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Rock Mechanics - A Canadian View

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Publisher's version / Version de l'éditeur:

<https://doi.org/10.4224/20358837>

Technical Note (National Research Council of Canada. Division of Building Research), 1965-08-01

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NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

No.

451

TECHNICAL NOTE

LIMITED DISTRIBUTION

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CHECKED BY C. B. C.

APPROVED BY R. F. L.

DATE August 1965

PREPARED FOR Executive Committee, International Society of Soil Mechanics and Foundation Engineering and a Special List

SUBJECT ROCK MECHANICS - A CANADIAN VIEW

In the early months of 1962, the writer of this Note was privileged to receive, and to see copies of, an interesting exchange of correspondence regarding the inter-relation of soil mechanics and rock mechanics, especially at the international level. Among those exchanging views at that time were Drs. Terzaghi, Bjerrum, Casagrande, Macdonald and Skempton.

The Canadian picture was then far from clear but the writer promised to record his views when there appeared to be something useful to contribute from the Canadian point of view. That time appears to have come, at long last, and so this Note has been prepared, not only in answer to the letters mentioned above but also in the hope that it may possibly prove to be of use when the subject under review is discussed, as it almost certainly will be, by the Executive Committee of the International Society of Soil Mechanics and Foundation Engineering (ISSMFE) when it meets in Montreal in September next.

It must be stressed that, apart from the factual information that it presents, this Note presents the opinions of the writer only. He believes that the views he expresses are shared by his immediate colleagues, as also by a number of his Canadian friends. There is, however, no "Canadian position" on the subject, nor have the responsible Canadian committees made any official pronouncements. There has not been opportunity to circulate a draft of this Note for critical comment outside of DBR/NRC, so that it must be regarded as a personal statement only.

ROCK MECHANICS AND SOIL MECHANICS

The over-all inter-relation of these two subjects, if one accepts the two titles as literally exact descriptions, is well expressed in the following words:-

"It is suggested by the writers that rock, as a hard material ringing to the hammer, can grade through various types to a soil that can be cut with a palette knife, so that rock mechanics on one end of the scale can grade into soil mechanics on the other end and that the techniques of these two sciences can usefully be combined when dealing with material that has some of the properties of both" (1).

This is such an "obvious" statement that an outsider might well wonder how so much misunderstanding, if this word can be used to describe a variety of reactions, could possibly have developed in the rapid growth of the scientific study of the mechanical properties of soil and rock. The writer ventures to suggest that there are two main explanations, one semantic but the other more complex and deep-seated.

In the first place, when the English term "Soil Mechanics" first came into general use, just prior to the first conference of ISSMFE at Harvard University in 1936, as the most convenient, if not the most accurate nor semantically correct translation of Erdbaumechanik, nobody regarded it as anything more than a general title. Since the writer was at the 1936 meeting, he can state positively that he heard no suggestion at that time for restricting this new discipline to the study of soils as such. There was then such pleasure, and indeed excitement, at the promise given by this new approach to the study of earth materials that a semantic analysis of the accuracy of the title proposed was about the last thing that anyone present at that meeting probably considered.

An examination of statements made at the 1936 meeting, and in particular of the main address of Dr. Terzaghi, will confirm this suggestion and show how groundless are assertions that ISSMFE first thought about

(1) Müller, L., P.G. Fookes and J.M. McKenna in Discussion of "An Approach to Rock Mechanics" by K.W. John; Proc. A.S.C.E., Vol. 89, S. M. 2, p.137-140, March 1963.

rock mechanics in 1961, and that "Prof. Terzaghi himself regarded Rock Mechanics superfluous only a few years ago" (2).

That such statements can be made at all, and quite seriously, shows that something "has gone wrong." Part of the trouble can now be seen to be, at least by the writer, a lack of recognition, in the early years, of the semantic inadequacy of the term "soil mechanics." That the term could be held to include snow and ice mechanics was seen, even in the nineteen forties, by Swiss workers. On the other hand, the number of good papers on rock mechanics in volumes bearing the title "Soil Mechanics" might understandably have irritated some of those whose interests lay with solid rocks, while they are still probably unknown to many others with similar interests whose literature searches have been limited in coverage.

