THE GEOLOGICAL SOCIETY OF AMERICA

The Engineering Geologist

THE QUARTERLY NEWSLETTER OF THE ENGINEERING GEOLOGY DIVISION OF THE GEOLOGICAL SOCIETY OF AMERICA

Vol. 1, No. 1 April 1966

EDITOR'S NOTE

The Engineering Geologist is a newly expanded version of the Newsletter of the Engineering Geology Division.

It is a far easier task building on the solid foundation furnished by Alice Allen, past Assistant Secretary of the Division, than it would be to start an entirely new publication.

The Engineering Geologist will be mailed to all members of the Division four times a year, in January, April, July and October.

Each issue will contain, in addition to announcements and news items, one or more articles of general interest, and a number of more or less regular features dealing with engineering geology of dams, geology in underground works, new developments in geology and geomorphology, legal aspects of engineering geology and related work, building construction, recent conferences and activities of societies, new books and literature, and personal activities of affiliates.

You are invited to address items on these subjects to the Editor at 475 Hearst Mining Building, University of California, Berkeley, California. Short announcements of job opportunities will also be included.

The Newsletter is being produced on a small budget and any criticisms and suggestions for its inexpensive improvement will be much appreciated.

We may publish letters to the Editor if they appear to be of general interest.

UPCOMING CONFERENCES

Geological Engineering Summer Course. A one week course on geological engineering, conducted by invited engineers and professors, will be held at the University of California, Berkeley, August 15 - 21, 1966. For further information write to the Engineering Extension, 2223 Fulton Street, Berkeley, California.

Eighth Symposium on Rock Mechanics. To be held at the University of Minnesota, Minneapolis, September 15 - 17, 1966.
The Symposium will consist of five half-day sessions devoted to a thorough discussion of the State of the Art of Rock Mechanics with regard to:
1 Fundamental mechanisms of rock failure 2 Underground design and excavation 3 Surface construction 4 Rock drilling 5 Blasting.
Authorities in rock mechanics will prepare comprehensive reviews of knowledge in each of these five areas. These will be available in pre-print form in mid-June for distribution to registrants. Technical sessions will consist of summaries by the review authors plus papers prepared by other authorities in the five areas and intended to supplement the reviews. For further information write to:
Eighth Symposium on Rock Mechanics, Nolte Center for Continuing Education, University of Minnesota, Minneapolis, Minnesota 55455.

First International Congress of the International Society of Rock Mechanics.
To be held in Lisbon, Portugal, September 25 - October 1, 1966.
Papers will deal with the following themes: exploration of rock masses, description of rocks with a view to their physical and mechanical behavior, properties of rock and rock masses, residual stresses in rock masses, comminution, natural and excavated slopes, underground excavations and deep borings, and behavior of rock masses as structural foundations. No case histories will be presented. Address all inquiries to Secretariado do 1st Congresso Internacional de Mecanica das Rochas, Laboratorio Nacional de Engenharia Civil, Lisboa 5, Portugal.

Annual Meeting of the GSA, November 14 - 16, 1966, San Francisco.
For a hint of what the Engineering Geology Division is planning, see the proceedings of the meeting of the Management Board summarized at the end of this issue
Please indicate your interest in the Field Trips by writing to Mr. Elmer Marliave, [illegible] Park Drive, Sacramento, California

Pan-American Conference on Soil Mechanics and Foundation Engineering
The Third Conference will be held in July 1967 in Caracas, Venezuela.
Details for submission of papers have not yet been formulated.
Please address inquiries to Professor Ronald C. Hirschfeld, Room 1-330, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

ENGINEERING GEOLOGY FOR DAMS

W. Harold Stuart

With this issue of the Newsletter we are initiating a feature entitled Engineering Geology for Dams. The purpose of this series is to provide a means for keeping our members informed, on a timely basis, about work under way, about new procedures for studies and investigations, unusual and interesting geological problems encountered during investigations or construction, proposed and actual solutions to foundation or material problems, effectiveness of foundation treatment used and indeed any other newsworthy item on the subject of Engineering Geology for Dams. Articles of 100-600 words are solicited from members. Your draft should be submitted to W. Harold Stuart, 430 N. W. Maywood Drive, Portland, Oregon 97120.

The first article which follows is interesting because it illustrates the value of detailed geological mapping during construction and the use of geological techniques on a man-made structure where the results are more susceptible to evaluation than in bedrock.

Engineering Geology Techniques used in Ice Harbor Lock Repair

C. J. Monahan

Cracking of the two downstream gate monoliths at Ice Harbor Lock occurred in February 1965 and led to unusual application of engineering geology techniques. Vertical cracks extending diagonally downstream from the gate slot and reaching almost the entire 155 feet of height of the monoliths showed almost perfect symmetry in the two opposing monoliths. Detailed foundation maps prepared by the Resident Geologist at the time of construction showed that although several prominent inclined joists exist in the foundation their locations and attitudes are such that they bear no relation to cracking observed in the monoliths. Investigation of cracks in concrete required the use of the same tools and skills the engineering geologist uses for foundation studies. Four NX core holes were drilled in each monolith and mapped using a bore hole camera. The exact location of each crack, its width of opening (0. 003 to 0. 06 inch normal width)and configuration of the surface of parting was obtained. The camera mapping proved that only a single crack existed in each monolith and that the parting surface curved around aggregate particles, a feature that implied failure by tension rather than rotation or shear.

A combined system of crack grouting and prestressing was used to restore the monoliths to elastic structures working as a one unit system. The crack grouting insured uniform load bearing area at the cracked joint. A secondary benefit of the grouting was to seal the joint and to prevent leakage through the crack. Description of the design of the prestressing system is given in the May 6, 1965 issue of Engineering News Record.

