TECHNICAL NOTE

REPORT ON

THE SECOND (1978) MICROZONATION CONFERENCE

R. J. Bentley *

The writer attended the second Microzonation Conference at San Francisco in December, 1978. The Conference lasted five days and papers were delivered on a wide variety of subjects. Discussion here is limited to topics where new developments appear to the writer to be of general interest. These notes therefore hardly constitute a review of the conference, but they may assist earthquake engineers not directly involved in engineering seismology or in microzoning studies to keep aware of current developments.

Papers are referred to by page number and a list of proceedings is appended. The proceedings (in three Volumes) will shortly be available from the Ministry of Works and Development and University libraries. Copies can also be obtained from the Conference Organiser: Professor Mehmet A. Sherif at the University of Washington, Seattle⁽¹⁾.

1. THE EARTHQUAKE SOURCE

Numerical methods developed in recent years have made the synthesis of ground motion records, based on plausible assumptions about the physics of ground rupture, a much more tractable problem. The source-observer geometry can also be modelled realistically.

The basic technique described in the paper by Archuleta and others (page 255) involves a finite element method that allows the fracture to propagate from a hypocentre and to spread with a prescribed rupture velocity over a given fault area embedded in a half space. As the fracture spreads it relaxes the stress enclosed by its rupture front. Figure 1 illustrates a comparison of the synthetic and actual record obtained at station five in the Cholame-Shandon array in the 1966 Parkfield earthquake.

Models of this kind are useful in examining the influence of various parameters on the ground motion. Figure 2 (from the same paper) illustrates contours of peak ground velocity for two very similar fault models. The top figure is for a uniform distribution of shear stress with depth, and the lower figure is for a parabolic shear stress distribution - with the same average value as the first. The distribution of shaking can be seen to be quite different. The authors state that an important feature is that the amplitude of the particle velocity increases in the direction of rupture propagation"..... this focusing of energy is a combination of both the directivity associated with a moving source and the buildup of stresses on the fault ahead of a subsonic rupture. This focusing can be an important consideration in microzonation because the largest amplitude ground shaking depends not only on the stress but also the rupture velocity and its direction of propagation. It should be mentioned that if the rupture nucleates at depth and propagates towards the free surface, the particle velocity will increase in amplitude as it approaches the free surface. The free surface has the additional effect of nearly doubling the

amplitude of the particle velocity should the rupture front break through the surface."

Despite many limitations (e.g. large earthquakes rarely occur on one fault) it appears that source modelling studies may allow better estimates of the engineering significance of earthquake source size, focal depth, surface faulting, magnitude, tectonic regime (etc.). This information would allow considerable refinement in estimates of earthquake risk.

2. SITE RESPONSE

Evaluation of the effects of local soil and geological conditions on site response during earthquakes has been a major research topic for many years. Most analytical procedures have been based on the use of linearly elastic models of the soil profile, and more refined procedures (e.g. the computer program SHAKE) use the wave propagation method in place of lumped mass models and include non-linear effects by reducing the shear modulus of the soil to a value proportional to some assumed average strain.

The limitations of this approach were reviewed by Donovan (page 55), who points out that the elastic approach tends to concentrate the energy in the soil around the natural period, whereas most soft ground accelerograms show response over wider frequency bands. Martin (page 1089) described the development of non linear analysis techniques (including soil failure and degradation) for assessing site response. These are thought to be particularly applicable where large deformations occur during strong shaking, and model studies do show considerable 'flattening' of spectral shapes at high levels of ground acceleration.

A major difficulty with these techniques is that they assume vertical shear wave propagation. Donovan points out that if this was a correct assumption there would be little difference between the response spectra of individual components in the horizontal directions at the same site. These often differ by significant amounts.

Senior Engineer, Beca, Carter, Hollings and Ferner Ltd., Wellington.

Ground motions are much more complex (see for example Bolt page 617). Donovan suggests that any means of site modelling based on a simple type of exciting motion should be used only as a guide to estimate of site effects and not for the development of acceleration time histories for design.

The expanding collection of strong-motion data has enabled statistical studies of ground response for broad categories of site condition to be undertaken with increasing confidence. The conference proceedings include reports of several new studies including those of Werner and Ts'ao (page 1077), Crouse and Turner (page 1117), Iwasaki and others (page 705), Sadigh and others (page 801) and Alonso and Urbina (page 523). Collation of this data has shown more clearly the wide variations in the patterns of ground shaking in earthquakes. Donovan states that ".... these empirical procedures carefully applied with the use of mean values and reasonable degree of conservatism offer a much more attractive means of evaluating site effects on ground motion than is possible with any presently available one or two dimensional linear or non linear site model."