It is, therefore, unfortunate that some such term as "Geotechnical" was not used from the start to describe this invaluable new scientific discipline, the proper study of earth materials for engineering purposes, especially so in Canada where soil, rock, ice, snow, muskeg and "permafrost" are all included in such studies in view of the character of the terrain of the country. There appears to be, however, an additional but more deep-seated explanation of the misunderstandings that have developed.

ROCK MECHANICS AND MINING

It is no disservice either to the mining industry or to mining engineers to suggest that, until comparatively recent years - in effect the years since the end of the Second World War - mining research tended to concentrate on the geological aspects of mines and mining rather than on the mechanical properties of the rocks encountered in mining operations. This certainly appears to have been the case in Canada where serious "rock bursts" in the Kirkland Lake area appear to have directed attention in relatively recent years not only to the use of geophysical methods for the study of rock stresses, but also to the study of the mechanical properties of the rocks themselves.

This has been a most welcome and healthy development, but it has suffered from a lack of inter-disciplinary communication. Civil engineers

(2) Circular letter from Dr. L. Müller, dated 21st February 1963, p. 2.

have studied stresses in rock for decades in connection with tunnelling work. Possibly they were at fault in not communicating the results of this type of work to mining engineers when the latter have to grapple with stress problems underground. Whatever the reasons, and a study of them would probably be as interesting as it would be unprofitable, it is clear to the writer that certainly in Canada, probably in the United States, and possibly in other countries also, there has been an unfortunate gulf between civil engineering and mining engineering research. And the psychological implications of this situation are undoubtedly partially responsible for the rock - soil mechanics dilemma, and certainly for some of the emotional overtones that continue to complicate the situation.

Looking ahead, rather than backward, current interest and activity in mining research involving rock mechanics, as exemplified by the situation at Canadian Universities and in the Federal Mines Branch, is cordially to be welcomed by all with similar interests. There is so much to be gained by cooperative endeavour, and so much to be lost by senseless "competition," that it is greatly to be hoped that current difficulties may soon be resolved, especially at the international level. Possibly Canadian experience can be of some more general use. It will, therefore, be described in summary form.

THE CANADIAN SITUATION

Soil mechanics (using the term in its original broad sense) has been recognized in Canadian civil engineering practice since the nineteen thirties. Instruction was first given in civil engineering departments of Canadian Universities as early as 1932. Six Canadians were present at the Harvard meeting of ISSMFE in 1936.

In 1944 the National Research Council (NRC) established its Associate Committee on Soil and Snow Mechanics (ACSSM) initially to undertake secret wartime research, but after the end of the war to correlate and stimulate research work in this field throughout Canada. It did this through organizing research meetings and seminars and by making grants for University research. It is the Canadian National Committee for ISSMFE.

In 1958, NRC decided to recognize the Earth Sciences as a major scientific discipline: since that year grants for research in this very broad field have been made directly by the Council. They have included grants for research into the mechanical properties of soil, rock, snow, ice, muskeg and permafrost, considered without distinction except that of scientific merit. (Contrary opinions with reference to rock research have unfortunately been circulated in Canada but without any foundation in fact.)

In 1947, there was established under the Federal Department of Mines and Technical Surveys (DMTS), a National Advisory Committee on Research in the Geological Sciences (NACRGS) which has, similarly, correlated and stimulated geological research in Canada. In recent years, this Committee has also had funds at its disposal for research grants. These, too, have been awarded across almost the whole spectrum of the earth sciences, selection being based always on scientific merit.

There has always been complete cooperation between these two grant-making agencies through the medium of "interlocking" memberships on the two committees. The total now annually available in this way for research in the earth sciences approaches the sum of \$1,400,000.

In April 1963, the Mines Branch of DMTS convened a meeting in Ottawa of representatives of the Canadian mining industry and mining departments of Canadian universities to review rock mechanics, in the light of a symposium on the subject held at McGill University in October 1962, naturally with special reference to mining problems. A Canadian Advisory Committee on Rock Mechanics (CACRM) was established at this meeting; it has also had some funds assigned to it for assisting with university research in its own special field.

