Session Summary

by

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Earthquake engineering is a technical science which studies the means of aseismic design and construction of structures based on the knowledge of earthquake motions. The earthquake motion observed on the ground is subjected to the magnitude and mechanism of the earthquake at the origin, as well as to the modulation due to the length of the path and to the nature and the structure of the medium wherein the seismic waves are propagated.

Seismic regionalization or zoning, and subsoil studies are essential items in earthquake engineering. The behaviour of and damages to structures in and due to earthquakes provide us with useful knowledge for aseismic design and construction. Precise records of strong motion earthquakes and the responses of structures to known disturbances are important items of study in this field. These are included in engineering seismology, for which study seismologists engaged in earthquake engineering have hitherto concentrated their efforts.

In the present conference the fields more or less concerned with engineering seismology are dealt with in the sessions I, II, III and V.

I will here give brief summaries of the papers dealt with in the session III on Seismicity and Earthquake Ground Motion. At this session, convened in Room No. 2 on Tuesday, July 12, some miscellaneous papers were also presented, for conveniences' sake of programming, orally by the authors themselves or delivered in summarized form by a reader, together with those on Recent Strong Motion Earthquakes and the Resulting Damage.

But the papers relating to the theme of session V will not be included in this summary.

Three papers were presented on Seismicity by Hirono, Fedotov and Gajardo and Lomnitz. Into the second theme of this session, i.e. Earthquake Ground Motion, we may classify the papers of White, Kanai, Figueroa, Muramatsu and Yabashi and Sakabe. Those of Alford, Cloud and Carder. are close to this second category. The papers of Nasu, Kishinouye may also be assigned to the topics from session I. The papers of Chakravortty and Ghosh, Kumar and Buffinton may seem to have no connection with the topics of this session, but nevertheless we have no more suitable sessions for presenting of such papers. All the above papers were thus assigned by the Programme Committee of the Conference to this session. Now brief summaries of these papers will be given bellow.

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T. Hirono read a comprehensive paper on the "Seismicity of Japan" based on the result of 37 years' routine instrumental observations made at more than 100 stations under the Japan Meteorological Agency. The mean annual frequency, during the period, of perceptible earthquakes in Japan was 1497 while major earthquakes with magnitudes over 6, 7 and 8 respectively occurred 16, 2 and 0.1 times per annum. But fortunately about $\frac{1}{4}$ of the major earthquakes had a hypocentral depth of over 60km, and 80% of the rest were of sub-oceanic origin and only minor or no appreciable damage was caused on land by the deeper or sub-oceanic earthquakes. The regional variation of seismicity is shown.

In the paper on "Seismicity of the South of the Kurile Islands" S. A. Fedotov of the Institute of the Earth's Physics in Moscow reports the results of two years' observations at six stations in the southern Kurile Islands, and concludes that the intensity on these islands, on average, will not exceed 9 degree of the Modified-Mercalli scale, even in the case of a great earthquake with magnitude over 8.

E. Gajardo and C. Lomnitz of the Institute of Geophysics and Seismology, University of Chile presented a paper on "Seismic Provinces of Chile". In this paper, the authors collected the annual frequency of reported perceptible earthquakes during 17 years in each of the 37 compartments composing of one degree of latitude. They then calculated correlation coefficients between these time series, as was done by C. Tsuboi. From the magnitude of the corralation coefficient contingency between the two compartments was inferred, and consecutive compartments with high contingencies were grouped into one seismic province. Thus they could find four such provinces as follows: A. Pampa del Tamarugal; B. Atacama Province; C. Central Chile and D. Chile Sur.

In the paper entitled "An Empirical Formula for the Spectrum of Strong Earthquake Motion" K. Kanai gave a very convenient formula derived from his theoretical studies as well as from actual observations of earthquakes in Japan and the United States of America. We can now calculate by this formula the spectrum of an earthquake motion at any point on the ground provided we assign the magnitude and epicentral distance of the earthquake and the predominant period of the ground.

