The Engineering Geologist

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A NEW METHOD FOR CUTTING ROCK
or
The Age of Aquarius Comes to Mining

The University of Missouri-Rolla Rock Mechanics and Explosives Research Center is beginning research on a new method for cutting rock for use in mining and tunneling operations under the direction of Dr. David Summers.

The method uses a water jet instead of the conventional drill. The jet, about the width of a pin (one millimeter wide), moves at 2,000 feet per second at pressures up to 15 tons per square inch.

The main power source for the research will be a 4.25 gal/min water pump which will supply water at ultra-high speed through a small nozzle to make the jet. Because of high speed tests which are to be made, the rock will be held in the chuck of a lathe, and rotated in the jet path.

This equipment was installed in March and will be used to cut rocks ranging from a soft sandstone through limestone, marble and granites to the hard quartzite. Researchers will thus be able to find the best cutting pattern for the waterjet--determining how the water cuts through the rock, what is the minimum pressure needed to cut certain rocks, what is the best cutting speed, the best rotating speed and cutting angle in drilling. The rock used will be supplied courtesy of about 20 quarries in the United States.

According to Dr. Summers, many advantages will be gained from the water jet method of cutting rock. Preliminary calculations suggest that it is cheaper than conventional drilling. The water jet can drill at speed over five feet per minute in an abrasive rock such as sandstone while a conventional drill in the same sandstone generally cuts about one foot per minute.

In cutting, the water jet has no parts to replace while with most other methods the cutting head dulls in time, often very quickly, and must be replaced. The water from the jet can also be used to carry away the spoil.

Another advantage is that in coal mines, water jets are safer because they will not give off sparks as steel cutters can on hitting metal, these sparks can set off gas and coal dust explosions, while the water from the jet will suppress the dust.

Other advantages may appear as research progresses.

The work is being financed under a project THEMIS Grant to the Rock Mechanics and Explosives Research Center under the direction of Dr. George G. Clark.

As part of the research, improved penetration will be attempted using research done at Leeds University in England by Dr. Summers.

COMING EVENTS

16-28 Aug — River-system Engineering, a short course in Lincoln, Nebr. (R. R. Marlette, Dept. of Civil Engineering, University of Nebraska, Lincoln, 68508)

8-11 Sept — International Congress of Intl Assn of Engineering Geology, Paris (J. Gazel, Secretaire General de Conrite d'Organisation Congres International de geologic de l'ingenieur, BRGM, BP 818, 45-Orleans RP, France)

21-26 Sept — International Society for Rock Mechanics, 2nd Congress, Beograd, Yugoslovia. (Sekretaryat 11 Kongresa Medunarodnog drustra Za mehaniku stena, Institut Za rodoprivredw Jaroslav Cerni, Bulevar Vojrode Misica 43, Beograd, Yugoslavia)

20-23 Oct — Association of Engineering Geologists, annual meeting, Washington, D. C. (C. F. Withington, U. S. Geological Survey, Washington, D. C. 20242)

8-12 Nov — Society of Exploration Geophysicists annual international meeting, New Orleans. (Howard Breck, Box 1067, Tulsa, Oklahoma 74101)

11-13 Nov — Geological Society of America, annual meeting. Milwaukee (GSA headquarters, Box 1719, Boulder, Colo. 80302)

A symposium on "Geological Factors in Rapid Excavation," will occupy the major part of the program on November 11 of the Engineering Geology Division. The program will be made up of invited papers, but anyone having exciting developments to report in a contributed paper should send his ideas to Howard J. Pincus, Dept. of Geological Science, Univ. of Wisconsin, Milwaukee, Wisconsin, at once.

14-16 Nov — Symposium on Earthquake Engineering. University of Roorkee, India. (School of Research & Training in Earthquake Engineering, University of Roorkee, Roorkee, U. P. India.

16-18 Nov — Symposium on Rock Mechanics, University of Missouri, Rolla. Papers invited. (G. B. Clark, Rock Mechanics & Explosives Research Center, University of Missouri, Rolla 65401)

INTERNATIONAL ADVISORY CONFERENCE ON TUNNELING DEEMED A SUCCESS

Note. The recent June 22-26, 1970, conference on tunneling, held in Washington, D. C., was judged to be a successful step in reaching agreement on a number of recommendations that it is hoped will greatly advance the art of tunneling on a world-wide basis.

This conference was regarded by OECD (Organization of Economic Cooperation and Development) as an experiment in international cooperation, to demonstrate the feasibility of using the combined knowledge and expertise of many countries to arrive at sounder, more balanced judgments about technological policy. As such, it represented a fresh approach to the role of technology in international planning; consequently, it is believed the results will be reviewed with a great deal of interest.