Immediately after the meeting, the Director of the Mines Branch wrote to the writer of this Note (as Chairman of the ACSSM) offering the cooperation of the new group. For reasons quite unconnected with the subject (actually, the "Cox and Box" official lives of the two men involved) it has only recently been possible to follow up this suggestion but this has now been done and the Chairman of CACRM will be an ex-officio member of ACSSM, with a reciprocal return arrangement. Similar liaison will be developed between the CACRM and the NACRGS, so that there will be complete correlation of effort.

It may, perhaps, be worthy of note that in explanation of the close links between CACRM and the mining industry, and with mining research, it has been pointed out that the volume of rock excavated annually from Canada's mines greatly exceeds the corresponding amount excavated in civil engineering construction. Although the relative figures are not a direct yardstick, the comment is a useful one, confirming the eminent desirability of having this mining interest closely associated with all others who are concerned with the mechanics of earth materials.

One of the initial activities of ACSSM was the holding of the annual Canadian Soil Mechanics Conference. After about fifteen years of operation, these have become too "popular" to be useful research seminars and so, by agreement, their future operation was passed over to the Engineering

Institute of Canada. Responsibility for operating the conferences was placed in the hands of a new Division of the EIC Committee on Technical Operations. This new group was called the Geotechnical Engineering Division of CTO/EIC.

At about the same time, rather protracted negotiations were proceeding that led eventually to the establishment of two Canadian journals to serve the field under review. The second of them is a new part of the NRC Canadian Journal of Research, called the Canadian Journal of the Earth Sciences. This is essentially a scientific research journal, primarily geological but intended to serve all the earth sciences, including soil and rock mechanics. The first journal is sponsored by ACSSM and GEO/CTO/EIC and is self-supporting financially. After much consideration, it was decided to call it the Canadian Geotechnical Journal. It is intended for the publication of more "applied" papers in the geotechnical field.

It will be seen, that the word "geotechnical" is already in official use in Canada. It is not, therefore, surprising that in its periodic critical reviews of its own activities, ACSSM should have given much thought to its own name. Despite the fact that the name has now a history of twenty-one years' of activity behind it, the Committee has decided to recommend to the NRC that its name should be changed to the Associate Committee on Geotechnical Research, in recognition of the broad field of research which it now serves and with which it is associated.

THE SITUATION IN THE U.S.A.

The corresponding situation in the United States is rather more complicated, with more organizations involved and the additional factor of strong official interest in such extra-terrestrial matters as lunar geology, with all the popular overtones that this involves. Some of the interested groups may be listed.

The Geological Society of America, through its Division of Engineering Geology, has a Committee on Rock Mechanics which has, inter alia, sponsored (with the aid of the Rand Corporation) a Symposium at Santa Monica, California in June 1963.

The American Society of Civil Engineers, through its Soil Mechanics and Foundation Division, has a sub-committee on Rock Mechanics (parallel with similar working groups on Rock Grouting, Engineering Geology etc.). GSA/DEG and ASCE/SMFD have a joint liaison committee, so that these two operations have good connection.

The American Society for Testing and Materials has a strong and very active Technical Committee D.18, originally concerned with "Soils for Engineering Purposes." When the Society was asked to take action in developing standard tests for rocks, its Board of Directors reviewed the whole field very carefully and decided to ask its Committee D.18 to add rock mechanics to its scope. This was done, and so the new title of "D.18" is "Soil and Rock for Engineering Purposes." A sub-committee on Rock Characteristics and Tests has been organized and is already active, with a useful symposium planned for November 1965.

Other bodies that have taken an active interest in rock mechanics include the American Institute of Mining Engineers, the American Association of Petroleum Geologists, the Association of Engineering Geologists and the Highway Research Board. In addition, the Departments of Mining at the Colorado School of Mines, the University of Minnesota, the University of Missouri at Rolla and the Pennsylvania State University have sponsored symposia on Rock Mechanics. The Seventh Symposium in June 1965 was sponsored jointly with the Society of Mining Engineers, AIME.

Clearly there is danger of duplication of effort with so many important bodies interesting themselves in rock mechanics. The National Academy of Sciences/National Research Council through its Division of Earth Sciences recently recognized this possibility and convened a meeting in Washington in May 1965 at which the necessary and desirable liaison between all the groups mentioned was discussed. A further meeting is to be held in November 1965 at which it is probable that a continuing arrangement for an NAS/NRC liaison or advisory committee on rock mechanics will be determined.