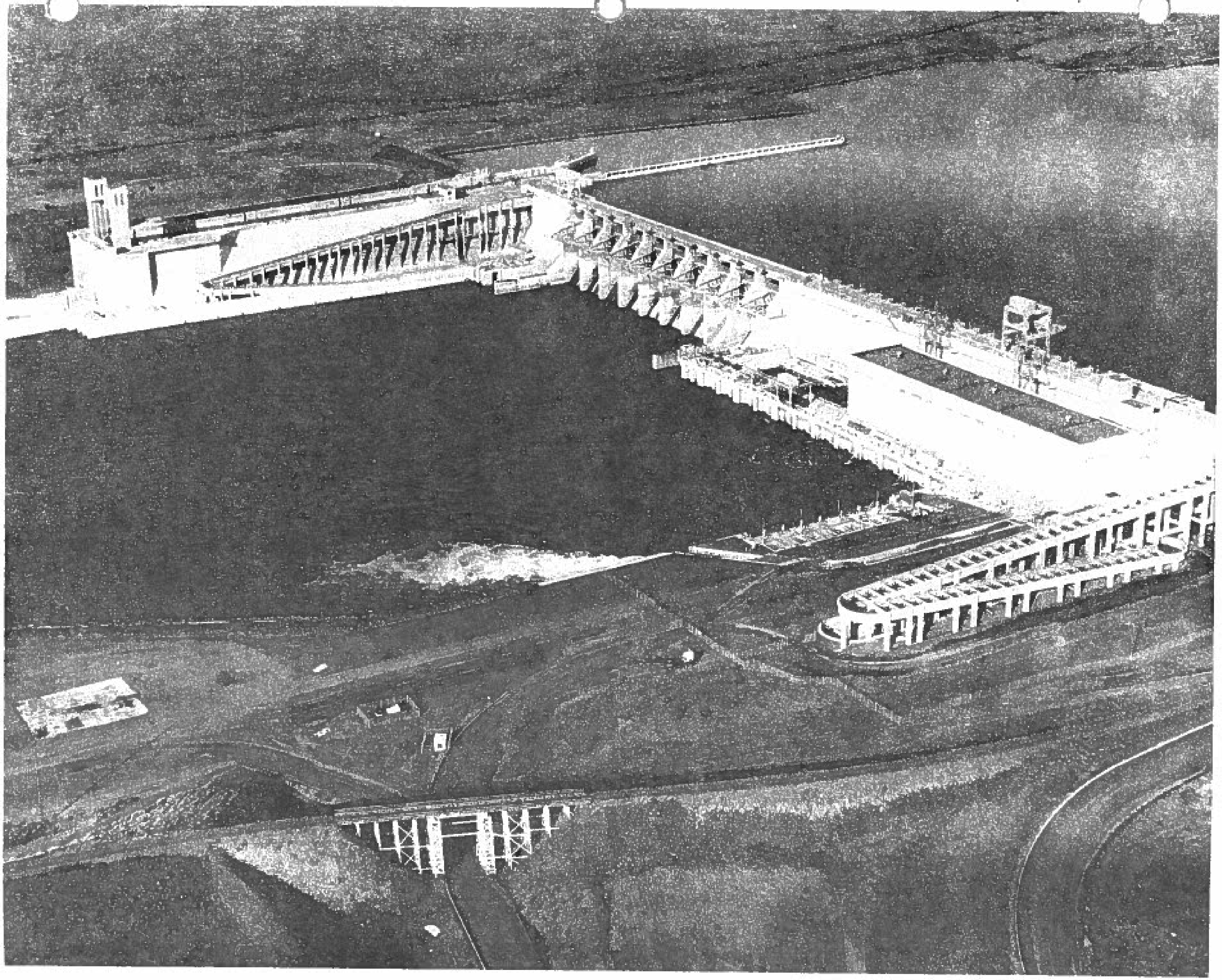
To accomplish this work 28, 000 lineal feet of diamond drill holes were cored in the concrete and into the basalt foundation rock;97% of the drilling was 3-7/8 inch diameter. All drill holes were nearly horizontal and passed through the crack, a feature that permitted their dual use as grout holes. Their spacing ranged from 3 feet to 16 feet horizontally and 5 feet vertically.

Grouting of the crack was accomplished in a manner similar to consolidation grouting of a foundation. Nearly horizontal holes and interference from concurrent drilling overhead were primary differences. To prevent settlement of ground in the holes, and to assure that fresh grout was constantly passing across the crack opening and into the crack, a circuit system of grouting, sometimes used for foundation work, was adopted with the inlet pipe extending 5 feet beyond the crack. Sufficient packers were used to grout all holes in 3 concrete lifts (15 feet) with a neat grout of Type III Portland Cement, fluidifier, and shrinkage compensator. The mix ratios varied from 3:1 to 1:1 water-to-cement ratio by volume and were controlled by a consistency meter. The design concept was to begin grouting at the lowest elevation in each monolith and, using low pressures, fill the crack from the bottom up in successive lifts. This was successfully accomplished even though no grout stops existed and the cracks carried running water from the drilling overhead. Frequently grout vented from other holes both above and below the three concrete lifts; in such cases packers were put in such holes. To insure completeness of filling the cracks, the holes were systematically bled and individually grouted. Grout was cleaned from the holes for receiving tensioning bars.

Repair work was started on March 17 and all drilling, grouting and installation of prestressing units ready for loading was completed by the 4th of August. Compressive strains, induced in the concrete during stressing ranged from 0 to 90 millionths of an inch. No additional strains along the crack or in the crack opening occurred during filling or emptying of the lock and the water tightness of the grouting job was shown by absence of leakage under a head of 98 feet. By having adequate foundation records from construction, investigation of the foundation was not required. By use of engineering geology tools and methods, the needs of the structural engineer for knowledge of construction methods were met.

MICA DAM

The MICA DAM Project, located in the Big Bend section of the Columbia River, in British Columbia, Canada is now under construction, with abutment stripping operations and the driving of the twin diversion tunnels being advanced. Tunneling is by a joint venture group headed by the Perini Corporation. Engineering for the project is by CASECO Consultants Ltd. of Vancouver, British Columbia who have retained Drs. Arthur Casagrande and Ralph Peck as soils engineering consultants and Dr. Frank Nickell and Mr. Thomas F. Thompson as consultants on engineering geology. The site is located about 90 miles upstream from Revelstoke in an area dominated by pre-Cambrian rocks - mostly gneisses and mica schists. The fill dam is to be of the central core type with shells composed of compacted gravel available from extensive deposits upstream. This will be one of the highest dams of its type in the world.