Official delegations from 19 countries attended the conference. There were approximately 215 official delegates at the conference plus another 150 or more observers. The United States Delegation consisted of 39 members of which your editor was a delegate. The GSA membership was also well represented by Alan L. O'Neill, Don U. Deere, John Handin, Bill Judd, and Norm Dixon, who were in attendance either as observers or in some other official capacity.

Six reports related to the following subjects were prepared and reviewed by each national delegation prior to the conference. These reports were: (1) Report on Tunneling Demand, (2) Report on Hardrock Tunneling, (3) Report on Soft Ground Tunneling, (4) Report on Cut-and-Cover Construction, (5) Report on Immersed Tunnel Construction, (6) Report on Research and Development Related to Tunneling.

These reports were first discussed in technical sessions and then presented for discussion by the entire body of delegates at Plenary sessions.

At the end of the conference, a set of recommendations was presented, discussed, and then approved by each of the national delegations.

While reading the recommendations, it should be kept in mind that the essential aim of the OECD advisory Conference on Tunneling was to advise governments on what steps should be taken to respond effectively to the challenge of the growing demand for underground excavation. This demand is not only from increased requirements in the traditional sectors, i.e., mineral extraction, utilities, transportation, and hydroelectrical development, but also from special needs of urban areas. As urban populations expand and cluster into even larger and denser units, it becomes increasingly necessary to conserve the surface land and to protect the quality of the environment by placing underground many of the essential functions and facilities that have until now been left at surface level (e.g., power plants, parking garages, sewage works, reservoirs, factories, warehouses, and fuel storage facilities).

The Conference Recommendations are published in full. I have underlined those statements which I think should be of most interest to us as engineering geologists.

L. B. Underwood

CONFERENCE RECOMMENDATIONS

Introduction

These recommendations have been established by the OECD Advisory Conference on Tunneling, at which the following countries participated: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

The world demand for tunneling*, already considerable, is expected to grow at an increasing rate. According to the survey conducted in preparation for the Conference, a total of at least 13,000 km (430,000 km including mining) of tunnels, with an excavated volume of at least 300 (4,000) million cubic metres, was constructed during the decade 1960-1969 in OECD countries. At the date of the Conference, the value of tunneling in these countries was running at an annual rate of the order of $1,000 ($3,000) million. The figures in parentheses include tunneling associated with mining, which is otherwise excluded. During the decade 1970-1979, the demand for tunneling is expected to be at least doubled by comparison with the previous decade.

The growing level of demand stems not only from increased requirements for underground excavation in the traditional sectors--mineral extraction, utilities, transportation, hydroelectric development, and the like--but also from the newer and special needs of urban areas. As urban populations assemble in ever larger and denser units, it becomes increasingly necessary to conserve surface land and to protect the quality of the environment by placing underground many of the essential functions and facilities that have hitherto been left at surface level (e.g., power plants, car parks, reservoirs, sewage works). As cities continue to grow, this aspect of demand for tunneling will increase, and increase rapidly, posing a difficult challenge to those who must plan and implement urban development.

The essential aim of the OECD Advisory Conference on Tunneling is to advise governments on what steps should be taken to respond effectively to this challenge. In this sense, the Conference differs from any previous international meeting on tunneling--or for that matter from any past technical conference. Most of today's technical meetings are designed to review the state of knowledge in a given field and to serve as a forum for the exchange of information, views, and experience. This Conference is being used deliberately to focus attention on the social requirements for a specific technology, namely tunneling. The Conference is therefore concerned with assessing the potential of tunneling and with developing guidelines for a positive

*"Tunneling" as used in this Conference refers to the construction by any method of a covered cavity of predesigned geometry whose final location and use are under the surface, whose cross-sectional area is greater than 2 sq. metres.

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public strategy that may permit this potential to be exploited.

Considerable progress has been made in specific types of tunneling during the last ten years or so; where the most concerted efforts have been applied, the costs and construction periods of a few specific types of tunneling have been reduced by 50 percent or more. There is nevertheless broad agreement among the nations which participated in the survey preparatory to this Conference that further substantial improvements in the art of tunneling need to be, and can be, achieved. Not only can construction costs and the periods of construction be significantly reduced, but also the undesirable impacts of tunnel construction, particularly on the urban environment, such as noise, dust, vibration, and ground movements, can be minimized as well. Appropriate action by governments is expected to hasten the rate of advance and, in some respects, is considered essential if particularly intransigent obstacles to advance are to be surmounted.

That is not to say that progress will be instant and easy. There are no simple panaceas to the existing problems. The overriding importance of the diversity of ground conditions, the uneven degree of technical advances in particular types of tunneling, the many processes involved in tunneling apart from the advancing of the tunnel length, the variability of working conditions, the relationship between the size of project and the optimum scheme of construction--all these factors contribute to the complexity of the task and preclude simple solutions of universal application.