It will, therefore, be seen that both in Canada and the USA, and despite some initial difficulties that may best be attributed to what can so happily be called "an excess of zeal" on the part of a few enthusiasts, reasonable liaison has been developed between all main groups concerned with the mechanics of earth materials, with the recognition - at least in Canada - of the term "geotechnical" as more accurately descriptive of what the original use of the name "soil mechanics" was intended to cover.

THE INTERNATIONAL DILEMMA

Possibly this North American experience can be of some assistance when the international aspects of rock mechanics are considered, complicated though these may appear to be. Before considering the position of ISSMFE, the interests of other bodies may usefully be reviewed.

Probably the oldest body with direct interest in this field is the International Congress on Large Dams (ICOLD). It handles its technical discussions through stated "questions" (three or four at each Congress) and some of these have included studies touching upon rock mechanics. There appears, however, to be a rather definite resistance within ICOLD to any fragmentation of its operations so that even the appointment of an ICOLD working committee on rock mechanics appears to be doubtful, although problems involving both soil and rock mechanics in connection with large dams may be expected to receive due attention at future ICOLD meetings.

An even older international group is that associated with the International Geological Congress; these meetings have been concerned almost exclusively with geology as such and not with its applications until the last few years. At the next Congress (in Prague in 1968), engineering geology is to be given official recognition on the program, it is believed for the first time. There has now been formed the International Geological Union. Liaison between the long-standing Congress organization and the new Union is being satisfactorily developed. At the last meeting of the governing board of the Union, a proposal was advanced to establish an International Society on Engineering Geology. Action on this was deferred so that the proposal could be referred to ISSMFE at its September meeting in Montreal. A submission on this subject may therefore be expected.

The International Union of Geology and Geophysics is very active holding a large congress every four years. It operates through a number of Associations in various geophysical and geodetic fields. One of them deals with Hydrology and under this is a Commission on Snow and Ice. Although small, this is an active group, being the only international organization that brings together workers in snow and ice research. There have been discussions regarding its somewhat anomolous position as subsidiary to Hydrology. Apart from this one activity, IUGG touches geotechnical matters only incidentally, such as in connection with seismic research, but its interests certainly run parallel with those of ISSMFE.

Current activity - excessive activity in the view of many including the writer - in the international publishing field has added its own complications. The Salzburg-based "Geologie und Bauwesen" apparently plans to broaden its coverage, already useful in its special field and has changed its name to "Rock Mechanics and Engineering Geology." A new journal, however, has been added to the list, "Engineering Geology" published by the Elsevier company in Holland. Although one may regret additions to the multiplicity of journals already available, they must be accepted since they are the production of private publishers who are naturally

free to risk their money in such ventures. At the same time, the very existence of these journals (in addition to "Géotechnique," "The Canadian Geotechnical Journal" etc.) removes one of the arguments in the current dilemma, that of the difficulty in getting good papers published.

There remains to be considered the (proposed ?) International Society for Rock Mechanics - Internationale Gesellschaft für Felsmechanik. It would be so much easier to discuss this interesting development if it were not for the inaccurate and almost emotional letter of Dr. Leopold Müller, dated at Salzburg on 21st February 1963, to which reference has already been made. If this letter represents in any way the considered view of those associated with Dr. Müller in this venture, with its completely unfounded statements about what ISSMFE has done, or will do, nothing would be gained by giving any further consideration to the matter. Comments from some who attended a 1963 meeting in Salzburg give some grounds for hope that the above assumption is not correct, but the reported rather hurried convening of another meeting of this group in advance of the Montreal meeting of ISSMFE only serves to confirm initial doubts. It is to be hoped that at Montreal quite accurate information about this interesting development will be available.