3. DESCRIBING EARTHQUAKE STRONG MOTIONS FOR NORMAL ENGINEERING PURPOSES

A variety of parameters are now used to describe earthquake strong-motions. Peak ground acceleration and velocity are common choices, but there is increasing emphasis on response spectra and on parameters derived from response spectra.

Donovan (page 55) and Whitman (page 1247) suggest that effective peak acceleration and effective peak velocity are suitable parameters for scaling strong-motions. EPA and EPV are used in the ATC-3 provisions⁽²⁾ to characterize strong ground shaking.

Whitman uses liquefaction potential to describe EPA. The actual time history of shear stress can be converted into an equivalent periodic shear stress with a limited number of cycles (see Figure 3). Thus for liquefaction, EPA is the peak acceleration in a series of uniform cycles which produces liquefaction in some standard number of cycles - say ten cycles.

For structures the EPA would be that intensity of shaking which, when applied over the standard duration, produces the same response as the actual motions. 'Response' might be a deformation criteria of some kind. EPA is therefore less than peak ground acceleration because:

- (a) very high frequencies, typified by spike of high acceleration but very short duration, have little effect upon the response of most structures, and
- (b) for structures being strained into the inelastic range, duration of motion or number of cycles of straining has a great influence on the damage.

Donovan describes the ATC-3 recommendations:

"The five percent damped spectrum for the actual motion is drawn and fitted by straight lines between two sets of periods

(see Figure 4). The ordinates of the smoothed spectrum are then divided by 2.5 to obtain the EPA and EPV. The EPA and EPV thus obtained are related to peak ground acceleration and peak ground velocity but are not necessarily the same as or even proportional to peak acceleration and velocity. The introduction of an EPV term as a second scaling parameter was required because a single parameter related to acceleration cannot even approximately describe response spectra which result from large distant earthquakes."

However, it is the writer's impression that EPA and EPV are not yet widely accepted measures of ground shaking in earthquakes. One reason may be that as defined by Donovan, EPA and EPV do not appear to contain a great deal of new information about the ground motion.

4. ASSESSMENT OF EARTHQUAKE RISK

One paper I would recommend for a second reading is by Professor Bolt (page 617) who critically examines procedures for predicting future earthquake intensities at a site. Perhaps his most important suggestion is that (for strike-slip events) peak acceleration values should be related to stress drop rather than magnitude. Magnitude appears to describe better the duration of shaking and the size of the meizoseismal area. The implication of this is that strong-motions recorded close to small (strike-slip) earthquakes contain important information on peak parameters in the largest earthquakes. Earthquakes in this category are Parkfield 1966, Koyna (1967) and Managua 1973. If magnitude is an unreliable scaling factor for ground motions, then the many attenuation curves based on magnitude are unreliable.

Bolt also tackles the vertical wave propagation problem and notes that (1) near the source the pulse (of SH motions) reaches the surface obliquely with wavelengths of the order of hundreds of metres (which are much greater than the thickness of surficial soil layers) and (2) surface waves do occur at periods of engineering interest. This severely limits the applicability of the vertical wave propagation model.

The conference included a number of reports of case studies of earthquake risk assessment including the Auburn Dam (page 457) (where an unexpected magnitude 5.7 earthquake with faulting occurring near the site of a proposed dam) and at offshore sites at Alaska (page 1291), and California (page 1343). There were also several reports on seismotectonic studies in the Middle East (page 571, 669 and in America (page 571, 1329, 329).

5. STRUCTURAL ASPECTS

The problems of specifying design earthquakes are discussed by Bertero and Mahin (page 1145). When serviceability controls the best approach is to specify earthquakes using smoothed response spectra. When damageability or collapse controls design earthquakes are often specified by modifying smoothed elastic response spectra. The authors demonstrate that there are

difficulties in this procedure and that the technique is not always conservative.

A more rational approach to drawing inelastic design spectra can be based on displacement ductility requirements for single degree of freedom systems with specified damping (see Figure 5). Although similar diagrams have been published by researchers as far back as 1960, engineering seismologists seem to ignore them in presenting strong-motion data. Until a substantial collection of these diagrams are available little progress will be made along the lines suggested by the authors. For example the new series of strong-motion data reports from the United States Geological Survey contains a variety of quite complex measures of the response of SDOF elastic systems only. (The same can also be said about the data presentation at the DSIR Physics and Engineering Laboratory).

