SOIL RESPONSE RESEARCH SUBPROGRAM

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OBJET SOIL RESPONSE RESEARCH SUBPROGRAM

SUBJECT

The need for a well-defined subprogram on soil response within the Division of Seismology has been pointed out on several occasions during the past. Although this need may be quite obvious, it is difficult to define and to evaluate objectively. There exists now a number of reasonable methods for calculating seismic ground motion on rock, but there is lacking any accepted method of predicting soil response. The awareness of this lack of good solutions to the soil problem, and the lack of Federal Government expertise and involvement in this field, may lead to different definitions and levels of need. Pressure from outside the Division may eventually develop for us, as the most likely experts, to become involved; competition with other groups or agencies, which are certainly no more qualified to lead the Federal effort in the field, makes it desirable for us to define a subprogram now without waiting for a stimulus from above; finally, the "need" for the subprogram may simply consist of availability of suitable personnel, coupled with the ambition to move into a new field. It appears to the Study Group that there exists a happy combination of elements of all three types of reasons, making the initiation of a soil response subprogram within the Division very attractive and almost inevitable.

There is not yet a compelling outside pressure which forces us into this field. However, the Division is officially expected to continue to supply meaningful input to the Canadian Building Code, and the quality and detail of these contributions must be expected to increase. In the past, this function of the Division was sometimes made difficult by the lack of well-defined demands by the engineering profession. To improve on this communication gap and to supply the more detailed seismological information needed in response to increasingly better defined demands from the engineers appears to be a valid, if not yet compelling, outside pressure to expand Divisional efforts into this area.

From within the Division, there exists the desire to systematically complement current Divisional efforts in an attempt to further improve on the occasionally met image of this Division as merely an excellent data gathering institution: if we are not careful, it may happen that others will interpret for us our strong motion records hopefully collected by our western office during the next major earthquake. In that sense, theoretical support of the western experimental effort is, therefore, urgently needed. Since the eastern strong motion network is operated by another agency, there is also clearly an element of competition. Logically, the seismologist should be able to analyze and interpret strong ground motion at least as effectively and probably better than the structural engineer; in any case, it would be very desirable to have experts on the subject from both types of background and training.

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These general considerations, plus considerations of the third type to be considered below, have convinced this Study Group that the Division should initiate a modest effort in soil mechanics during the coming year.

Personnel

Personnel problems for a soil response subprogram do not appear to exist. On the experimental side, the west coast office has, of course, been active for many years, and a slight expansion, as suggested later, can be carried and, in fact, would be welcomed by Dr.W. Milne and G.C. Rogers.

It would perhaps be logical to begin a theoretical program in the west coast office. However, present west coast staff, especially G.A. McMechan, who might be most qualified, has expressed no inclination to do this. In the Ottawa office, computational-theoretical work on crustal response functions of the mantle and a layered crust, to both body and surface waves, has been carried out by H.S. Hasegawa. Much of this experience is applicable to the program and, at least initially, Dr. Hasegawa's collaboration and experience in getting the theoretical part of the program off the ground will be indispensible, and he has agreed to do this. In the long range, however, Dr. Hasegawa has expressed the desire to concentrate his efforts on earthquake mechanisms, while Dr. Weichert has professed interest in the soil response program. Dr. Weichert's recent experience is strongly computational-oriented. This, in connection with his background, past theoretical experience and inclination, make him a promising candidate to carry this program. A few semesters of civil engineering and eight years in the construction industry should prove an asset for fruitful communication with the engineering profession, the principal customers of results from our soil response subprogram. After an initial transitional period perhaps on the order of a year or two, it is therefore proposed that Dr. Weichert carry the main responsibility for the program.

The Theoretical Program

For the first year this should be modest, but will nevertheless not be easy. Dr. Hasegawa has collected and distributed to this Study Group some 500 pages of papers relevant to the subprogram. The initial effort will consist of a thorough study of this material, plus the 2 volumes of the <u>Seattle Conference</u> on <u>Microzonation</u>, designated by Dr. Hasegawa as a most important background. Hand-in-hand with this study, we should make an effort to collect existing relevant computer programs, study these, gain experience in running them and interpreting their output. Finally, based on the experience from the study of the literature, we should be able to select a starting point for original work applicable to the Canadian scene, which should later be pursued at a higher part-time level than the initial survey.

