Angeles Dept. of Water & Power pamphlet of motion picture programs, Nov. 1956; Univ. Calif. Extension film catalogue for 1956-58.

APPENDIX H

SUGGESTED COURSES OF STUDY FOR PREPARATION IN ENGINEERING GEOLOGY

1. Liberal Arts College

FRESHMAN YEAR	No. Semesters Work
Mathematics (Algebra, Trig., Analyt. Geom.)	2
Chemistry (General and Qualitative Analysis)	2
Geology (Physical and Historical)	2
English, Literature, Language (according to institution)	2
Engineering Drawing and Descriptive Geometry	1-2
Nontechnical subjects according to institution	
SOPHOMORE YEAR	
Calculus	2
Chemistry (Quantitative analysis)	1
Physics (General)	2
Mineralogy-Crystallography	2
Surveying	1-2 (or summer)
Nontechnical subjects according to institution (e.g., Economics, Humanities, History)	1-2
JUNIOR-SENIOR YEARS	
Petrology	1
Structural Geology with Laboratory	1
Field Geology	2 (or summer camp)
Optical Mineralogy	1
Geomorphology	1
Regional Geology or Geology of North America	1
Principles of Ore Deposits	1
Paleontology (optional)	1
Principles of Petroleum Geology (optional)	1
Engineering Geology and/or Ground Water Geology (according to offering)	1 (each)
Technical Report Writing	1
English, Speech, Language, or Literature (according to institution)	2
Economics, History, Humanities, or Philosophy (according to institution)	2-4
Fluid Mechanics and/or Hydraulics (according to offering)	1
Nontechnical subjects according to institution	
GRADUATE COURSEWORK (Suggested for completion fifth year at a Technical College)	
Geophysical Methods or Applied Geophysics	1
Principles of Mining Engineering and Excavation Methods	1
Engineering Economics	1
Introduction Soil Mechanics	1
Strength of Materials	1
Or a combination of: Introductory Soil Mechanics and Strength of Materials	1 or 2 (alternative)
Or for geologists only if prerequisites lacking: Soil Mechanics for Geologists	1 (alternative)
Strength of Materials for Geologists	1 (alternative)
Air Photo and Map Interpretation	1
Petrography	1
Sedimentation	1
Principles of Stratigraphy	1
Metalliferous Deposits (if not completed undergrad.)	1
Nonmetallic Mineral Deposits	1

GRADUATE COURSEWORK (Contd)	No. Semesters Work
Ground Water Geology (if not completed undergrad.)	1
Engineering Geology (if not completed undergrad.)	1
Seminar (optional) Application of Geologic Principles to Engineering Practice (emphasis case histories)	1
Depending on student's interests or option may take some or all of the following:	
Fluid Mechanics and/or Hydraulics (if not completed undergrad.)	1
Hydrology	1
Ground-Water Hydrology	1
Oceanography	1
Glacial Geology	1
Seismology	1

2. Technical College (or under Geological Engineering Curriculum)

FRESHMAN YEAR	
Mathematics (Algebra, Trig., Analyt. Geom.)	2
Chemistry (General and Qualitative Analysis)	2
English	2
Engineering Drawing	1
Descriptive Geometry	1
Geology (Physical and Historical)	2
Orientation	1
Nontechnical subjects according to institution (e.g., Military Sci., Phys. Ed.)	
Surveying (summer)	2 (equivalent)

SOPHOMORE YEAR	
Calculus	2
Chemistry (Quantitative Analysis)	1
Physics (General)	2
English, Literature, or Speech	2
Mineralogy-Crystallography	2
General Psychology, Elective in Arts and Sciences, or Surveying according to institution requirements and offering	1
Nontechnical subjects according to institution (e.g., Military Sci., Phys. Ed.)	