A number of papers were presented on the seismic design of offshore platforms. Of particular interest is a paper on concrete platforms by Watt and Byrd (page 1409). The paper describes the difficulties of modelling structure-water interaction, soil-structure interaction, vertical response and other considerations peculiar to such massive undersea structures. Kallaby and Mitchell (page 1459) describe the philosophy underlying the seismic provisions of API-RP2A, the American Petroleum Institute recommendations for planning designing and constructing offshore platforms.

6. EARTHQUAKE REPORTS

A seismic microzoning map for Bucharest was prepared in 1973. The paper by Madrescu (page 399) gives detailed information on the geological and soil characteristics in the Bucharest area and describes the damage pattern in the city in the 1977 Vrancea earthquake (often called the Bucharest earthquake). A main conclusion is that microzoning using the stiffness of the surface soils (10 - 15 m) did not prove satisfactory.

The conference proceedings contain four papers with reports and photographs on the damage during the Japanese Miyagikan-oki earthquake (12 June 1978) which caused extensive damage in Sendai (page 587).

The February 4, 1976 Guatemala earthquake ($M = 7.5$) caused more than 10,000 landslides. A paper by USGS geologists and engineers (page 353) on the landslides concluded that the local distribution of landslides in Guatemala city was inconsistent with the intensity data. Important factors in determining landslide locations include rock type and structural and topographic features, and a 'landslide concentration map' for the Guatemala area has been prepared.

7. MICROZONING TECHNIQUES

At the first (1972) Microzonation conference seven papers were presented by the USGS on the preliminary analysis of seismic microzonation in the San Francisco Bay region. The progress of these studies can be considered to give a guide to progress in microzoning techniques generally.

Eight papers on the seismic zonation in

the San Francisco Bay region were presented by the USGS at this conference. Progress since 1972 as summarized by Borchardt (page 229), includes: the discovery of three new faults in Northern San Francisco, logging of 59 drill holes, developments in the use of synthetic seismograms, mapping of liquefaction susceptibility in Santa Cruz County (1" to one mile), and development of new techniques for mapping slope stability and for estimating building damage in earthquake.

Two Japanese studies were reported. Shima (page 433) discusses the microzoning of Tokyo using shear wave velocity data (from down hole measurements). Yoshikawa and others (page 445) present a microzoning study of Osaka involving consideration of regional tectonics, likely design earthquake, local geology and soil characteristics and liquefaction potential. The resistance of wooden houses to earthquake shaking is related to ground strain and an assessment of the risk to houses is prepared using a 500 metre square grid.

Trifunac and Anderson (page 559) report a study of the variation in seismic risk in a region about 140 km x 150 km (the Los Angeles region). They conclude that the maximum difference in seismic risk between sites is smaller than the uncertainty involved in the estimate of a single site. Thus very few zones (at most 2 or 3) can be justified for the area. The conclusion appears to have some relevance in other seismic regions.

8. SOCIAL ASPECTS AND MICROZONING

Hutten and Mileti (page 179) believe that the potential for catastrophic loss in major earthquakes in developed communities is increasing. Microzoning studies could provide an important first step toward implementing comprehensive damage reduction programs for earthquakes.

Increasing concentrations of people and development lead to increasing levels of potential loss. The historic record of damage and loss can be very misleading. Losses in a major earthquake near San Francisco are estimated now to be up to \$20 billion, and in Los Angeles \$25 billion (40,000 and 12,000 lives lost respectively).

According to the authors there are five areas where hazard reduction measures may be implemented.

Earthquake resistant construction: Codes effectively reduce damage from moderate earthquakes. However they are intended only to provide minimum requirements for public safety and in a large earthquake some code buildings may be total economic losses. Dense occupation of expensive structures in areas of high risk is a major contribution to the rapid growth in potential loss.

Land use management: The sole use of building codes as a strategy to control loss continues to have little effect on the trend of growing potential loss. This will continue until decisions to locate in areas of high hazard are discouraged (by comprehensive land use management programs). There is a misconception that damage from

fault movement is a major loss in earthquakes. Local ground failure (slope stability in particular) may be a major factor in earthquake loss. Microzoning studies provide a basis for the development of comprehensive land use management programs.

Prediction and warning systems: Forecasts of damaging earthquakes may be available in less than a decade but because a reliable system for prediction may not be available in the foreseeable future reliance on this adjustment is not recommended.