Rapid improvement in the art of tunneling is further inhibited by a variety of institutional factors. Progress has been hindered, for example, by the tendency to regard tunneling for different purposes as involving different techniques and skills; there has been too much emphasis on the differences and too little regard for the essential similarities in the methods of tunneling. Secondly, tunneling tends to be considered too much as an amalgam of separate techniques rather than as a unified system. Research effort is unevenly distributed among the various elements of the tunneling process, with some important areas receiving comparatively little attention. Finally, the often intermittent and unpredictable nature of the tunneling market is not conducive to the rapid introduction of innovation. The most notable recent innovations have occurred generally where there has been a sustained promotion of tunneling for a specific purpose over a period of years.

The factors described above--inherent technical difficulties in tunneling, institutional obstacles, and inadequate recognition of the merits of subsurface alternatives--have all contributed to a reduced rate of progress in the art of tunneling. The object to be achieved is that of making the best use of tunneling in the interests of society. Obstacles to this endeavor must therefore be identified, defined and, where practicable, circumvented.

NEED FOR A FOCAL AGENCY IN EACH COUNTRY

The first step toward advancing the state of the art and creating a climate conducive to more widespread use of underground construction would be the establishment or designation in each country of an organizational entity to serve as the focal point for tunneling activity within the country. This organization or agency would undoubtedly take a different form in different countries. In some, the organization might be small, with the primary function of coordinating the activities of other working groups and insuring that some working group is responsible for performing each of the essential activities. In other countries, the focal agency may be a much larger group which actually performs many of the essential tasks.

Recommendation 1

It is recommended, therefore, that each country should designate an agency at the national level with responsibility for the coordination of the assessment of tunneling activity and, where appropriate, for the stimulation of improvements in tunneling technology. At a minimum, such an agency should undertake or cause to be undertaken the following activities:

1. *Collection and dissemination of technical information related to tunneling, including current research, development and innovative activities, as well as data on cost and performance of tunneling components and systems.*
2. Continuing assessment of the state of the art in tunneling to identify technical needs which might be met through research and development, to ascertain the over-all level and structure of research and development and to review periodically the extent to which it is appropriate to the future demand for different types of tunneling, and to stimulate cross-fertilization of advanced technology developed for other purposes.
3. Periodical statistical demand forecasting and collection of demand data regarding the amount of subsurface construction planned for the future for all uses, classified by ground conditions, size, use and type of structure, and divided into two categories, namely: (a) short-range (say 5 years) demand resulting from conventional uses, current technology and current sponsor preferences; (b) medium-range (say 10 years) demand, including unconventional uses, new technology and potential changes in user patterns.
4. *Systematic compilation of geological data for geographical areas in which tunneling activity is expected, particularly areas of anticipated urban growth.*
5. Review of existing legal requirements and traditional standards as to their effectiveness for obtaining the maximum benefit from tunneling for the community at large.
6. Study of contracting practices in relation to the present state of the art of tunneling, including the consideration of how the risks are shared among the respective parties to the Contract.
7. Action necessary to improve the understanding on the part of planners, officials and the general public of the benefits to be obtained from increased and planned use of the subsurface.
8. *Review of the adequacy of training of engineers in the field of tunneling.*
9. Participation in international activities concerned with the applications, planning and practice of tunneling.

PLANNING THE USE OF THE SUBSURFACE

The subsurface of a city or other center of population has great value and it is highly desirable, therefore, that its use should be determined by positive, comprehensive planning. As a starting point, a single agency in each such locality should be charged with the duty of maintaining detailed records of position and purpose of all existing underground facilities and structures. Future planning of the use of the subsurface should be coordinated with a view to establishing priorities between conflicting requirements, and promoting multi-purpose underground structures and services, all with a regard to the future as well as to the present needs.

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Recommendation 2

It is desirable that, in every urban area, a single agency should be required to maintain detailed records of the present use of the subsurface and that a master plan for coordinated underground construction should be prepared and periodically updated. It is recommended, therefore, that each government should take the appropriate action towards this end.

USE OF THE TOTAL COST/BENEFIT CONCEPT IN INVESTMENT AND PLANNING DECISIONS

The current practice of evaluating proposed investments in terms of construction costs only, without taking into account the differential in the social and environmental costs and benefits of surface and underground facilities, tends to make the gap between the cost of an underground facility and that of a comparable surface alternative appear wider than it actually is. The subsurface alternative would often appear more attractive if appropriate weight were given, for example, to the social cost of surface activities, including interference in access, obstacles to future land use, inconvenience and loss of business time during construction; to the reduction in ratable value or tax base through permanent occupation of land; and to the beneficial effect on environmental quality of setting a particular facility underground, thereby reducing for perpetuity noise, vibration, fumes and visual intrusion.