Ice Harbor Lock and Dam on the Snake River in Washington. The repaired navigation lock monoliths are shown in the upper left hand corner of the photograph.

GEOLOGY IN UNDERGROUND WORKINGS

Lloyd Underwood

It is hoped that this feature will keep us informed of latest developments in geologic exploration techniques, instrumentation and excavation methods for tunnels, shafts and other underground workings. With this in mind we welcome information pertaining to these topics as well as any information on underground works which may be of special interest to engineering geologists.

We have received the following communication from Professor Niles E. Grosvenor of the Colorado School of Mines, who recently returned from Europe:

"The trip behind the 'Iron Curtain' was interesting and educational. I visited the Civil Engineering Labs of the University in Leipzig and the Geophysics Labs, as well as the Rock Mechanics Labs at the University of Freiberg, also in East Germany. The Civil Engineering Labs and Rock Mechanics Labs were doing about the same work and using the same equipment as we do. The Geophysics people work closely with the mining industry. They have done a lot of seismic work on determining how solid the rock is in tunnels. Also, they test the rock by geophysical methods where they plan to place concrete dams. They have developed a very simple hand-held vibrator that has a range from 20 cycles per second to 10,000 cycles per second. They go along the walls of a tunnel to check for poor rock etc. They use this same tool to check the bottom of an excavation to see how solid the rock is."

Chicago Tunnel Test Program

The Metropolitan Sanitary District of Greater Chicago has a group of progressive engineers who are taking a new look at tunnel design based on an elaborate instrumentation program (ENG, 16 Dec. 1965, p. 212). The engineers propose a $250,000 electronic test instrument program to gain tunnel design data which it is hoped will ultimately save millions of dollars in tunnel construction costs.

Goals of the instrumentation program are to answer the following questions: 1 How do tunnel support loads at the heading compare with loads ahead and behind the heading ? 2 Do loads on tunnel supports behind the heading become stable? 3 How much influence does compressed air have in decreasing tunnel support loads? 4 How are loads transferred from soil to support to lining? To obtain answers to these questions a variety of instruments will be installed, among which are: air pressure cells, concrete stress cells, tension-compression cells, pore-water pressure cells, and special extensometers. For more complete information on the instrumentation the reader is urged to look up the ENG article (see above).

While most of Chicago's tunnels are driven through glacial till, stream laid alluvium and lacustrine deposits, these mixed soils are similar in many respects to some weak shales and other soft rocks found throughout the world. Since 1963, mechanical moles in Chicago have bored over 26,000 feet of tunnels through this material. The tunnels vary in diameter from 8 feet to 22 feet.

BUILDING CONSTRUCTION AND LAND DEVELOPMENT

Gary Melickian

Geologic and Engineering Properties of Alluvial Fan Soils

Alluvial fans are common, yet striking, features in most of the arid and semi-arid regions of the world. Due to their position in desert basins, they usually are the first desert areas to be developed, both for agriculture and for housing. Approximately 20% of the land surface of California and 30% of the land surface of the southwest is covered by fans. Many of the geologic and soils investigations in the southwest have dealt with the engineering and construction problems related to founding structures on fans. In addition, fans are sources of ground water and construction materials.

An alluvial fan is a body of detrital sediments by a mountain stream at the base of the mountain front. The surface of a fan forms a segment of a cone that radiates downslope from the point near which a stream emerges from the mountains. (A small alluvial fan is often termed an alluvial cone.)

An alluvial fan grows in two directions. As the rock slope retreats, detrital material is added to the alluvial surface which is then extended further down slope. Practically all reduction of rock slopes and contributions to the fan are during brief and infrequent periods of rainfall. However, climatic and tectonic changes in the drainage basins affect the rate, mode and locus of deposition.

Alluvial Fan Deposits

There are two distinct types of deposits characteristic of alluvial fans. These are: water-laid deposits and mudflow deposits. A third type, which is transitional, appears to have the characteristics of both.

Water-laid deposits result from the same "rules" of accepted hydraulic theory that most engineers and geologists are familiar with. These deposits generally consist of layers of sand and silt deposited by a network of braided streams or of lenticular bodies of sand and gravel deposited in the beds of the main stream channel. The water-laid sediments in the main stream channels are usually coarser-grained and more poorly sorted.

Mudflows, on the other hand, do not appear to have resulted from the "rules" of accepted hydraulic theory. A mudflow is a layer of mud, from a few inches to a few feet thick, which covers a limited portion of the alluvial fan surface. It behaves generally like a viscous fluid. The requirements for mudflow conditions are rather different from those required for typical water-laid deposition. There appear to be four requirements for the formation of mudflows. These are: a source of unconsolidated material that becomes slippery when wet; slopes which are steep enough to induce flowage in this material; a sufficient, but not over-abundant, amount of water; and a lack of vegetation cover.

A mudflow slides or glides over the surface without the internal churning that a sediment-laden stream would be characterized by. Thinner mudflows are more fluid and move more rapidly. The thicker the mudflow, the larger the boulders that can be carried. One of the most striking features of many mudflows is the abundance of boulders which may range up to several feet in diameter. In excavation of mudflow deposits, many of the boulders will not rest on the ground beneath the flow, but will lie on the flow itself. In addition to large boulders, mudflows can be recognized by the presence of twigs, air pockets and elongated pebbles with no preferred orientation.

Some Engineering Properties

Desert soils are usually characterized by slow developing and shallow profiles, poorly defined structure, only slight weathering of minerals, and high content of calcium carbonate or other salts. The specific physical and chemical characteristics depend mostly on the nature of the parent rock, since soils remain moist for only a short time during each year and biological activity is limited.