Emergency response: Community preparedness for emergency response will minimize the risk of associated hazards of fire and flood. There is a widespread lack of knowledge about the vulnerability of utilities, communications and health services to earthquake. Planning should take better account of the implications inherent in the failure of vital life lines and inaccessible services due to earthquake damage.

Pre-event planning for reconstruction: Studies indicate that the reconstruction process is ordered, knowable and predictable and preplanning in a general way for reconstruction appears to be possible.

9. WHAT IS MICROZONATION

Olson states (page 1475) that it is evident that (1) there is no universally accepted definition of the term, and (2) the policy implications of seismic microzoning have not been clearly recognized:

"From the viewpoint of public policy, microzoning appears to be a process consisting of several techniques used to evaluate the seismic, geologic, and soils characteristics of areas as large as perhaps a multi-state region or as small as a building site for the purpose of determining the potential susceptibility of damage to structures from earthquakes. Logically, the next step would be to apply more or less stringent practices, standards and procedures on the use of land and construction."

Hutton and Mileti are more specific: "Microzone studies have a tremendous potential contribution to make to planning efforts made by public and private managers to reduce earthquake hazards. In order to make the contribution, many obstacles must be overcome. Some of the more obvious next steps are:

- A thoughtful specification of the elements comprising ideal microzoning is needed. For microzoning to be most useful to local decision makers the information needs to go beyond delineating soil and foundation data. Maps may include judgements about especially vulnerable segments of population, secondary hazard potential (fire), and especially hazardous facilities, including structures. More detailed information may better illustrate mitigation decision priorities to local decision makers
- Formal criteria are needed to determine the priority areas for microzoning earthquake effects. Earlier candidates for microzoning may be those places where growth has yet to occur rather than areas where population density is high. Preventing incompatible development is cheaper than correcting existing facilities.

- Ultimately, local decision makers need more detailed information than currently provided with which to make more comprehensive land use decisions for earthquake and other hazard mitigation efforts"

10. EARTHQUAKE INSURANCE AND MICROZONATION

Steinbrugge (page 203) identified three elements in evaluating the risk to building - geologic hazards, seismicity and building damage patterns. Microzoning could be limited to describing the principle geologic hazards; active faults, potential land-slide areas and structurally poor ground areas. However movement of active faults has no impact on losses and can be ignored (except for individual major structures). Furthermore, experience shows that land-slide microzone maps are difficult to interpret and to apply consistently.

Because low valued building have low premiums (for earthquake insurance) site studies are therefore uneconomic. Generalised microzoning schemes may be useful for setting premiums for this class of building.

However analysis indicates that differential earthquake insurance premiums will probably have no effect on home owners (the premium is relatively small). Thus Steinbrugge concludes that microzoning will have greater benefits as part of the building construction regulatory process.

11. CONCLUDING COMMENTS

The conference drifted away from microzoning and entered many fields in earthquake engineering. A contributory reason for this may be that there is confusion over the nature and purpose of microzoning. This situation may continue until there is greater awareness amongst city planners and elected officials of both the nature of the earthquake risk to them, and of possible actions to reduce the risk.

ACKNOWLEDGEMENTS

One of the reasons the writer attended the Conference is to assist a project being carried out by Beca Carter Hollings and Ferner, Consulting Engineers, under the aegis of the New Zealand Government Bilateral Aid Programme to the Government of Indonesia. The assistance of the Ministry of Foreign Affairs, who contributed toward the costs of attending the Conference, is gratefully acknowledged.

REFERENCES:

1. Proceedings of the Second International Conference on Microzoning for Safer Construction - Research and Application, San Francisco 1978.
2. Tentative Provisions for the Development of Seismic Regulations for Buildings. Prepared by Applied Technology Council for the (US) National Science Foundation and the National Bureau of Standards 1978.

Paper received 15 March, 1979.

FIGURE 1:

FIGURE 3:

FIGURE 5,

CONTOURS OF PARTICLE VELOCITY ON THE FREE SURFACE FOR (TOP) UNIFORM SHEAR STRESS WITH DEPTH AND (BOTTOM) PARABOLIC SHEAR STRESS DISTRIBUTION.

FIGURE 2:

Illustration of how Effective Peak Acceleration (EPA) and Effective Peak Velocity (EPV) are defined from a response spectrum with 5 percent damping.