Recommendation 3

It is recommended, therefore, that in the evaluation, comparison and choice of public inveatment, account be taken of the indirect as well as the direct costs and benefits of surface and subsurface alternatives.

In order to facilitate implementation of this recommendation by the many diverse governmental and other public bodies who are responsible for planning decisions, more definitive data and more adequate methods should be developed to measure the social impacts of more intensive and effective use of the urban subsurface through:

1. Studies of the effect of alternative construction processes on the urban environment and the urban dweller to develop a basis for determining total costs, including indirect costs attributable to business disruption and impact on the health and well-being of the urban population.

2. Studies of the psychological and other social impacts of greater use of the subsurface, including unconventional applications such as underground plants.

3. *Studies of the differential effects on the urban environment, including its ecology, of greatly increased use of the subsurface, both during and after construction, e.g., changing water table, utilization of disposal of excavated material, susceptibility to earthquake damage, changes to urban life, etc.*

4. Comparison of the costs of all alternatives, of surface, cut-and-cover construction and underground tunneling taking into account all costs including social costs.

ENCOURAGEMENT OF TECHNOLOGICAL ADVANCE

General agreement has been expressed, in response to the survey, that the scope of research and development related to tunneling should be broadened and the level of effort increased. In view of the geological and other differences between countries and the variety of tunneling techniques, it is not surprising that diverse opinions were expressed in the survey concerning the priorities for such research.

A recurring observation in individual replies to the survey called attention to the apparent difficulty of applying the results of research to problems of tunnel design and construction. A related problem is insufficient use of the best available techniques in actual practice.

It is clear that there are weak and even missing links in the chain of events that starts with research, continues through development, testing, evaluation, modification and re-evaluation and which should finally end in diffusion, wide acceptance and general use of a given technology in appropriate circumstances. To some extent this is due to the particularly variable conditions encountered in tunneling and the consequent diversity of problem areas. There is, moreover, in general a lack of common purpose in research, design and construction of tunnels leading, in many instances, to failure to achieve a solution best suited to its purpose and to a tendency to consider each aspect in isolation from the others.

It may be noted that, in the presentation of the OECD Demand Report on Tunneling, with the exception of the mining sector, tunneling projects are very largely constructed by public funds for public ownership or use, e.g., water supply, sewers, or transportation. It is axiomatic that the investment of public funds for research and development in tunneling should result in cost savings to the funding authority.

Recommendation 4

It is recommended, therefore, that each country should, as soon as practicable, take action to promote a more rapid, effective and wide-spread use of technical advances in the field to tunneling. The basic elements of such action should include:

2. *Comprehensive programme of observations of ground loads, groundwater and seismic behaviour, stresses and movements associated with tunnels, including long-term studies of completed tunnels, for comparison with predictions.*

2. Encouragement and, where appropriate, requirement to use best existing techniques and equipment on construction projects, including fully adequate site investigation at the planning and design stages of a project.

3. *Encouragement of research projects related to the practical problems of the construction and maintenance of tunnels.*

4. Sponsorship or promotion of full-scale trials and demonstrations of new or unconventional techniques and equipment on actual construction projects.

5. *Participation in the development of full-scale test facilities, in a range of ground conditions appropriate to the country, for development testing and evaluation of prototypes, of components and systems.*

INTERNATIONAL COOPERATION

Direct action will, in general, be undertaken at the national rather than international level. Thus, the most effective action that could be undertaken internationally is the encouragement of a free flow of information, leading to understanding and cooperation in the solution of common problems.

Recommendation 5

It is therefore recommended that close working ties be established between the national focal agencies, either directly or through an international commission, so that international efforts may be directed toward:

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1. Establishing and maintaining links with other international organizations which have interest in the technology of tunneling and in tunnel operation.

2. *Promoting the establishment of standard procedures and terminology (in conjunction with the established international organizations such as the International Societies for Soil and Rock Mechanics) for the national collection and analysis of data concerning demand for tunneling, geological conditions, statistics, design and construction techniques.*

3. Providing coordination of the advances in tunneling made by each nation so that the total research requirements may be more easily identified on an international scale.

4. Investigating the desirability of establishing standard tunnel sizes and shapes, particularly in relation to the adoption of standards for tunneling machines.