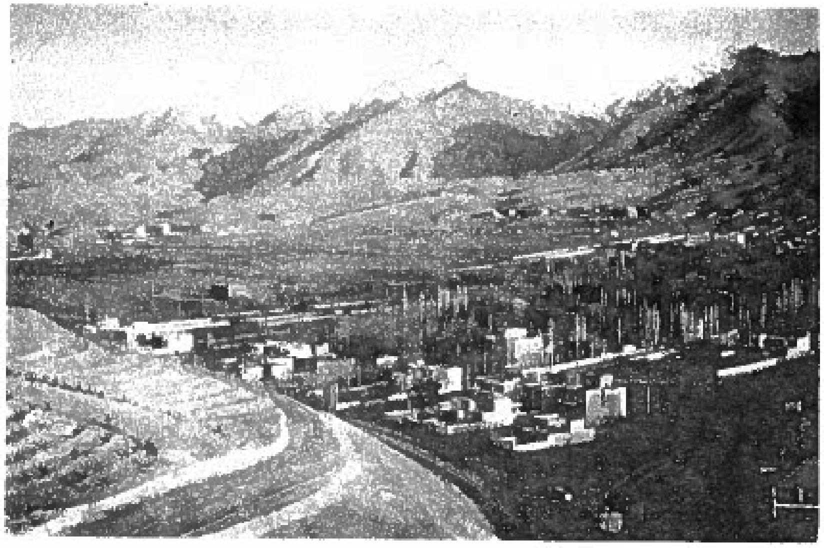
Alluvial fan soils are mostly mixtures of sands, silts and clays in varying percentages with no over-all predominant feature. Some of these soils are dangerous foundation materials in that they appear firm or hard in place. The density and porosity vary rapidly over relatively small distances. Yet, in view of the apparent firmness and uniformity of surface conditions, the uninformed engineer or geologist may feel that a foundation investigation is an unnecessary expense to the client. In the long run this is an expensive decision.

Desert soils are frequently dessicated; that is, they are materials that have been exposed to the air and the free water evaporated. In the arid southwest, this condition is widespread. In alluvial materials the soils may be laid down in layers during storms of short duration. As a consequence, each layer may dry out quickly without saturating the underlying deposits. Thus, each layer will dry out with a low-density structure, which is not resaturated by subsequent deposition.

Upon drying, surface tension due to the remaining pellicular moisture produces an apparent cohesion. This condition occurs in both granular and cohesive materials. The degree of apparent cohesion depends upon grain size, degree of dessication, mineral content, and porosity, among other things Apparent cohesion is often readily relieved when the soil is saturated

Frequently, these dessicated alluvial materials appear so hard that an inexperienced engineer or geologists will classify them as rock. If the materials do not soften readily, the "feeling" of hardness may represent the true engineering properties. A relatively close examination is often necessary for correct determination.

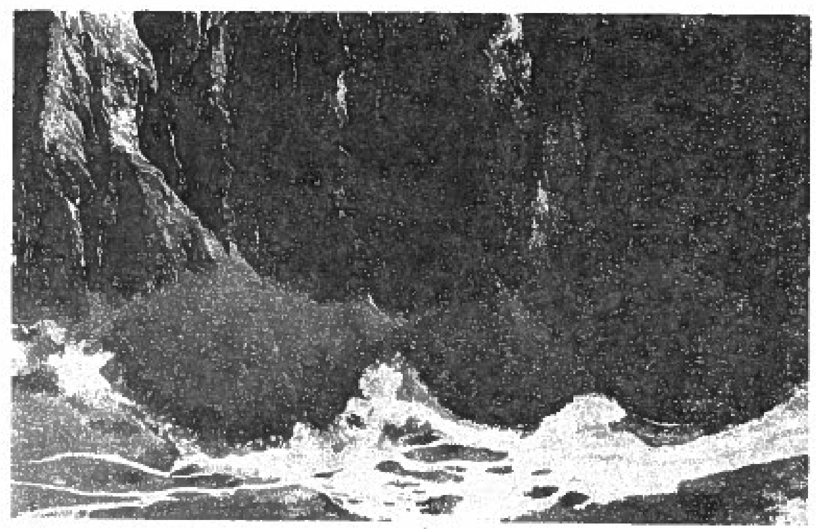
If it can be assured that moisture increase will not occur, there may be advantages gained by making use of the higher shear strength of the partially saturated soils. However, such an assumption is seldom warranted. Based on the possibility of a change in moisture, there are two significant engineering properties. When moisture is added to the granular soils, there may be a loss of



Portion of city of Teheran, Iran, located on extensive alluvial fan at the base of the Elbury Mountains.

Typical erosion pattern on fan surface.

Portion of a small mudflow, several months old, in western Fresno County, California.



Typical alluvial fans in the California Basin and Range Province.

strength due to the decrease in apparent cohesion. Also, the addition of water to partially saturated fan soils can create large settlements or collapse.

Saturation and Partial Saturation

The most frequent engineering calculations are for the bearing value and amount of settlement. The bearing value is based on the cohesion and angle of internal friction of the materials being studied. There is often a considerable difference between the shear strength obtained under saturated conditions and that obtained under partially saturated conditions. This is particularly true of highly dessicated soils. It is important to determine which condition should prevail and the safety factors to be applied to the values calculated for these conditions. The solution will vary with such factors as drainage, intended use, paving, planting, proximity of groundwater and so on.

When site conditions are such that saturation is unlikely, it is economically sound to design for the higher shear strength of the partially saturated conditions. However, the saturated shear strength should always be considered, since it represents the worst possible conditions, and may occur as the result of irrigation of landscaping, leaking utility lines, and so forth.

A similar problem exists where calculated settlements for saturated conditions are several times as great as settlements calculated for the partially saturated conditions. As an example, some desert soils may settle several feet under their own weight when they become saturated. When the possibility of saturation is low, the estimated settlement can be based upon the consolidation test data obtained for the more favorable conditions. Since it is always possible that saturation could occur under portions of the foundation, resulting in differential settlement, such an estimate is not usually made. If differential movement could cause structural failure, or damage beyond tolerable limits, then the foundations need to be reinforced or redesigned or else the soil conditions must be modified.

For instance, a two-story office building in Arizona was badly damaged when portions of the building settled. It was determined that the portions adjacent to lawns were undergoing several inches of settlement while areas of the building which adjoined paved areas experienced little, if any, settlement. In this case, the problem soils did not extend more than 20 or 25 feet below the ground surface. The landscaping and lawns were replaced, the soils below the settled portions were stabilized by grouting and the building was reveled.

There are other very interesting engineering and construction problems related to alluvial fan materials. Some of these will be discussed further in the next issue.

