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DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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REPORT ON ATTENDANCE AT THE 'SCIENCE AND MAN IN THE AMERICAS CONFERENCE', MEXICO CITY AND THE 5TH WORLD CONFERENCE ON EARTHQUAKE ENGINEERING, ROME, JUNE/JULY 1973, AND VISITS TO SEISMOLOGICAL INSTUTIONS IN MEXICO, U.K. AND YUGOSLAVIA

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SUMMARY

The writer attended the Geodynamics and Earthquake Engineering symposia at the 'Science and Man in the Americas Conference' at Mexico City. This conference was a joint meeting of the American Association for the Advancement of Science and the Mexican Consejo Nacional de Ciencia y Technologia.

In Rome the writer attended the 5th World Conference on Earthquake Engineering (5WCEE), at which he presented two papers describing the results of some of the Bureau of Mineral Resources' (BMR's) work in Canberra and New Guinea.

After the 5WCEE, institutions, specializing in earthquake engineering, were visited in London (England) and Skopje (Yugoslavia).

1. INTRODUCTION

This Record describes my visits to two conferences (at Mexico City and Rome) and three institutions (at Mexico City, London, and Skopje) during the period 17 June - 9 July 1973.

Earthquake Engineering was the central theme for the visits. This subject has recently become important throughout the world for two main reasons. The first results directly from the growth in the world's population. As the population has increased so has the number of buildings that have been constructed in regions of high seismic risk. The potential risk from earthquakes relates directly to the population; this is confirmed by most of the damaging earthquakes that have occurred in recent years, e.g. Peru, 1970; San Fernando, California, 1971; and Managua, Nicaragua, 1972. In general if these earthquakes had taken place earlier the resultant damage would have been less.

The second reason results from the increased public demand for higher-safety criteria to be adopted for all large structures, such as dams, nuclear power plants, auditoria, and tall office blocks. Collapse of such important buildings as a result of earthquakes (or any other causes for that matter) is simply not acceptable.

The BMR has made significant contributions in Earthquake Engineering by operating a network of strong-motion accelerographs in Australia and Papua New Guinea and by developing a Strong-Motion Data Centre in Canberra. During these visits I was able to describe some of the results of the BMR's work and also to study similar work being carried out at other institutions.

2. NATIONAL UNIVERSITY OF MEXICO, MEXICO CITY

On 19 June I visited the Universidad Nacional Autonoma de Mexico (an open-university with over 100 000 students) and called on the Director of the Instituto de Geofisica, Dr J. Adem; the chief of the Servicio Sismologico Nacional, Dr C. Lomnitz; and Professor Rosenblueth and Dr G. Prince of the Instituto de Ingenierra.

Servicio Sismologico Nacional

The Servicio Sismologico Nacional operates a network of 20 seismograph stations in Mexico. These stations consist of a variety of seismographs employing photographic, hot-wire, pen, and smoked paper methods of recording. Hypocentres of earthquakes taking place in Mexico are computed using a modified U.S. Coast and Geodetic Survey program. Earthquake magnitudes are measured on Wood Anderson seismographs. A bulletin, which contains lists of Mexican earthquakes, is published monthly.

All the seismograms are mailed to Mexico City for analysis, which is carried out by 8 people. In the near future it is hoped to telemeter all recordings directly to the University using microwave links, which have been offered free of charge from the Federal Department of Cummunications.

In addition to the 20 stations operated solely by the University, 8 stations have been installed around the Gulf of California as part of a joint project with the California Institute of Technology (Caltech). These stations are powered by solar cells, and record on photographic paper. The first station began operating in 1969. The aim of the project is to study the ocean-ridge system in the Gulf of California. There are no other seismograph networks in Mexico.

Instituto de Ingenieria

Professor Rosenbleuth is head of the Earthquake Engineering section of this department; his main work involves the analysis of earthquake risk. Dr J. Prince is in charge of the section that collects and analyses strong-motion records. There are about 60 accelerographs of several makes operating in Mexico. One technical officer is employed full-time in maintaining and servicing these instruments.

In the environs of Mexico City a special seismic telemetry network including 4 seismographs and 7 accelerometers is being installed. All the data will be telemetered to the University where it will be recorded in real time on two 14-channel Pemtek tape recorders. The system will use Datum clocks, and Kinemetrics VR-1 pen recorders as monitors for the seismographs. Each tape will record continuously for about 36 hours and then the second recorder will automatically take over.

Assistance in the form of man-power (3 UNESCO visiting experts) and money (UNESCO are providing the capital costs of the project) is being provided by UNESCO to establish the network. In addition to Dr Prince, the Institute have two permanent professional officers - one working on the reduction and analysis of the accelerograms and another in the electronic aspects of the telemetry programme.