What are the main "guide lines" that can assist in the discussion by the ISSMFE Executive Committee of international service to rock mechanics? Although not now a member of the Executive Committee, the writer ventures to suggest the following:

- (1) First and foremost is the unfortunate semantic misunderstanding (already discussed) about the original name of ISSMFE. Study of the sets of Proceedings will confirm that this title has not restricted treatment of rock mechanics, snow and ice mechanics, and engineering geology, at the Conferences of ISSMFE.
- (2) Already there are far too many international meetings, especially for those not resident in Europe where so many international meetings quite naturally tend to be held. Anything, therefore, that can consolidate, rather than fragment, those personal international contacts that such meetings promote should be supported strongly.
- (3) In the absence of information to the contrary, the Salzburg-based group with its yearly meetings appears to be the European equivalent of the North American rock mechanics group already mentioned, and not the equivalent of the truly international ISSMFE.

- (4) Organizing the Montreal Conference of ISSMFE has made clear to the writer that restriction of its official languages to English and French probably cannot long continue, even though 80% of the papers submitted were in English.
- (5) Correspondingly, it appears to be even more certain that the Montreal conference will be the last at which the technical sessions are held as one meeting for all those attending. Concurrent sessions appear to be inevitable, as has been found by all comparable international bodies, and this could broaden the coverage of subjects discussed.
- (6) In view of the new and alternative media for the publication of geotechnical papers now available, it may not be necessary to include in future Proceedings all the papers presented to conferences of ISSMFE. The pressures exercised in connection with the limitation of length and number of papers for the Montreal conference suggests that some change in this direction is inevitable.

Against the background of these suggestions, two current suggestions that will be discussed in Montreal may be considered:

- (i) That ISSMFE should change its name to the International Geotechnical Society, thus recognizing the fact of its existing broad coverage, extending far beyond soil mechanics as such; or
- (ii) That ISSMFE should not change its name, since this has now a history of thirty years behind it and is well recognized internationally, but that it should take the lead in organizing an International Geotechnical Council or Union.

As always in such matters, there is much to be said in support of, and against, each proposal. The second would appear to be in parallel with IUGG and IGU and would retain the valuable continuity of name. On the other hand, ISSMFE would have to reorganize itself, to divest itself of all interest in rock mechanics, snow mechanics etc. even though there are not yet well recognized truly international groups in these and allied specialist fields.

The first proposal does suffer from the unfortunate necessity of a change in name, but in the long view is this really so very important? (On the national level, the corresponding Canadian committee does not think so,

and is proposing to change its name, as has the British national committee.) It would be public recognition of what all members of ISSMFE know to be its scope, even though this will continue to be questioned by some who are not members and who base their opinions on incorrect information.

The rapidly expanding fields of rock mechanics, snow and ice mechanics, and engineering geology would have to be given increased recognition but some reorganization of the structure of the Society, of the conduct of its Conferences, and of the publication of its Proceedings is necessary in any case, so that the two operations might very well be combined.

Given a modicum of good will, it should not be impossible to develop close and effective liaison with such allied groups as the Salzburg rock mechanics group, the Commission on Snow and Ice of IUGG, the International Peat Conference (concerned with muskeg) etc. and in this way to effect coordination of meetings and effort.

A close parallel to what appears possible is provided in North America by the Geological Society of America. It has assisted, even financially, in the organization of several of what can be called "splinter" specialist societies, the most recent being the Geochemical Society. Most of these now have their own secretariats and their own journals. But they all meet together at the time of the annual meeting of GSA which carries the main burden of organizing what is now one of the leading annual scientific conferences of North America. "Everyone is there" in the broad field of the earth sciences, but with independence of operation for each of the specialist groups - some as Divisions of GSA and some as specialist societies.

Knowing what can be done by a great Society, under wise direction, and appreciative of the fact that ISSMFE is already a great Society, the writer has finally come to the conclusion that the first of the two courses of action is that which should be followed. Accordingly, he looks forward, with mixed feelings of regret and anticipation, to seeing the Society change its name at Montreal, and to adjusting its future operations accordingly.

Finally, genuine regret must be recorded at the inevitable necessity of including in this Note occasional references to misunderstandings. The writer is convinced that most, if not all of these could have been avoided if, for some years now, ISSMFE had published its own journal. "Géotechnique" and, in a junior position, "Canadian Geotechnical Journal" are doing a fine job in publishing technical papers but there is no news either of ISSMFE or of international geotechnical developments ever circulated to the members of ISSMFE except through occasional national circulars. Here is a real gap. Once the future of the Society has been determined, it is suggested respectfully that the filling of this gap is the next matter of urgency to be tackled.