INSTRUMENTATION FOR ENGINEERING GEOLOGY

Sig. Schwartz

Instrumentation of various types is often employed by the engineering geologist or engineer to obtain data pertinent to the geologic evaluation of the engineering site or other problems related to engineering geology. Principal areas of availability and use for such instrumentation are in subsurface exploration by geophysical methods, instrumentation of existing or potential earth or rock failures, rock mechanics, groundwater studies, blast vibration measurements and engineering seismology.

The use of specialized instrumentation in our field had been taking place for many years on a limited scale and has seen an almost exponential growth over the past few years. This growth is certain to continue in the future. Few Engineering Geologists have a thorough working knowledge of more than a few instrumentation techniques of "tools" that are available because of the specialized nature of equipment and techniques as well as inadequate communication within the field.

The field of engineering geology is emerging rapidly from the field of general geology as a distinct and identifiable profession. As this occurs, increasingly greater responsibility is being placed on and accepted by engineering geologists to identify, accurately define, and evaluate geologic conditions and potential hazards. With this responsibility comes the necessity to know and understand the application of all available tools and methods that can be applied to a specific problem. Conclusions based upon inadequate information can result when these tools are not employed or if an improper method of selection is made.

It will be the primary purpose of this article in future issues of this publication to describe various types and methods of instrumentation employed in engineering geological studies as well as their advantages and limitations. The second objective of future articles will be to encourage communications within the field which may result in the development of new uses or improvement of existing instrumentation as well as the development of new and more advanced techniques and methods. You are encouraged to send information of new tools and instruments or applications of instruments to me at GeoRecon, 1105 N. 38 St., Seattle, Washington.

KENNECOTT AND MISSOURI G. S. HAVE OPENINGS

Kennecott Copper Company is looking for several engineering geologists with rock mechanics backgrounds. Write to Dr. Allen H. James, Staff Geologist, Kennecott Copper Company, Salt Lake City, Utah.

Missouri State Geological Survey and Water Resources Division. There is a position for an engineering geologist. Write to Dr. W. C. Hayes, State Geologist, P. O. Box 250, Rolla, Missouri.

We would like to print more of these notices as a service to the profession. Write to the Editor.

DR. EKBAW GETS BERKEY GAVEL

At last year's GSA meeting in Kansas City our past Chairman of the Engineering Geology Division was presented the Berket Gavel. He also received the following letter:

"The members of the Engineering Geology Division wish to express their appreciation of your many years of devoted service in the field of engineering geology. We hope that the symbolic 'Berkey Gavel' which accompanies this letter will serve that purpose. As you know, the original 'Berkey Gavel' was made from a short length of diamond drill core from the east coast of the United States. It was presented to Dr. Charles Peter Berkey by the Division of Engineering Geology in recognition of the great stimulus he had given to the application of geology to the art of engineering. We thought it appropriate that our memento be a sample of a west coast formation, and that it be the product of geologic exploration for a significant engineering project. The replica consists of Tejon Lookout granite formation from the Tehachapi Mountains, California. It was obtained during exploration for the five mile Carley V. Porter Tunnel, a feature of the California Aqueduct which is now under construction and scheduled to convey water to the Los Angeles Coastal Plain in 1972. The core hole from which this sample came was located between the San Andreas and Garlock faults, not far from the intersection of these great features. The sample is from a depth of 1,600 feet. Understandably it is one of the larger segments of intact rock obtained.

In closing we of The Geological Society of America wish you a speedy recovery and hope to see you at the annual meeting in San Francisco next year."

EDUCATION

Geotechnical Engineering at Berkeley Engineering Geology, Geological Engineering, and Rock Mechanics have joined with Soil Mechanics, Foundation Engineering and Highway Materials Engineering to form a strong graduate program in Geotechnical Engineering at the University of California in Berkeley. The program is part of the offerings of the Department of Civil Engineering, Professor Harry B. Seed, Chairman. Geologically oriented members of the faculty are P. A. Witherspoon, R. E. Goodman, Roger Rhoades, Thomas Thompson, and T. A. Lang, the last three as part-time lecturers. At the undergraduate level, by suitable selection of elective courses, a complete gradation exists between pure soil mechanics and pure geological engineering programs. For further information write to the Graduate (or Undergraduate) Advisor for Geotechnical Engineering, 473 Hearst Mining Building, University of California, Berkeley, California.

Activities at Arizona The Geological Engineering Department now has 18 graduate students and 29 undergraduates. An active research program is underway including: application of shallow seismic investigations to determine rock strength in open pit mines; dynamic testing of soils in-situ; and study of subsiding mudflow deposits in the Tucson basin. For further information write to Professor W. C. Lacy, University of Arizona, Geological Engineering Department, Tucson, Arizona.

CONFERENCES AND ACTIVITIES OF SOCIETIES

R. E. Goodman

Symposium on Hydrology of Fractured Rocks Dubrovnik, Yugoslavia, Oct. 7-14, 1965
This conference was sponsored by UNESCO as part of the International Hydologic Decade. Thirty countries were represented by 120 persons in attendance and 70 papers were presented. Of these 4 dealt with sea water intrusion, 19 with basic hydrogeology, and 38 with hydrogeology of karstic terrain including 25 papers on the hydrologic budget of karst terrains, 2 on water flow in mines and limestone, 2 on surface hydrology of karst terrains, 2 on artificial recharge, and 7 on theoretical studies. Only 9 papers dealt particularly with fractured rock, as follows: Karel Zima (Czechoslovakia) discussed "Some Details of the Circulation of Groundwater in Non-Karstified Fissured Formations in Czechoslovakia". There were 2 papers from Hungary, one by Tettamanti on "Hydrological and Hydraulic Characteristics of Waters Flowing from Fissured Carbonate Rocks into Mines", and the other by Willems on "Characteristics for the Communication of Water in Fissured Carbonate Strata" Bachmat, from Israel, discussed the theory of steady state flow in porous media with some reference to fractured rocks in a paper entitled "Basic Transport Coefficients as Aquifer Characteristics". Yamamoto (Japan) considered "Hydrology of Fractured Rocks in Regions of Volcanos". Rofail (UAR-Egypt) discussed "Analyses of Pumping Tests in Fractured Rocks". Vecchioli from the USGS in Trenton, New Jersey, described directional hydraulic behavior in fractured shale in New Jersey; and Rats and Tchernychov (USSR) described "Statistical Aspects of the Problem of the Permeability of Fractured Rocks".