Apart from the accelerographs being installed near Mexico City there is a conventional network of 25 strong-motion instruments mostly situated in the western part of the country. The digitization and processing of the accelerograms is carried out at the University computer centre using the techniques developed by Caltech.

3. 'SCIENCE AND MAN IN THE AMERICAS', MEXICO CITY

The 125th annual meeting of the American Association for the Advancement of Science (AAAS) was held in Mexico City from 20 June - 4 July 1973, as a joint meeting with the Consejo Nacional de Ciencia y Technologia. The objectives of the AAAS are to further the work of scientists, to facilitate co-operation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress. To these ends the 125th annual meeting of the AAAS contained ten central themes:

The sea and its resources

Ecology and environmental deterioration

Deserts and arid lands

Nutrition and new food technology

Earthquakes and earthquake engineering

Science, development and human values

The problems of population

The importance of education in development

Non-nuclear energy for development

The earth sciences in world development

In addition to the central themes, 30 specialized symposia were organised, including one on geodynamics. The meetings were held in a series of 9 auditoria at the Centro Medico Nacional and the conference was opened on 20 June by the President of Mexico Lius Echeverria Alvarez. I divided my time between the geodynamics and the earthquakes and earthquake engineering symposia which was held concurrently during the first three days of the congress.

Although billed as 'Science and Man in the Americas' the conference participants were almost entirely from Mexico and the US, with poor representation from any other American nation. Neither the abstracts nor the full texts were available, so although there was no permanent record of what was presented, at least most of what was said was new and not restricted by a stale text written 6 months previously.

In the earthquake engineering symposium the most significant contributions were those describing the effects of the earthquake at Managua, Nicaragua, which caused over 10 000 deaths in December 1972. This earthquake has probably provided more useful information regarding damage to buildings resulting from strong ground motion and soil subsidence during the shaking than any other except the San Fernando earthquake of February 1971. An added bonus was an SMA-1 accelerogram written close to the area of maximum damage which recorded a maximum ground acceleration of about 35% g.

Milne and Davenport presented two worthwhile papers on earthquake risk and seismic zoning in Canada. Since the earthquake risk in Canada (apart from the west coast) is similar to that in Australia the Canadian zoning map, which is updated every 5 years, will be useful guide when the Australian map is being prepared.

The geodynamics symposium suffered from the non-appearance of speakers listed on the program, but there were some useful contributions describing some new results in the Gulf of California ridge/fracture zone/ spreading centre, and some interesting technical papers on driving mechanisms for the lithospheric plates; it now appears that in any planetary body with a composition similar to the earth a convection system of some sort must develop, but the problem of determining the detailed model has still to be solved.

4. THE 5TH WORLD CONFERENCE ON EARTHQUAKE ENGINEERING, ROME

The 5th World Conference on Earthquake Engineering (5WCEE) was held at Rome, Italy, from 25-29 June 1973 and was attended by 860 delegates from 47 countries. The conference was more than twice the size of the 4WCEE, which was held at Santiago, Chile, and was attended by 380 delegates from 29 countries. The largest numbers of participants at Rome came from Italy (200), United States (199) and Japan (137). Ten participants were present from Australia, which had a larger representation than New Zealand (8).

The increasing interest in earthquake engineering throughout the world results from the large investment in engineering projects in all countries and the recent destructive earthquakes in Peru (1970); San Fernando, California (1971); and Managua, Nicaragua (1972). The impact of earthquakes is now so important that, whenever large buildings are constructed, earthquake risk is usually considered, even if the designs are not modified to cope with the additional forces resulting from earthquakes, and even if the buildings are sited in zones of low seismic risk.

After the opening ceremony in the Main Hall of the Palazzo dei Congressi, the meeting was divided into four concurrent sessions covering the following topics:

1. Recent destructive earthquakes
2. Seismicity and ground motions
3. Earthquake engineering instrumentation
4. Response of structures to ground shaking
5. Dynamic tests of structures
6. Dynamic behaviour of structural elements
7. Dynamics of soils and soil structures
8. Design and repair of structures
9. Earthquake instrumentation
10. Earthquake ground motions
11. Earthquake ground motions and zoning
12. Formations and soil-structure interaction
13. Earthquake resistant design
14. Seismic design of nuclear-power facilities
15. Statistics and assessment of seismic risk
16. Special problems of earthquake engineering
17. Disaster prevention

A total of 440 papers were submitted at the conference. This large number entailed restricting the scheduled presentation time to 10 minutes for each paper. Many of the authors were unable to cope with such severe restrictions on their verbosity and several of the papers presented late in each session did not always receive a proper hearing.