FIGURE 4:

TABLE OF CONTENTS

VOLUME I

STATE-OF-THE-ART SESSION

	Page
C. Kisslinger	3
P. C. Jennings D. V. Helmberger	27
N. C. Donovan	55
M. A. Sherif I. Ishibashi	81
A. S. Veletsos	111
L. S. Cluff	135
V. J. Murphy	153
J. R. Hutton D. S. Miletic	179
H. J. Lagorio E. E. Botsai	193
K. V. Steinbrugge	203
N. S. Remmer	215

MICROZONATION SESSION

Progress on Seismic Zonation in the San Francisco Bay Region	
E. E. Brabb R. D. Borchardt	1. Introduction and Summary 229
D. G. Herd	2. Neotectonic Framework of Central Coastal California and Its Implications to Microzonation of the San Francisco Bay Region 231
R. D. Borchardt J. F. Gibbs T. E. Fumal	3. Progress on Ground Motion Predictions for the San Francisco Bay Region, California 241
R. J. Archuleta W. B. Joyner D. M. Boore	4. A Methodology for Predicting Ground Motion at Specific Sites 255
T. L. Youd J. C. Tinsley D. M. Perkins E. J. King R. F. Preston	5. Liquefaction Potential Map of San Fernando Valley, California 267
D. K. Keefer G. F. Wiczorek E. L. Harp D. H. Tuel	6. Preliminary Assessment of Seismically Induced Landslide Susceptibility 279
S. T. Algermissen K. V. Steinbrugge	7. Earthquake Losses to Buildings in the San Francisco Bay Area 291
W. J. Kockelman E. E. Brabb	8. Examples of Seismic Zonation in the San Francisco Bay Region 303
J. B. Perkins	9. The Use of Earthquake and Related Information in Regional Planning--What We've Done and Where We're Going 315
W. G. Milne D. H. Weichert	The Sensitivity of Seismic Risk Maps to the Choice of Earthquake Parameters in the Georgia Strait Region of British Columbia 323
J. A. Fischer J. G. McWhorter	The Microzonation of New York State: Progress Report No. 2 329
J. Kuroiwa E. Deza H. Jaén J. Kogan	Microzonation Methods and Techniques Used in Peru 341
E. L. Harp R. C. Wilson G. F. Wiczorek D. K. Keefer	Landslides from the February 4, 1976 Guatemala Earthquake: Implications for Seismic Hazard Reduction in the Guatemala City Area 353
S. T. Mau C. S. Kao	A Risk Model for Seismic Zoning of Taiwan 367
H. K. Acharya	Ground Motion Attenuation in the Philippines 379
K. Moazami-Goudarzi H. Parhikhteh	A Quantitative Seismotectonic Study of the Iranian Plateau 391
N. Măndrescu	The Vrancea Earthquake of March 4, 1977 and the Seismic Microzonation of Bucharest 399
J. Petrovski	Need for Experimental Evidence in Development of Seismic Microzoning Methods 413
S. Hattori	A New Proposal of the Seismic Risk Map Based on the Maximum Earthquake Motions, the Ground Characteristics and the Temporal Variations of the Seismicity 421
E. Shima	Seismic Microzoning Map of Tokyo 433

S. Yoshikawa Y. T. Iwasaki M. Tai	Microzoning of Osaka Region 445
D. R. Packer L. S. Cluff D. P. Schwartz F. H. Swan, III I. M. Idriss	Auburn Dam - A Case History of Earthquake Evaluation for a Critical Facility 457
E. J. Bell D. T. Trexler J. W. Bell	Computer-Simulated Composite Earthquake Hazard Model for Reno, Nevada 471
A. S. Patwardhan D. D. Tillson R. L. Howack	Zonation for Critical Facilities Based on Two-Level Earthquakes 485
W. W. Hays S. T. Algermissen R. D. Miller K. W. King	Preliminary Ground Response Maps for the Salt Lake City, Utah, Area 497
C. E. Glass	Application of Regionalized Variables to Microzonation 509
J. L. Alonso L. Urbina	A New Microzonation Technique for Design Purposes 523
A. S. Patwardhan L. S. Cluff	The Concept of Residual Risk in Earthquake Risk Assessments 535
S. Murakami K. Midorikawa	Land Use Technique for Microzonation 547
J. G. Anderson M. D. Trifunac	Application of Seismic Risk Procedures to Problems in Microzonation 559
B. A. Schell	Seismotectonic Microzoning for Earthquake Risk Reduction 571
A Report on the Miyagiken-oki, Japan, Earthquake of June 12, 1978	
	Abstract 587
H. Kobayashi K. Seo S. Midorikawa	I. Strong Ground Motions and Seismic Microzoning 588
Y. Yoshimi I. Tohno K. Tokimatsu	II. Geotechnical Aspects of Damage 600
T. Katayama	III. Damage to Lifeline Utility Systems (A) 606
H. Shibata	IV. Damage to Lifeline Utility Systems (B) 612
Index of Authors	