The Editor has a list of participants with addresses. We are indebted to Professor Paul A. Witherspoon, who attended, for this information on the conference.

A Symposium on Engineering Geology and a New Journal in India. Indian geologists have started a new society of engineering geology. Last October the society held a symposium on geological and engineering problems of India's river valley projects in which about 70 papers were presented. The society will shortly publish the Proceedings in its own new journal.

Intersociety Committee on Rock Mechanics, Seattle, November 1, 1965. The second meeting of representatives from scientific and professional societies with interests in rock mechanics. In attendance were Society representatives: Orson Anderson - SSA, Carl B. Crawford - ASTM, Ken Gray - SPE, John W. Handin - AGU, Howard L. Hartman - AIME, Laurence B. James - GSA, Richard E. Goodman - AEG, Thomas H. Lang - ASCE, Gerald Leonard - HRB, Louis Panek - SME, Harry E. Stommel - SEG, E. F. Cook - National Academy of Sciences, and William R. Judd - NAS Committee on Rock Mechanics.

The following motions were made and passed:

1 That an Intersociety Committee on Rock Mechanics (ICRM) be formed.
2 That NAS appoint an ex officio, non-voting member to ICRM from the NAS Rock Mechanics Committee, subject to a reciprocal appointment to the NAS Committee.

3 That the objectives of ICRM be: a. To improve intersociety communications on all aspects of rock mechanics. b. To promote an intersociety annual conference on rock mechanics. c. To function as representative of the United States at meetings of the International Society of Rock Mechanics. Amended to defer action until the next meeting of ICRM.
Dr. Gerald Leonard was elected Chairman of ICRM and Carl Crawford was appointed Secretary.

The proposal made at the Washington, D. C. meeting to expand the present Four-School AIME Symposium on Rock Mechanics was next reviewed. The four schools are willing;however, AIME would be amenable only with the provision that it publish all proceedings. For this privilege, AIME would underwrite all costs of publication. This condition imposed by AIME provoked some debate.

The following recommendation was made in the form of a motion and was passed subject to ratification by the executive bodies of the member societies:

The Intersociety Committee on Rock Mechanics recommends that member societies enter into co-sponsorship with AIME and the present host institutions of the Annual Symposium on Rock Mechanics on the following basis:

1 Responsibility for program planning, selection of papers, and editing of publications in the Proceedings shall rest with a Symposium committee.
2 Members of the Symposium committee will be appointed by the Intersociety Committee on Rock Mechanics with the concurrence of host institutions. The Chairman will be selected from the host institutions. A majority of the committee members will be selected from the participating members of the departments at the host institutions.
3 The Proceedings volume will constitute the sole publication of the conference. AIME will publish the Proceedings on behalf of the Intersociety Committee.
4 Additional host institutions may be invited to participate with approval of ICRM and the host institutions.

The proposal that ICRM function as the group to represent the United States at international rock mechanics meetings was considered. The Chairman of ICRM will write the National Academy of Sciences recommending that ICRM assume the responsibility.

The meeting adjourned at 2 a. m. , November 2nd.

The GSA has since ratified the objective and the motion on an annual meeting above. The AEG Executive Council passed the objectives a and c but withheld approval of the annual meeting recommendation because it felt each of the societies should take turns conducting the meeting, rather than asking universities to be hosts each year. The other societies have not yet been heard from.

ACTIVITIES OF ENGINEERING GEOLOGISTS

Arthur Cleaves

In this feature we will trace the doings of our colleagues and in the process tour projects involving engineering geology around the world. Address communications to me, Dept. of Earth Sciences, Washington University, St. Louis, Missouri.

J. M. Neilson - Geological Consultant and Professor of Geological Engineering, Michigan Technological University, Houghton, Michigan, has been doing consulting work for the past several years in Western Australia on the Iron Ores of the Opthalmia Region, Western Australia. Although known since the 1930's, the true significance of these deposits has only recently come to light. "Western Australia may well contain the world's largest known reserves of iron ore." This reserve is placed in recent reports at 15 billion tons, which may be conservative. See his recent article in Transactions, Society of Mining Engineers, December 1965, pp. 328-338. This is a very interesting article.

Robert O. Vernon - State Geologist, Florida, writes: "As you may recall, the Biscayne Aquifer, which supplies the water for the Broward, Palm Beach, and Dade County megatropolis, is the most permeable in the world. Permeabilities of 50 million gallons of water per day per foot have been recorded. Several attempts to place foundations, elevator wells, and basements by dewatering the aquifer have resulted in high construction costs generally well above bid estimates. It has been found more practical to treat these foundations as if they were to be constructed in open water. Where possible, the subground structures are constructed above ground, water-proofed, floated into a previously excavated hole, sunk into place, and emptied of water."

Richard M. Foose (Pete) - Amherst College, is consulting on ground surface collapse in the Witwatersrand mining district (South Africa) of catastrophic proportions, which resulted from a major dewatering program by a group of mines near Carletonville, 50 miles west of Johannesburg. There has been extensive property damage and loss of life.

"The mines are within the 'Oberholzer compartment', a large block of ground, tens of square miles in area, that is bounded by two thick vertical N-S trending syenite dikes. These dikes cut across the E-W striking and southward dipping dolomites and dolomitic limestones of the Transvaal series and effectively seal off all movement of groundwater along the strike of the rocks. The dikes cut through the entire 4,000 feet of carbonate rocks as well as the underlying gold-bearing Rand series to the deepest extent of mining.

The dolomites are deeply weathered so that the range in thickness of the unconsolidated debris is between a few feet and more than a thousand feet. The former ground surface (water), prior to dewatering, stood at about 350 feet below the topographic surface. Now the groundwater surface has been lowered during the past few years to as much as 1,200 feet below the surface. Within the large 'cone of depression' where the unconsolidated debris column has been unwatered, a wide variety of subsidence phenomena have occurred.