Fortunately both papers from BMR were scheduled for the start of their respective sessions and they were heard by good audiences. Considerable interest was shown in the strong-motion data obtained from Papua New Guinea and several requests for strong-motion records were received.

In spite of four sessions being held at the same time I was able to attend all the sessions of interest to our work at BMR except one on recent destructive earthquakes, which clashed with a session on seismicity and ground motion.

Strong Ground Motion

Some of the most important papers presented at the conference resulted from the large number of strong -motion records that have become available in the last three or four years. The call at the 4WCEE in Chile was for more accelerograms. Now with over 2000 accelerograms installed throughout the world at least 700 accelerograms have been obtained and the main call has been answered.

However, it appears that, because of the complicated radiation patterns generated by earthquakes and the diversity of the elastic parameters close to the surface, there are no simple formulae that can relate maximum ground acceleration, velocity or displacement with earthquake magnitude, and hypocentral distance. Furthermore because of the complicated source-site parameters it seems that no one number can be used to describe the ground-motion records obtained. New quantities such as energy flux and velocity-response envelope spectra are being tried, but the techniques for using these parameters have not been developed to the stage where they can be used as standard measurements.

The results of these studies have cast some doubt on the validity and applicability of seismic-zoning maps, but at present the concensus of opinion seems to be that, although the present maps may not serve all the purposes for which they were drawn, they are nevertheless the best available way of describing earthquake-risk zones for building code purposes.

The problem of interpreting observations from the epicentral region was highlighted by Ambraseys in his invited paper 'Dynamics and Response of Foundation Materials in Epicentral Regions of Strong Earthquakes'. He showed that because internal yielding of the ground can begin at very low levels of acceleration (10% g) buildings can collapse as a result of ground failure rather than high levels of shaking. This is clearly what happened in 1964 at Niigata, Japan, where maximum ground accelerations did not exceed 30% g, but maximum permanent displacements relative to bedrock reached about 0.5 m.

It therefore appears that, when the geometry and the properties of the superficial layers are known, it should be possible to calculate the maximum acceleration that the ground should be capable of transmitting to the surface. For strong foundation materials or for small amplitude accelerations the deposit will behave elastically and it may therefore amplify the bedrock motion. As the strength of the material decreases, or as the intensity of motion increases, the response may bring about internal or near-surface yielding, as a result of which accelerations above a certain level will not be experienced at the surface.

In view of these arguments it seems paradoxical that Earthquake Codes recommend a base-shear coefficient which increases with decreasing strength of foundation materials.

The San Fernando earthquake of 1971 provided over 100 accelerograms from the Los Angeles region and if any general conclusion could be drawn from this wealth of data it was that, for the implications of seismic zoning, the local site characteristics in themselves seldom offer a decisive justification for a reduced estimate of maximum ground motion shaking in a particular subzone.

In other words it is not possible to predict accurately the behaviour of the ground in the epicentral region of a large earthquake.

<u>Instruments and Data Processing</u>

One excellent aspect of the 5WCEE was the instrument exhibition and all the popular accelerographs were on display; these included:

SMAC	:	Akashi Seisakusho, Japan
SMA-1	:)	
SMA2	:)	Kinemetrics, USA
AR-240	:)	
RFT-250	:)	Teledyne Geotech, USA
MO2	:	Victoria Engineering, New Zealand
UAR	:	USSR

The most common accelerographs are the SMAC of which there are about 670 (all except 18 in Japan) and the SMA-1 (500) which is rapidly becoming the standard strong-motion instrument.

Processing the accelerograms throughout the world is based on the techniques developed at the California Institute of Technology and involves digitizing the records at intervals of 0.025 and using filtering techniques to remove noise. These methods have been used at BMR for about 2 years.

It is evident that in the next few years the number of accelerographs will increase rapidly as each country develops its own network, and this will result in more accelerograms to study.

6WCEE

At the end of the conference a meeting of national delegates decided to hold the next WCEE in India - probably in the northern winter of 1977/78.

5. IMPERIAL COLLEGE, LONDON

Although most of the staff and students from Professor Ambrasey's Department of Civil Engineering were at Izmir (Turkey) during the week after the conference, Dr Sarma was in London and I was able to visit Imperial College and inspect their facilities. The main work carried out in the department involves the running of a post-graduate course in Engineering Seismology. Students attend from many countries and the course provides a link between earth sciences and civil engineering. Its aims are to solve both the engineering problems arising from seismic ground movements and the effects of strong ground motion, not only on foundation and building materials, but on structures also. The units offered include: physics of earthquakes; structural geology; engineering seismology 1 & 2; earthquake engineering; basic tectonics; structural dynamics; soil properties; foundations; stability of slopes; embankment dams; rock mechanics, and basic seismotectonics.