It is clear that the familiarization study would be greatly aided by personal contact with the international experts in the field. The currently leading school is considered to be the Earthquake Engineering Research Laboratory of

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Caltech, Pasadena. In conjunction with the 1975 Annual Meeting of the SSA, Prof. Housner of the EERL will organize a special symposium under the topic heading "Strong ground motion parameters; toward clarifying earthquake engineering demands". This indicates the current relevance of the deliberations leading to our subprogram. It is strongly recommended that this meeting be attended by the staff involved, to the point of relaxing the rule of attendance-withpaper-presentation-only.

Currently, our input to CANCEE is predominantly through the subcommittee on seismic risk and zoning. At the expiration of the present term of Dr. K. Whitham in March 1975, it should be considered to replace him by Dr. Weichert as member on the subcommittee for soils and foundation.

With a view towards the longer range, we must begin to cultivate contacts with university geology and geography departments and with the Terrain Sciences Division of GSC, in order to gain better access to their expertise with regard to parameters associated with soil types and dimensions of surficial geological features, and to other talents such as microzonation surveys of the type done by Wuorinen for the University of Victoria; to gain some influence in planning or initiating future surveys of this type; finally, to cooperate with land-use planning boards to ensure that our findings have some practical use.

The Experimental Program

The west coast office has operated an observational program for several years. This is expected to continue at least at its current level. Moreover, this Study Group supports a modest expansion of the soil study orientation of the present program along the lines suggested in G.C. Rogers' memo of 5 Sept. 74 to the Division Chief; however, we feel that quantitative endorsements of these proposals are beyond the terms of reference of this Group.

In addition to enlarging the strong motion network, it is recommended to move into a program of soil response observation, utilizing the more common sources of seismic energy: near-field records from velocity transducers on different soils near repetitive sources of explosions, (mines, quarries, etc.) would cover high frequency response; teleseismic records of body and surface waves (higher modes) the lower frequencies. It is recognized that this type of observational program will not attack the problem of inelastic and plastic response observations, but, given the general availability of these sources, it should be a valuable complement for the strong motion subprogram. Present staff in the Victoria office, supplemented by casual help, might be able to carry out such a program at a low but sufficient level of activity.

The Group considered the possibility of additional funding coming from the WEOC program. These funds would have to go almost completely towards "Buy" projects with minimal supervision from our Victoria staff. The first project considered is a survey of existing strong motion seismograph sites, possibly involving drilling, hammer seismic, and other methods for obtaining the

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appropriate soil parameters. However, this project needs more preparatory study, e.g., of the soil parameters already available from Terrain Sciences Division of G.S.C.

Another project proposed by a Vancouver firm some time ago involves drilling at Roberts Bank Port to record amplitudes of seismic waves at various depths within the soil. If money becomes available under WEOC, it is proposed that the possibility of a contract or grant to a Canadian company to proceed with this experiment be explored. This financial support is not expected before fiscal year 76/77.

It may become desirable for us to initiate a soil response "Buy" project in New Brunswick, the region from St. John's to the U.S. border. This would not be an attempt to compete with the N.R.C. eastern strong motion network, but to supplement it with possible future WEOC-equivalent funds for the Maritimes, which might become accessible to us. The reasons for suggesting such a project are the current interest in locating a nuclear reactor station in this region which has a possibly significant seismic history, and the availability of suitable and interested personnel at the University of New Brunswick as contractor.

Conclusions

We believe that the logic and need exists within the program of the Seismological Service to initiate a well-defined subprogram on soil response. Firstly, the level and complexity of input to the National Building Code required from this Division must be expected to increase beyond the expertise and experience currently available in the Division. We continue to be the logical agency to fill this need and possibly to grow as the need increases. Secondly, we are already deeply involved in an experimental program of strong ground motion observations which is likely to expand independently of the creation of a theoretical support program, thus risking the danger of having its results interpreted by outside groups. The level of new involvement, as recommended in this memorandum, is modest enough so that its implementation can be achieved without upsetting the Divisional budget and manpower pool.

I. Workat

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