JUNIOR YEAR	
Mechanics (Statics and Dynamics)	1
Fluid Mechanics or Hydraulics	1
Physical Chemistry (optional)	1-2
Strength of Materials	1
Introductory Soil Mechanics (or Senior yr., according to institution)	1
Geophysical Methods or Applied Geophysics	1
Principles of Mining Engineering and Excavation Methods	1
Petrology	1
Structural Geology with Laboratory	1
Metalliferous Deposits	1
Principles of Stratigraphy	1
Paleontology	1
Field Geology (including underground mapping techniques)	2 (or summer camp)
An elective or required course according to institution	

SENIOR YEAR	
Economics	1

SENIOR YEAR (Contd)	No. Semesters Work
Report Writing or Technical Exposition	1-2
Principles of Engineering Design or Concrete	1-2
Optical Mineralogy	1
Petrography	1
Nonmetallic Mineral Deposits	1
Geomorphology	1
Engineering Geology	1
Air Photo and Map Interpretation	1
Elective or required courses according to institution	

GRADUATE COURSEWORK (Suggested for completion fifth year, includes any courses listed above not completed as undergraduate):

Rock Mechanics or Rock Testing and Foundations	1
Engineering Economics	1
Sedimentation	1
Advanced Structural Geology	1
Regional Geology or Geology of North America	1
Advanced Physical Geology (includes surficial deposits)	1
Seminar, Application of Geologic Principles to Engineering Practice (emphasis case histories)	1
Sedimentary Petrology	1
Seismology	1
Subsurface Exploration Methods and Interpretation (optional)	1
Depending on student's interests or option may take some or all of the following:	
Hydrology	1
Ground-Water Hydrology	1
Oceanography	1
Glacial Geology	1
Foundation Engineering	1
Contracts and Specifications	1

APPENDIX I

SYLLABUS FOR COURSE IN EARTH SCIENCE
UNIVERSITY OF MELBOURNE, AUSTRALIA[25]

Offered by Department of Civil Engineering[26]
(For third year civil and agricultural engineering students)

Course consists of approximately 85 lectures, 3 hours laboratory per week plus practical work throughout the year, and 5 field excursions.

1. Fundamentals of Geology and Engineering Geology

   Part A - 24 lectures. Elements of crystallography with special reference to mineralogy. The more important minerals and rocks. Elementary structural geology and physiography (including underground water). Introduction to stratigraphy with special reference to Australia.

   Part B - 9 lectures. Special aspects of engineering geology, e.g., building stone, concrete aggregate, foundations, dam and reservoir sites.

   Laboratory work: 3 hours each week first term; Field work: 3 one-half day trips.

2. Soil Chemistry

   25 lectures. Introduction to colloid chemistry applied to soils. Crystal structure of clay minerals. Elementary soil chemistry. Soil texture and structure; types and profile formation. Erosion.

   Laboratory work: 6 sessions of 3 hours each, second term; Field work: one day and one half-day field trip.

3. Soil Mechanics and Soil Physics

   25 lectures. Soil-water relationships. Soil classification and identification, compaction, consolidation, and shear strength. Elementary stability theory-earth pressures, stability of slopes, bearing capacity. Site investigation.

   Laboratory work: 8 sessions of 3 hours each, second and third terms.

Additional

An essay is required on the material of Part B, Section 1.

25. R. F. Legget, Personal communication, May 13, 1957. Compiled during an inspection, University of Melbourne, 1956.
26. Professor A. J. Francis, Head of the Department of Civil Engineering; Dr. Trollope, instructor of earth science course.

APPENDIX J

PARTIAL LIST OF ORGANIZATIONS IN THE UNITED STATES EMPLOYING ENGINEERING GEOLOGISTS PART- OR FULL-TIME

(Does not include organizations utilizing consultants only)