I. Muramatsu and T. Yabashi deduced a similar spectrum function to that of Kanai's at a dam site based on actual observations on the spot and from a neighbouring seismic station. They used statistical data based on historical records and gave an expectancy of earthquake force as a function of the period of earthquake motion to be used as a reference in the antiseismic design of a dam to be constructed at that point.

In his paper on "The Meaning of the Spectra of Earthquake Records Obtained in or near Structures" M. P. White of the University of Massachusetts suggested an explanation for the existence of many maxima in the spectra of earthquake motions in or near buildings as the effects of vibrations from neighbouring building as well as those of the building in which the seismometers are installed. He based his explanation on the fact that forced vibration of a building by a mechanical vibrator generated a wave in the surrounding ground which was observed as far as 750 feet with an amplitude of 0.6% of that on the roof of the building.

J. Figueroa A. of the Institute of Geophysics, National University of Mexico analysed seismograms obtained at four Mexican stations located on terrains of different geological formations. He derived the conclusions that motions with the periods of 1 sec. and 1.22 sec. predominate in earthquake motions on hard ground and in less firm ground respectively. Motions with the longer periods predominate on the surface of shore-fillings. It is also concluded that the larger are the amplitude and the duration of earthquake motion the poorer is the ground.

Although the paper on the damage of Fukui earthquake and the distructive power of similar earthquakes by Y. Sakabe of Fukui University, Japan, seems to belong to the topics of session V, it is proper to review it here because the subject of the paper is mainly concerned with the true nature of destructive earthquake motions. The author describes his personal experience, information from his friends and observations of the destructive Fukui Earthquake of June 28, 1948. This earthquake was one of the severest earthquakes ever experienced in Japan. Based on data from the above mentioned sources, the author emphasizes the importance and effects of a strong jerk in the earthquake motion in the destruction on man made structures. He refers to this sudden thrust as a shock, and suggests that this might be a result of a faulting motion which should be able to be observed in the epicentral area. The fading out of such shocks with the distance, as revealed in the seismograms at distant stations, is explained by the larger attenuation of such a large shock which he considers to be in the plastic range of deformation.

The paper of J. L. Alford of the Harvey Mudd College, Claremont, California, deals with the relation between the maximum safe charge and the distance. Examining the results hitherto published, he shows that this critical magnitude of ground motion caused by blasting is its velocity and it ranges between 4.3 and 4.7 inches per second. He recommends, allowing a margin of safety, an operating limit on the ground velocity of 2 inches per second. But in view of the fact that the ground motion caused by blasting may have a spectral intensity variation, he recommends further investigations of damage problems from blasting including the collection of information on the shape and magnitude of response spectrum as related to the weight of the explosive charge, distance and type of ground.

D. S. Carder and W. K. Cloud of the United States Coast and Geodetic Survey presented a paper on the "Ground Motions Generated by Underground Nuclear Explosions" which attracted the attention of a large audience. Carder had arrived at a formula

$$\log A = 0.75 \log W - 2.9 - \log R - 0.06 R$$

for the maximum ground displacement A (single component) in centimetre at a distance R (in km) to the explosion point where nuclear energy equivalent to that of W tons of TNT is released In the above formula, it is assumed that the observation is made on granite, quartzite or lime-stone, but on deep alluvium the ground motion was revealed to be of a higher amplitude than at like distances on granite, the comparative figures being 2 to 3.5. He calculated the energy sent out as elastic waves at $10^{18.5}$ ergs which is equivalent to a 4.8 magnitude earthquake.

W. K. Cloud analysed 11 radial component acceleration records of the events Blanca (19 kilotons) and Logan (5 kilotons) by means of a response analyser, and he evaluated the average maximum response velocity for the oscillator period as ranging 0.1 to 2.0 sec. The plot of this value against distance showed a very uniform attenuation as the 1.78 power of the distance. These response spectra show remarkable similarity to those of natural earthquakes.