5. Consider the wider adoption of standard contract procedure.

6. Arranging periodic international conferences at intervals to review the state-of-the-art of tunneling.

APPENDIX

RESEARCH REQUIREMENTS

Current Research Priorities

Despite a not unexpected lack of agreement in detail, there is agreement in principle on the need for improvement in every aspect of tunneling, the need being urgent in certain respects. Ahead of the proposed studies mentioned in Recommendations 1 and 3, it has therefore been thought useful to set out below the areas in which the present pace of advance is considered unsatisfactory, and where the need for improvement is most widely felt.

Obviously, the priorities for any individual country will largely depend upon that country's specific tunneling programme and needs. Furthermore, the measures necessary to initiate and undertake an R & D programme will vary among countries, depending on the type of work and the laws, customs and institutions that bear on government-industry relations. Where the community will derive, directly or indirectly, a high degree of benefit from the anticipated improvements, methods of financing research and development may take the form of: (a) direct government support, applied in such a way as to avoid a reduction in priviate initiative for innovation and development; (b) stimulation of private investment in research and development either by tax relief or by appropriate cost sharing; or (c) encouragement of cost saving innovations through schemes for sharing benefits gained in tunnel works.

The principal areas in which research is considered to be a matter of priority are listed briefly below.

1. Geology and Hydrology

1.1 Development of geophysical methods for exploring the ground from the surface and ahead of a tunnel face.

1.2 Development of techniques for obtaining more and better information from boreholes drilled in soil or rock, by geophysical methods.

1.3 Improvements in methods of obtaining "undisturbed" soil or rock samples, including continuous sampling.

1.4 Development of standardized terminology and engineering classification for rocks and soils.

1.5 Development of improved methods of determining groundwater conditions and soil permeability in all directions, of estimating water inflow into excavations, and effects of groundwater lowering and recharge.

1.6 Development of better techniques for detecting and identifying buried services, cavities, and underwater obstacles.

1.7 Study of effects of waves and currents on constructing immersed tunnels.

1.8 Development of improved techniques for determing bedload transport and for predicting the rate and extent of silting of immersed tunnel trenches.

2. Rock and Soil Mechanics

2.1 Basic studies of rock mechanics and soil mechanics to broaden and strengthen the understanding of underlying principles.

2.2 Development of more reliable and economical methods for evaluating in situ properties of soil or rock.

2.3 Study of time dependant in situ behaviour of ground interacting with tunnel structure.

2.4 Improvements in present knowledge of compaction of soils in confined spaces.

2.5 Study of effects on tunnels in different types of ground subject to earth tremors.

2.6 Improvements in methods of predicting the stability of underwater trench slopes for immersed tunnels.

3. Excavation Process

3.1 Basic studies in rock breakage.

3.2 Development of improved cutters and bearings for mechanical boring machines to increase dependability and range of ground hardness in which machines can operate efficiently.

3.3 Development of types of equipment, processes, etc., that are adaptable to changing ground and adverse water conditions.

3.4 Evaluation of new processes for excavation, including unconventional methods of using explosives.

3.5 Development of excavation methods and equipment to minimize detrimental effects on the surrounding material, adjacent structures and the urban environment.

3.6 Standardization of tunnel dimensions to allow more intensive use of machines and equipment.

3.7 Development of simple, accurate guidance systems for tunnel boring (see also *6.3* below).

3.8 Better correlation of rock and soil mechanics data with the performance of excavation machines.

3.9 Development of tunneling methods which support tunnel face in water-bearing ground without necessity to work in compressed air.

3.10 More intensive investigation of the possibility of using unconventional techniques for rock and soil disintegration and excavation.

3.11 Development of improved equipment and processes for accurate excavation of underwater trenches for immersed tunnels.

3.12 Development of improved methods for measuring the depth of trenches for immersed tunnels.

4. Materials Handling

4.1 Studies of the basic behaviour of material particles with regard to flow characteristics, effect of particle size, etc.

4.2 Development of more compact materials handling systems.

4.3 Development of means of disposal of spoil appropriate to urban areas.

4.4 Study of hydraulic and pneumatic systems of spoil disposal.

4.5 Development of improved integrated systems of excavation, loading, transport and disposal of spoil.

4.6 Development of auxiliary systems for sand jetting under immersed tunnel elements at great depth.

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5. Ground Support and Tunnel Lining

5.1 Improved methods for calculating ground support and underwater slope stability.

5.2 Development of more rational methods for evaluating the capability of support systems, especially shotcrete, rock bolts, tie-back systems, diaphragm walls, driven and bored pile retaining walls.

5.3 Initiation of a comprehensive programme for the collection of data regarding the in situ behaviour of the soil or rock mass (including back-fill for cut-and-cover tunnels), the support system, and the interaction between the two for use in developing and verifying design methods for all types of tunnel construction (see also item *2.3* above).