1. FEDERAL AGENCIES	Headquarters for Information
Air Force	
Cambridge Research Center	Hanscom Field, Bedford, Mass.
Research Studies Institute	Air University, Maxwell Air Force Base, Alabama
Atomic Energy Commission	c/o Organization and Personnel Division, 1901 Constitution Ave., Washington 25, D.C.
Bureau of Public Roads (Dept. Commerce)	Washington, D.C.
Bureau of Reclamation (Dept. Interior)	Denver Federal Center, Denver, Colo.
Civil Aeronautics Authority (Dept. Commerce)	Washington, D.C.
Corps of Engineers (Dept. Army)	
Civil Works and Military Construction	Office, Chief Engr's., Washington, D.C.
Waterways Experiment Station	Vicksburg, Mississippi.
Engineering Research and Develop. Lab.	Fort Belvoir, Virginia.
Snow, Ice, Permafrost Research Estab.	1215 Washington Ave., Wilmette, Illinois (Dartmouth College 1958).
Arctic Construction and Frost Effect Lab.	Washington, D.C.
Dept. of Agriculture	
Forest Service	Washington, D.C., or Regional Office
Soil Conservation Service	Washington, D.C., or Regional Office
Geological Survey (Dept. Interior)	
Alaskan Branch	4 Homewood Place, Menlo Park, Calif.
Alaska Terrain and Permafrost Section	Washington 25, D.C.
Engineering Geology Branch	Denver Federal Center, Denver, Colo.
Foreign Geology Branch	Washington 25, D.C.
Military Geology Branch	Washington 25, D.C.
International Boundary and Water Comm.	El Paso, Texas (U.S. Section)
Tennessee Valley Authority	Knoxville, Tenn.
2. STATE AGENCIES (Exclusive of Highway Depts. and Toll Authorities)	
California Dept. of Water Resources	Sacramento, Calif.
Kansas Geological Survey	Lawrence, Kansas
Illinois Geological Survey	Urbana, Illinois
Indiana Geological Survey	Bloomington, Indiana
Missouri Geological and Water Resources Survey	Rolla, Missouri
New York State Power Authority	New York, N.Y.
Ohio Dept. Natural Resources	
Division Geological Survey	c/o Ohio State University, Columbus, Ohio
Division Shore Erosion	c/o Ohio State University, Columbus, Ohio

3. STATE HIGHWAY DEPARTMENTS - TOLL AUTHORITIES, TURNPIKE COMMISSIONS

The majority of the State Highway Departments have geological departments or staffs; check with department of specific state. Also Toll Authorities and Turnpike Commissions.

3. STATE HIGHWAY DEPARTMENTS (Contd.)

Pennsylvania Turnpike Commission	P.O. Box 531, Harrisburg, Penn.

4. MUNICIPALITIES AND MUNICIPALLY OWNED UTILITIES

Boston Metropolitan Water District	Boston, Mass.
Chicago Public Works Dept.	Chicago, Ill.
Los Angeles County Flood Control Dist.	2250 Alcazar St., Los Angeles 33, Calif.
Los Angeles City Dept. of Water & Power	207 S. Broadway, Los Angeles, Calif.
New York City Board of Water Supply	120 Wall St., New York, N.Y.
New York City Dept. of Public Works	New York, N.Y.
San Francisco Dept. of Public Works	San Francisco, Calif.
San Francisco Dept. of Water Supply	San Francisco, Calif.

5. PRIVATE UTILITIES

American Telephone and Telegraph Co.	Chicago, Ill.
Idaho Power Company	Boise, Idaho
Pacific Gas & Electric Company	San Francisco, Calif.
Southern California Edison Company	601 W. 5th St., Los Angeles, Calif.
Tacoma Light & Power Company	Tacoma, Washington

6. RAILROADS

Atchison, Topeka & Santa Fe RR.	Los Angeles, Calif.
Atlantic Coast Line RR.	Wilmington, North Carolina
Baltimore & Ohio RR.	Baltimore, Maryland
Chicago & Northwestern RR.	Chicago, Illinois
Denver & Rio Grande Western RR.	Denver, Colo.
Great Northern RR.	Saint Paul, Minnesota
Louisville & Nashville RR.	Louisville 1, Kentucky
Northern Pacific RR.	St. Paul, Minn.
Norfolk & Western RR.	Roanoke, Virginia
Southern Pacific Co. (and affiliates)	65 Market St., San Francisco, Calif.
Union Pacific RR.	Los Angeles, Calif.