It is well-known that the intensity of an earthquake is very much influenced by subsoil conditions, and earthquake motion coming to the layered earth's surface is modulated by multiple reflections. And these motions with periods near a certain period which is characteristic of the site, and called a predominant period, are much enhanced in their magnitudes. A knowledge of this vibration characteristics of ground is very important in antiseismic problems. In the Earthquake Research Institute of Tokyo University a team concerned with subsoil research consisting of its members have been engaged in this problem and presented a part of their study in the second session of this conference under the title "Earthquake Damage and Subsoil Conditions as Observed in Certain Districts of Japan". In the present session, the former director of the Institute N. Nasu who had presided over a committee for the "Investigation of the Ground in the Northern Part of the City of Yokkaichi in the North Ise District" presented a report on the work of the committee. The items studies were 1. geology from observations on the furface and the study of 30 new boring cores and pre-existent well-logs on land area as well as in the littoral sea area; 2. subsidence of the ground surface as inferred from precise levellings; 3. soil mechanical tests; and 4. observations of micro-tremors. From these data they could classify the ground according to the building code standards, and discuss the plan of utilizing the ground. It is to be noted that the bearing power and the possible subsidence of a structure of an assigned size and weight as well as the predominant period on the ground in the area are clarified in this investigation.

F. Kishinouye of the Earthquake Research Institute also presented a paper on "Microseisms and Subsoil Conditions" in which is described a new approach to the study of subsoil conditions by means of microseisms in the frequency band between 0.1 to 0.3 sps. or so. It is shown that the distribution in a large area of amplitude ratio of microseisms observed at a spot to that at a standard station is closely related to the subsoil structures a little larger in scale than those related to micro-tremors of shorter periods.

The paper on the "Movement of Faults" of D. Tocher of the University of California at Berkeley acquaints us with interesting observation on the progressive rupture of a winery building located on a fault line at a vineyard, seven miles south of Hollister, California. This was revealed to be due to the slow creep of the fault. The results of his precise measurement of this creep made clear that the movement of the fault is in the same direction as that observed at the time of the previous major earthquake. This study may lead to a modification of H. F. Reid's elastic rebound theory on earthquake occurrence.

"Seismological Study of the Crustal Layers in the Indian Region from the Data of Near Earthquakes" by K. C. Chakravortty and D. P. Ghosh, of Banaras Hindu University, India, contains interesting information from the seismological point of view on the thicknesses of the granitic and basaltic layers in this area of remarkable topography near the Himalayan range.

The paper of P. Kumar, of the Central Building Research Institute, Roorkee, India, on "Geotectonic Movements and their Influence on the Hydrography of the Indo-Gangetic Plains" will be of interest from the hydrographical point of view in India.

Lastly, the paper of P. G. Buffinton of the Factory Mutual Rating Bureau on "Earthquake Insurance in the United States - Reappraisal" will be reviewed. In the paper the author summarizes and analyses the development of the earthquake insurance business in the United States. which is, as is well known, a pioneer country in this field. The knowledge stated in this paper is of no small importance to the underwriters and also to the people of other earthquake countries in this field. The most of the damage incurred by severe earthquakes must be born by the people themselves. The insurance system provides for this coverage. Since the damage possibility to the properites of the people depends upon the rate of the seismicity and the liability of the structures to destruction in a strong motion earthquake. The problem in earthquake insurance must be largely solved by the progress of earthquake engineering. In conclusion of this paper, the author summarizes some of the most important factors which are needed for further investigation in connection with the general subject of earthquake insurance. The first of the factors is the area factor or the exposure to loss which depends on the seismicity and the quality of the structures, while the second is the attitude of the insurance buyer. The progress of earthquake engineering will, in the reviewer's opinion, contribute to the clarification and betterment of the above two factors. The author concludes that the seismologist can be of great assistance to the insurance underwriters and the buying public.

Although it is not necessary to say that the reviewer wants to add to the above conclusion the assistance of structural engineers in the same problem, we are happy to say that we can hope definitely for a salient development in earthquake engineering by the collaboration of the seismologists and structural engineers attending this conference. With this bright hope for a promising progress of earthquake engineering and the consequent promotion of the welfare of mankind, the reviewer would like to finish his summary.