5.4 Development of temporary support systems for tunnels that can be installed more quickly and closer to the face and which can be incorporated into the permanent support system.

5.5 Development of improved tunnel support systems that minimize handling and erection problems.

5.6 Development of improved material and procedures for ground stabilization by grouting or freezing.

5.7 Improvements in temporary support schemes for cut-and-cover tunnels, minimizing adjacent ground movements.

5.8 Improvement of techniques for design and utilization of precast tunnel linings, particularly those which restress the ground.

5.9 Development of techniques of soundwall blasting for minimizing rock damage, particularly in underground excavations.

5.10 Development of improved retaining walls for cut-and-cover construction and of (i) pile driving equipment with reduced noise and vibration characteristics and capable of being used in narrow, confined spaces; (ii) bored pile walls capable of providing greater accuracy, reduced requirement for working space and improved watertightness; (iii) bentonite replacement retaining walls for use in ground containing obstacles; (iv) I-beam retaining walls to achieve greater economy and better load transfer at the base.

5.11 Development of improved precast elements for immersed tunnels to reduce costs and jointing problems.

5.12 Development of methods of connecting immersed tunnel elements to piles without intervention of divers.

5.13 Improvement of methods of predicting effects of ground water lowering.

6. Environmental Control and Safety

6.1 Development of improved instrumentation for evaluating the intensity of concentration of noise, dust and gas.

6.2 Development of environmental quality standards for underground operations, particularly for novel excavation processes.

6.3 Development of remote control systems for guidance and operation of excavating machines to eliminate as far as possible the need for human presence in hazardous areas (see also *3.7* above).

6.4 Development of new and improved techniques for controlling dust, electromechanical hazards, fumes, heat, noise vibration and water.

6.5 Study and reduction of medical risks of working in compressed air.

7. The Tunneling System

7.1 Development of mathematical expressions and models to represent the processes of the tunneling system, to assist in identifying inadequacies.

7.2 Study and development of the capability of expressing geological factors in terms permitting their representation in mathematical models.

7.3 Study the merits of increased automation in tunneling to reduce personal hazard and cost.

NEW LITERATURE
ENGINEERING GEOLOGY

Raymond E. Whitla (Retiring as reporter)

TROUBLE-HIT KEBAN DAM TURNS TO MASSIVE CONCRETE CUTOFF WALL: Engineering News-Record, Vol. 184, No. 6, p. 41-42, February 5, 1970. This is a short article mentioning some of the difficulties that have been encountered in the construction of Keban Dam in Turkey. Keban is a concrete and rockfill structure, 3,598 feet long and 680 feet high, above streambed being constructed across First River about 330 miles from Ankara. The difficulties have been caused by the occurrence of massive solution cavities in a limestone foundation rock. These solution cavities have been a principal factor in hiking construction costs by some 53 million dollars and in delaying completion of the project by about two years. The article describes the problems and some of the solutions that have been adopted.

Mills, Alvro E., *STIMULATING HARD ROCK WATER WELL PRODUCTION WITH HIGH EXPLOSIVES:* Water Well Journal, Vol. 24, No. 2, p. 39-42, February 1970. This article is concerned only with shooting shallow water wells in hard, well-consolidated, brittle rocks to stimulate production. The author points out that shooting in clay-filled sandstone, conglomerate, loose sand, and similar plastic type materials is of no benefit and may destroy a well. The article discusses the type of explosive that one should use, safety factors, the way the rock behaves as it is blasted, and the contrast between stimulating a water well and constructing a cistern.

Bollman, S. K., *SLURRY BLASTING AGENTS:* Compressed Air, Vol. 75, No. 1, p. 16017, January 1970. Rock fragmentation is an important economic factor in qusrry or mine operation. This article makes a comparison of rock fragmentation obtained with slurry blasting agents with that obtained with ammonium nitrate fuel oil mixtures. It also discusses drill hole spacings and sizes of holes when using the slurry blasting materials. Cost savings by using slurries is pointed out.

Signor, D. C., Growitz, D. J., and Kam, William, *ANNOTATED BIBLIOGRAPHY ON ARTIFICIAL RECHARGE OF GROUND WATER*, 1955-67: U. S. Geological Survey Water-Supply Paper 1990, 141 p., 1970. Available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Price 65 cents. The bibliography was prepared because of a world-wide interest in the field of artificial recharge and the need for a single source of references to the literature published since 1954. It is a sequel to the "Annotated Bibliography on Artificial Recharge of Ground Water through 1954," by D. K. Todd, U. S. Geological Survey Water-Supply Paper 1477, published in 1959. The bibliography contains 505 annotated references. Although emphasis is on technology, it includes annotations of articles on waste-wster reclamation, ground-water management, and ground-water basin management. It also includes references on subjects closely related to artificial recharge, including colloidal flow through porous media, field or laboratory instrumentation, and waste disposal by deep well injection, where they specifically relate to potential recharge problems.