These include gradual subsidence of broad areas due to uniform compaction of the dried-out material on the one hand and catastrophic surface collapse with sink holes up to 300 feet in diameter and 125 feet deep on the other.

The large sink holes develop only where the unconsolidated debris column is thick and the bedrock surface deep and, of course, well within the cone of depression of the lowered groundwater surface. Evidence is accumulating also to indicate a rather high degree of irregularity of the bedrock surface in those areas of catastrophic collapse. Apparently the withdrawal of hydrostatic support from the debris column is accompanied by downward migration of soil and rock particles into underlying solution-widened joints within the bedrock while temporary stability of a vault-like roof is maintained above the growing cavity within the overburden. When the progressive occurrence of roof spalls and minor collapses results in a cavern roof too broad to support the overlying lithostatic load, sudden collapse results."

Detailed geologic and geophysical programs of investigations are being carried on;and "Pete" plans a more extensive report in the future aimed toward prediction of incipient subsidence areas, and protection to the surface areas above.

Thomas "Tommy" Thompson - Consultant, Burlingame, California, writes that geological and soil mechanics studies have been initiated in connection with the proposal for a new vehicular crossing of San Francisco Bay between San Francisco and Marin County. Problems involved are similar to those that faced the original construction of the Golden Gate Bridge and are occasioned by the presence of deep water, weak muds and valley-fill sediments, and the erratic nature of the bedrock. Bedrock along possible crossing routes is largely the Franciscan formation of Jurassic and younger age which contains masses of serpentine that is notoriously weak. The geological environment is complex from a structural viewpoint. Initially the studies will be directed toward selection of the most favorable type and route for the crossing, considering bridges, tunnels and submerged tubes as well as other means.

NEW BOOKS AND LITERATURE IN ENGINEERING GEOLOGY

Raymond Whitla

GROUTS AND DRILLING MUDS IN ENGINEERING PRACTICE, Butterworth, Inc., 7235 Wisconsin Avenue, N. W., Washington, D. C., 236 p., 1964, price $26.50. Although this book was published over a year ago, it is a relativelyrecent publication in the field of grouting and in the field of drilling muds. It consists of papers that were presented at a symposium organized by the British National Society of the International Society of Soil Mechanics and Foundation Engineering and held at the Institution of Civil Engineers in May 1963. The book contains 22 papers on grouting and grouting materials (cement, clay, and chemical) and 8 papers on the use of drilling muds in trench excavations and in the drilling of boreholes.

Hansen, Wallace R., EFFECTS OF THE EARTHQUAKE OF MARCH 26, 1964, AT ANCHORAGE, ALASKA: U. S. Geological Survey Professional Paper 542A, 69p., 1965, available from Superintendent of Documents, Washington, D. C. 20402, price $1.75. This is the first of 40 or more reports that are to be published as U. S. Geological Survey Professional Papers giving the results of investigations of the 1964 Alaska Good Friday Earthquake by the U. S. Geological Survey. The report is very well illustrated and brings out the relationship of the damages to the local geology.

Duncan, Neil, GEOLOGY AND ROCK MECHANICS IN CIVIL ENGINEERING PRACTICE: Water Power, v. 1?, no. 1, p. 25-32, Jan. 1965; no. 2, p 63-68, Feb. 1965; no. 3, p. 99-102, Mar. 1965; no. 4, p. 145-152, Apr. 1965; no. 5, p. 192-194, May 1965; no. 6, p 225-229, June 1965. As can be seen by the listing above, this is a series of six articles in the January to June 1965 issues of Water Power, a magazine published by Tothill Press, Ltd., London, England. The series starts with a discussion of the geologic factors that form the background of rock mechanics studies and ends with a discussion of the behavior of rock masses as foundation beds and of the application of geology and rock mechanics to the construction of buildings, roads, dams, reservoirs, and tunnels. In between are discussions of factors affecting the deformation and failure of rock masses, of in-situ stresses, of field tests for various rock properties, of stability problems, and of slope failures in rock masses.

Knill, J. L., and Jones, K. S., THE RECORDING AND INTERPRETATION OF GEOLOGICAL CONDITIONS IN THE FOUNDATIONS OF THE ROSEIRES, KARIBA, AND LATIYAN DAMS: Geotechnique, v. 15, no. 1, p. 94-124, March 1965. This paper is concerned with techniques of investigating geological conditions in dam foundations, the methods of recording the information obtained, and the manner in which the information can be presented in engineering terms. The first part of the paper discusses the general situation and reviews techniques of obtaining and recording information. The rest describes the geologic conditions, the exploration techniques and the methods of recording and of presenting the geological data at each of the three dams named in the title.

Delinois, Serge L., THE CHALLENGE OF THE 70'S - MINING ON THE MOON: Mining Engineering, v. 18, no. 1, p. 63-69, Jan. 1966. This article describes some of the problems that will be encountered in performing drilling, blasting and mucking operations on the moon when man starts construction and mining operations there. Those who are interested in lunar engineering geology should find it interesting.

Reprint of Glossary

The Swiss Society of Soil Mechanics and Foundation Engineering intends to reprint the following two publications:

The GLOSSARY in Six Languages on Soil Mechanics and Foundation Engineering (English, French, German, Spanish, Portuguese, Swedish). The reprinted edition will also include Italian and Russian. Price $4.60.

PROCEEDINGS of the Third International Conference of Soil Mechanics and Foundation Engineering, Zurich, 1953. Price $65.00.

The Glossary was scheduled for publication in October 1965. Proceedings will be reprinted when at least 250 copies have been ordered in advance. Orders should be sent to: Swiss Society of Soil Mechanics and Foundation Engineering, Gloria-Strasse 39, 8006 Zurich, Switzerland. Please indicate on the order whether you wish to pay C.O.D. by check or by transfer on post or bank account.

THE ENGINEERING GEOLOGIST

Editor -- Richard E. Goodman
475 Hearst Mining Building, University of California,
Berkeley, California

THE ENGINEERING GEOLOGIST is issued by The Geological Society of America, Engineering Geology Division.