7. ARCHITECT-ENGINEER COMPANIES

Dames and Moore, Soil Mechanics Eng'rs.	816 W. 5th St., Los Angeles 17, Calif.
Eustic Engr. Co.	3635 Airline Hwy., Metaire, Louisiana
Greiner, J.E. & Company	Cleveland, Ohio
Harza Engineering Company	400 W. Madison St., Chicago, Ill.
Porter, Urquhart, McCreary & O'Brien	615 Eighth Ave., New York, and other offices
Procter, Mueser, & Rutledge	415 Madison Ave., New York, N.Y.
Tippetts-Abbett-McCarthy-Stratton	62 W. 47th St., New York 36, N.Y.
Tipton & Associates	610 Insurance Bldg., Denver, Colo.
Woodward, Clyde & Associates	1150 28th St., Oakland, Calif.

8. ENGINEER-CONSTRUCTOR COMPANIES

Bechtel Corporation	727 W. 7th St., Los Angeles, Calif.

8. ENGINEER-CONSTRUCTOR COMPANIES

Ebasco Services Inc.	New York, N.Y.
Kaiser Engineers	1925 Broadway, Oakland, Caoif.
Peter Kiewit & Sons	Omaha, Nebraska
International Engineering Company	74 New Montgomery St., San Francisco, Calif.
Isabel Construction Co.	Reno, Nevada
E. J. Longyear Company	Foshay Tower, Minneapolis 2, Minn.
Morrison-Knudsen Company	120 Montgomery St., San Francisco, Calif.
Ralph M. Parsons Company	617 Olive St., Los Angeles, Calif.
Stone and Webster Engineering Corp.	New York, N.Y.

9. OTHER PRIVATE ORGANIZATIONS

Geological Exploration Companies:	
Geophoto Services	Denver, Colo.
Geophysical Exploration Companies:	
Fisher Research Laboratories	1916 University Ave., Palo Alto, Calif.
Stanford Research Institute	Menlo Park, Calif.
Irrigation Districts:	
Land Companies:	
Hawaiian Sugar Planters Association	Experiment Station, Honolulu, Hawaii
Kern County Land Co. (& Canal & Water)	600 California St., San Francisco, Calif.
Southern Pacific Land Company	65 Market St., San Francisco, Calif.
Others:	
Alpha Portland Cement Co.	Easton, Penn.
DuPont Corporation	Wilmington, Delaware
World Bank	New York, N.Y.
Utilizing Petrographers Primarily:	
Master Builders Research Laboratories	6515 Morgan Ave., Cleveland 27, Ohio
Portland Cement Association	33 W. Grand Ave., Chicago, Ill.
Sumner-Sollit Construction Co.	Chicago, Ill.
Universal Atlas	Biffington Station, Indiana
Major Oil Companies in Midwest and Rocky Mt. Regions (reservoir rock studies)	

APPENDIX K

ROSTER OF POTENTIAL GUEST SPEAKERS - ENGINEERING GEOLOGY AND SPECIALIZED SUBJECTS

(Listed by geographical area, with address, affiliation, and specialization)

WEST COAST

Howard A. Coombs
Dept. of Geology, Univ. of Washington
Seattle, Wash.
Dams, instrumentation

Claire P. Holdredge
3108 El Camino Ave.
Sacramento, Calif. (home)
Corps of Engineers
General engineering geology, public works

Laurence B. James
Calif. Dept. Water Resources
Sacramento, Calif.
Planning water-supply projects

Stewart M. Jones
352 Churchill Ave.
Palo Alto, Calif. (home)
Independent consultant
Petroleum construction

George A. Kiersch
1010 Grosvenor Place
Oakland, Calif. (home)
Southern Pacific Co. & private
General engineering geology, history, underground installations

John T. McGill
Engineering Geology Branch, USGS
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