After completing their course, several of the students continue at the college to undertake research. It is usual for them to study particular problems relating to their own country and in this way a considerable wealth of earthquake-risk data has been accumulated, particularly from Middle Eastern countries. In addition to particular studies relating to individual countries, work is being carried out on the problems associated with the response of soils to earthquakes. Under extreme conditions, an earthquake may cause drastic reduction in the bearing capacity of foundation materials, as a result of which a structure standing on them may be damaged, not due to severe shaking, but because of excessive differential settlements. Analytical, field and experimental work are being carried out on this problem.

The college does not operate any strong-motion recorders, but a large number of accelerograms have been obtained from various parts of the world and these are currently being analysed. One of the studies being undertaken at present involves the analysis of the radiation patterns observed close to the earthquake source in an effect to determine how the energy flux close to an earthquake is distributed.

Considerable interest was expressed in the New Guinea data obtained by the BMR and requests have been made by Imperial College for these accelerograms.

6. EARTHQUAKE ENGINEERING INSTITUTE, SKOPJE

In Yugoslavia I visited the Earthquake Engineering Institute and the Macedonian Seismological Centre, both at Skopje.

The Earthquake Engineering Institute is headed by Professor Kirijas and includes a staff of 50, of which 25 are professional officers. It was established primarily with UNESCO funds after the 1963 Skopje earthquake, which caused considerable damage in that city. Two main functions are carried out at the Institute. The first involves the operation of a post-graduate course in earthquake engineering. This course is similar to that given at Imperial College, and is designed primarily for civil engineers.

The second function involves operating a network of strong motion recorders throughout Yugoslavia and analysing the results obtained. At the time of my visit 79 out of a total of 116 SMA-1 accelerographs had been installed. When all these have been deployed, 300 seismographs will be sited where detailed microzoning studies are required.

Up to July 1973 only three accelerograms had been obtained. The facilities for processing the records were rather primitive; the X-Y digitizer, although accurate to about 0.1 mm, gives only a printed output on paper, and these numbers had to be transcribed onto punching sheets before they could be punched on cards and analysed in the computer.

One girl was employed full-time on the digitizer and three technical officers were employed to install and service the accelerographs and seismoscopes. Each accelerograph is inspected every three months and I was impressed by their maintenance program. A new digitizer is being purchased, and when this is available the strong motion facilities at Skopje will be excellent.

In contrast to the Earthquake Engineering Institute the seismological centre seemed outmoded. It operates six permanent stations in Macedonia but the central office, which is about 5 km from Skopje, is isolated from the town, the computer, and the university. The procedures for locating earthquakes are haphazard, and there seems to be no regular system for either obtaining phase data from neighbouring states in Yugoslavia or for calculating hypocentres using arrivals from other Balkan countries. For many years there have been plans for a Balkan seismological centre, but they seem unlikely to be realized in the foreseable future.

At present it is unlikely that the seismological network in Yugoslavia can provide the basic data required to use the accelerograph network to best advantage. It would appear that some earthquakes could trigger an accelerograph and yet not be accurately located.

7. DISCUSSION AND CONCLUSIONS

The earthquake engineering work carried out by BMR is, I believe, as advanced as that in most other countries - except USA and Japan. However, there is an urgent need for a seismic-zoning map of Australia, so that the earthquake provisions of the newly adopted building code can be put into practice. Since a seismic-zoning map is constantly being reviewed, I believe a new position should be created, so that the necessary man-power to prepare this map and to analyse the data accumulating at the BMR Strong Motion Data Centre can be undertaken. If this cannot be done in the near future, then someone should be seconded from another section to prepare the map while the case for a new position is being considered.

I believe that the present staff structure in the Observatory Group is inadequate to carry out properly the programs of geomagnetism, regional magnetic surveys, earthquake engineering, and seismology, which it should be performing. Perhaps an outside consultant should be brought in to investigate and report to the Department of Minerals and Energy or the Public Service Board on these matters.

The coverage of continental Australia by accelerographs is at present inadequate and I recommend that consideration be given to the purchase (in the long-term) of 8 more accelerographs for installation at Robertson (1), and Gunning (2) in New South Wales, Quorn (1) and Gawler (1) in South Australia, Morwell (1) in Victoria, and Meckering (1) and Gascoyne Junction(1) in Western Australia. Feasibility studies should be made to investigate the possibility of telemetering signals from the seismic stations into Canberra or into regional centres; throughout the world it is now proving to be more efficient and more reliable to telemeter into a central office so that the seismograms can be analysed in real time. Perhaps the use of a satellite should be considered in the long-term.