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New Literature...
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Richard H. Howe (New Reporter)

Alfonso, Rico R., Jose Springall C. and Guillermo Springall C., *SLIDES ON THE TIJUANA-ENSENADA HIGHWAY:* Contribution of the Ministry of Public works to the VII International Conference on Soil Mechanics and Foundation Engineering, 1968. Available from Sociedad Mexicana de Mecanica de Suelos, A. C., Apartado Postal 8200, Mexico I, D.F. $4.00 U.S. Spanish and English text. 213 p.

During the planning of this highway it was recognized that sidehill cuts and fills would be constructed on unstable hillsides. There was evidence of old dlides on the slopes where talus overlay marine shales and there was continual marine erosion at the base of the slopes. However, placing the highway in a more stable location would greatly increase the cost and severely reduce the benefits.

As expected, some slides occurred during construction, some afterward. The subsequent investigations of seven of the slides included detailed surface and subsurface surveys, geologic and hydrologic studies, and soil mechanics stability analyses of field data. Much of this information is presented in the numerous photographs, plans, sections, and inclinometer surveys of the appendices.

The successful remedies included lowering the subgrade, placing a filter gallery below the slide surface, and placing rock embankment foundation in a trench excavated below the slide surface.

This short book, 30 pages of text and 158 pages of appendices is highly recommended especially for anyone wanting specific examples of detailed field investigations of landslides.

DEEP INTERCEPTING CONDUITS AND CENTRAL OUTFALL: A New Sewerage System for the Federal District of Mexico, 1968. $3.00 U.S. Spanish and English text. Available from Sociedad Mexicana de Mecanica de Suelos, A.C., Apartado Postal 8200, Mexico 1, D. F.

This volume of 56 pages contains many excellent illustrations and a concise description of this 136 million dollar (U.S.) project, now about one half complete. The project includes the construction of 52 kilometers of collector tunnels in soft compressible clays and 50 kilometers of tunnel in rock and alluvium. This report covers not only the methods of constructing the access shafts and driving the tunnels, but also the geology, hydrology, and soil mechanics. Among the design problems discussed in this book are the determination of tunnel flow capacity, subsoil stratigraphy and mechanical properties, probable settlement of the collector tunnels, stresses on the tunnel linings, and stability of the floors of the access shafts.

This is recommended for any engineering geologist planning to visit Mexico City, even if he only has time to look at the pictures.

Winkler, E.M. and E.J. Wilhelm, *SALT BURST BY HYDRATION PRESSURES IN ARCHITECTURAL STONE IN URBAN ATMOSPHERE:* Geol. Soc. America Bull., v 81, p. 567-572, February 1970.

The authors have calculated theoretical hydration pressures for common water soluble salts. They find that the crystallization and recrystallization from a lower to a higher hydrate of sodium carbonate and sulphate and magnesium sulphate produce pressures exceeding the tensile strength of many rocks and concretes. Water containing these salts may enter by infiltration. In addition, these salts may be formed within the rock by the reaction of the minerals with the atmospheric moisture containing sulfuric and carbonic acids, prevalent in urban areas.

Extensive damage to Cleopatra's Needle, the obelisk in New York City's Central Park, is attributed to this process by the authors. Now monuments are protected from this by soaking in distilled water before they are put on display.

This article is an important contribution to an understanding of the mechanism of rock and concrete deterioration by environmental effects. It is hoped that it will be brought to the attention of the several researchers working in this area.

Powell, W.J. and P.E. LaMoreaux, *A PROBLEM OF SUBSIDENCE IN A LIMESTONE TERRANE AT COLUMBIA, ALABAMA:* Circular 56, Geological Survey of Alabama, 1969, 30 p.

This well-illustrated booklet (2 maps, 1 section, 19 photographs) describes the extensive subsidence which damaged several buildings, broke water lines and railroad tracks, and endangered a filter plant and a storage tank. The geology and groundwater hydrology are summarized and the causes of subsidence identified; corrective measures, precautions for future construction, and further investigations are proposed. The principal cause of subsidence is attributed to the loss of soil bearing capacity due to the removal of fines in the overburden by the movement of groundwater. The subsidence is related to a fault zone and to the municipal water supply wells.

This report is a good addition to the library of an engineering geologist making subsurface investigations in any limestone terrane.

Gray, W. A., *THE PACKING OF SOLID PARTICLES:* Chapman and Hall, Ltd., London, 1968. 134 p. 35s in U.K. Distributed in U.S. by Barnes and Noble, Inc.