ENGINEERING GEOLOGY DIVISION

GEOLOGICAL SOCIETY OF AMERICA

Proceedings of Meetings Held November 3 and 4, 1965 at Kansas City, Missouri.

W. Harold Stuart, Secretary

Management Board Meeting

The Management Board held its annual meeting on the evening of 3 November 1965. Chairman-Elect Laurence B. James announced that the officers elected for the Fiscal Year 1965-66 consisted of Chairman, Laurence B. James, Chairman-Elect Robert W. Karpinski, Secretary Donald H. MacDonald, and Counselor Don U. Deere serving the second year of a two-year term. Revision of the By-Laws and assessment of a $2.00 annual dues for all division affiliates received a favorable vote. Alice Allen, Asst. Secretary and Editor of the Division Newsletter had informed the Chairman-Elect that she would not be available for reappointment to these offices and it was agreed that Richard Goodman, Professor of Engineering Geology, University of California would be appointed to this dual responsibility. In discussion of the Newsletter it was agreed that efforts should be made to expand the Newsletter by including more Engineering Geology articles of current interest. Reports from liaison representatives and technical committee chairmen were discussed and it was agreed that 6 of the 19 committees and liaison representatives should be eliminated. Those eliminated are: Liaison representatives to ASCE Hydraulic Division and committees on Geohydrology, military Geology, Nuclear Engineering Geology, Coastal Engineering and Drilling, Sampling and Grouting. Several other committees which have not been active for the past year were continued for another year with a possibility that they should be eliminated at the end of this next fiscal year. Following the practice initiated last year, it was decided that a Program Chairman should be selected for the 1967 annual meeting by the Chairman-Elect so that two years will be available for setting up the program.

Scientific Sessions

The Division scientific sessions were held the morning and afternoon of 4 November in the Terrace Grill, Muhlebach Hotel. Eight papers were presented in the morning and seven in the afternoon. Subjects included Rock Mechanics, Engineering Geology Investigations, a discussion of the meaning of Engineering Geology, Photogeology, and use of Chert Aggregates in Portland Cement Concrete. Over 150 people attended these sessions.

Business Meeting

The Division's annual business meeting followed immediately after the luncheon on 4 November 1965 and was attended by 75 people. Chairman-Elect James explained that he was acting as chairman because Chairman Ekblaw had suffered a stroke last February and although improving was still unable to participate in any activity. He displayed a piece of polished core taken from one of the California Department of Water Resources tunnel projects mounted on a plaque as a memento to be presented to Chairman George Ekblaw for his service to the profession of Engineering Geology. He read a letter for presentation to Chairman Ekblaw along with the core and plaque. W. H. Bradley, outgoing President of The Geological Society of America, and Edwin C. Eckel, immediate Past President of the Association of Engineering Geologists were introduced as well as the outgoing officers of the Engineering Geology Division. L. B. Underwood, Program Chairman, and Charles Golder, Field Trip Chairman, were commended for the excellent programs and field trip arranged for this year's meeting.

Elmer Marliave, Program Chairman for the San Francisco meeting in 1966, presented a tentative outline for the 1966 program on Engineering Geology which is scheduled to include a half-day symposium and panel discussion on siting of nuclear reactor sites, a half-day on the Engineering Geology problems of the Bay Area Rapid Transit System and a half-day for general papers plus field trips which will be selected from the following possibilities:

1 Plane trip to Bakersfield following the aqueduct route to observe the saturation being performed to consolidate the ground and the pumping plant construction for the high lift pumping plants. (Estimated cost $35. Enrollment limited.)

2 Trip to Los Banos to inspect the San Luis project. (Estimated cost $20.)

3 Trip to Oroville Dam to see construction of the embankment and the underground powerhouse. (Estimated cost $20.)

4 A charter boat trip in the San Francisco Bay Area to observe installation of the tubes and the caissons plus an inspection of the San Francisco Bay Model at Sausalito or of the tunnels being driven for the Bay Area Rapid Transit System. (Estimated cost $10 to $14, each half.)

Alice Allen, Newsletter Editor, prepared 3 issues of the Newsletter with the help of regional reporters, A. J. Depman, J. A. Hageman, W. C. Hages, W. L. Gardner, R. C. Richter, R. F. Legget. She also reported the following affiliates had died:

Coryell, H. N.	Perini, V. C. Jr.
Gillson, J. L.	Roberts, H. M.
Hawkins, H. H.	Thorsen, C. E.
Lyons, M. S.	Wilson, J. W.

Chairman-Elect Laurence B. James introduced the officers elected for 1965-66:

Laurence B. James, Chairman
Robert W. Karpinski, Chairman-Elect
Donald H. MacDonald, Secretary
Donald U. Deere, Counselor (2nd yr. of a 2 yr. term)

Organization of the Division 1965

Chairman - George Ekblaw
Chairman-Elect - Laurence B. James
Secretary - W. Harold Stuart
Counselor - Don U. Deere

Committee Chairmen

Long Range Planning:	Ernest Dobrovolny	Reference List:	Raymond E. Whitla
Nominating:	John H. Melvin	Abstracts:	John Lemmish
Program Chairman:	Lloyd B. Underwood		

Liaison Representatives

Cordilleran Section, GSA	Ray Richter
Southeastern Section, GSA	John A. Hageman
Association Engineering Geologists	Elmer C. Marliave
Hydraulics Division, ASCE	Elmer C. Marliave
Society of Economic Geologists	John H. Melvin
Joint Committee on Engineering Geology (GSA-ASCE)	L. B. James/S. S. Philbrick
American Society of Photogrammetry	Jack R. Van Lopik

Technical Committee Chairmen

Dams and Reservoirs	William H. Bussey	Materials of Construction	W. H. Stuart
Engineering Seismology	Dean S. Carder	River Engineering	C. R. Kolb
Coastal Engineering	Norman E. Taney	Drilling, Sampling, Grouting	B. E. Clark
Military Geology	James R. Burns	Tunnels	D. U. Deere
Rock Mechanics	Dr. John Handin	Air Photos Interpretation	J. D. Mollard
Nuclear Eng. Geology	W. S. Twinhofel		

W. Harold Stuart, Secretary
Engineering Geology Division
Geological Society of America