This book is the second volume in a series on powder technology. The author is Lecturer, Fuel Department, University of Leeds. His research has included vibratory and pressure compaction of particulate materials and the properties of randomly packed beds of particles. In the Introduction to his book, Dr. Gray says "as Graton and Fraser pointed out in 1935 [J. Geol.], it might be expected that the subject of particle packing would have been, by this time, thoroughly explored. Such is not the case, however; the empirical approach adopted by many investigators has produced a certain amount of data for specialized applications but little precise, quantitative information, directly applicable to packing circumstances. This monograph is intended to provide a critical statement of information that is available and, thereby, that which is not."

The author devotes about seven pages to a most useful glossary and nomenclature which he follows with a discussion of the packing literature under these topics: the characteristics of a packing--density, porosity, strength and stability, packing geometry, and permeability; the variables that control packing--particle properties, container effect, mode of deposition, post depositional effects of vibration and pressure; and industrial applications. Among these industrial applications are the segregation of aggregate sizes in concrete, forming ceramic ware, design of mixtures for bituminous pavements, arching in bins, and moulding foundry sands.

Those who are interested in sedimentation, sinkholes, soil mechanics, and the production and testing of construction materials may find some stimulating ideas in this little book.

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New Literature...
(continued from page 7)

Engineering Geology in Southern California, Richard Lung and Richard Proctor, editors, 389 p., Association of Engineering Geologists, P. O. Box 1242, Arcadia, Calif. 91006, 1966. (Reprinted 1969.) Price $14.00.

Reviewed by George A. Kiersch, Geological Sciences, Cornell University, Ithaca, New York

Engineering Geology in Southern California is a unique publication, and first of its kind. The editors, Richard Lung and Richard Proctor, have assembled an outstanding contribution by 39 experienced authors that deals with the diverse and interrelated geologic problems of a geographic region. The publication combines the principles of theory and practice of engineering geology with the features of a geologic guidebook and reference on southern California. By interrelating the problems of the practitioner to the environmental geology, the authors have presented an approach that has not received adequate attention heretofore.

Southern California, one of the most urbanized regions of the world, is truly unique in its diversity of geological problems associated with major engineering works. Few regions possess the great number of active geological processes and features (hazards) of concern to the engineer that are in southern California. It is fitting, therefore, that the first regional source book assembled by the Association deals with this classical region and describes such important geologic circumstances as: active faults and seismic events; slide-prone slopes; subsidence; reactive aggregate materials; sea-water intrusion and groundwater; inadequate foundation conditions; beach erosion; and treacherous rock conditions encountered in tunneling. To this add the legal complications which are inherent to an urbanized society in this dynamic geologic environment and southern California is a truly unusual region for demonstrating the practice of engineering geology. Of special value and usefulness for practitioner and student alike is the inclusion of three oversized insert

The publication is arranged in 12 major chapters under the headings of: (1) Earthquakes and Faults; (2) Aqueducts, Dams and Tunnels; (3) Highways and Freeways; (4) Landslides and Urban Development; (5) Legal Aspects of Engineering Geology; (6) Grading Codes; (7) Ground Water; (8) Subsidence; (9) Flood Control; (10) Marine Geology and Beach Erosion; (11) Foundations, Soil Mechanics and Rock Mechanics and Rock Mechanics; and (12) Nuclear Reactor Siting.

Each chapter is a group of separate papers which cover the principles, practices, important case histories, along with an extensive bibliography on a major subject. The chapter on "Aqueducts, Dams, and Tunnels" is representative of this format with papers on: The California Aqueduct; The First and Second Los Angeles Aqueduct; The Colorado River Aqueduct; and Exploration for Foothill Feeder Tunnels; along with case histories on the St. Francis Dam Failure, Baldwin Hill Reservoir Failure, San Jacinto Tunnel, and Tecolote Tunnel. More than half of the papers are concerned with the principles of practice that are applicable anywhere in the world.

Many of the papers stand by themselves as separate publications and contain information scattered widely in the literature or previously unpublished. "Earthquakes and Fault Activities in Southern California" by Albee and Smith is such a paper as is Leighton's paper on "Landslides and Urban Development."

The 8½" x 11" publication has been reproduced by offset press. This format has allowed for the inclusion of many large and informative illustrations, tables and photographs.

The purpose of the publication as stated by the editors is -- "to enlighten and inform not only the technician and geological scientist, but the well-read layman who is interested in how engineering geology relates to the day-to-day affairs of society." Certainly the authors of "Engineering Geology in Southern California" have accomplished this goal. This volume seems destined to be a "must" as both a general guide and reference for the technician, scientist, teacher, or student alike who has an interest in the expanding field of engineering geology.