VOLUME II

GEOLOGY, SEISMOLOGY, GEOPHYSICS AND SITE EFFECTS SESSION

B. A. Bolt	Fallacies in Current Ground Motion Prediction 617
E. W. Hart	Zoning for the Hazard of Surface Fault Rupture in California 635
M. R. Ploessel	High-Resolution Geophysical Surveys, A Technique for Microzonation of the Continental Shelf 647
L. Estevá E. Bazán	Seismicity and Seismic Risk Related to Subduction Zones 657
W. D. Page W. U. Savage J. N. Alt L. S. Cluff D. Tocher	Seismic Hazards along the Makran Coast of Iran and Pakistan: The Importance of Regional Tectonics and Geologic Assessment 669
S. Kh. Negmatullayev G. S. Seleznyov D. W. Simpson C. Rojahn	Engineering and Seismological Observations at Dams 681
R. A. Wiggins G. A. Frazier J. Sweet R. Apse	Modeling Strong Motions from Major Earthquakes 693
F. T. Wu	Prediction of Strong Ground Motion Using Small Earthquakes 701
T. Iwasaki T. Katayama K. Kawashima M. Saeki	Statistical Analysis of Strong-Motion Acceleration Records Obtained in Japan 705
A. F. Shakal M. N. Toksöz	Analysis of Source and Medium Effects on Strong Motion Observations 717
F. J. Sánchez-Sesma	Ground Motion Amplification due to Canyons of Arbitrary Shape 729
E. Mardiross	A Method for Assessment of Seismic Design Motions 739
A. M. Rogers W. W. Hays	Preliminary Evaluation of Site Transfer Functions Developed from Earthquakes and Nuclear Explosions 753
K. Kudo	The Contribution of Love Waves to Strong Ground Motions 765
I. S. Oweis	The Relevancy of One Dimensional Shear Models in Predicting Surface Acceleration 777

N. Goto Y. Ohta H. Kagami	Deep Shear Wave Velocity Measurement for Evaluation of 1-10 Sec Seismic Input Motions	793
K. Sadigh M. S. Power R. R. Youngs	Peak Horizontal and Vertical Accelerations, Velocities, and Displacements on Deep Soil Sites during Moderately Strong Earthquakes	801
F. J. Sabina I. Herrera R. England	Theory of Connectivity: Applications to Scattering of Seismic Waves. I. SH Wave Motion	813
S. Midorikawa H. Kobayashi	On Estimation of Strong Earthquake Motions with Regard to Fault Rupture	825

SOIL DYNAMICS, SOIL-STRUCTURE INTERACTION AND GROUND EFFECTS SESSION

W. D. L. Finn Y. P. Vaid S. K. Bhatia	Constant Volume Cyclic Simple Shear Testing	839
Y. Yoshimi K. Tokimatsu	Two-Dimensional Pore Pressure Changes in Sand Deposits during Earthquakes	853
A. S. Arya P. Nandakumaran V. K. Puri S. Mukerjee	Verification of Liquefaction Potential by Field Blast Tests	865
H. Dezfulian S. R. Prager	Use of Penetration Data for Evaluation of Liquefaction Potential	873
T. Iwasaki F. Tatsuoka K. Tokida S. Yasuda	A Practical Method for Assessing Soil Liquefaction Potential Based on Case Studies at Various Sites in Japan	885
K. Ishihara K. Ogawa	Liquefaction Susceptibility Map of Downtown Tokyo	897
J. Isenberg D. K. Vaughan	Three-Dimensional Nonlinear Analysis of Soil-Structure Interaction in a Nuclear Power Plant Containment Structure	911
E. Alarcón J. Domínguez A. Martín F. Paris	Boundary Methods in Soil-Structure Interaction	921
Y. Sugimura	Seismic Shear Strain Induced in Soil Deposits	933
R. D. Singh W. S. Gardner R. Dobry	Post Cyclic Loading Behavior of Soft Clays	945
S. Nemat-Nasser A. Shokoh	A New Approach for the Analysis of Liquefaction of Sand in Cyclic Shearing	957
K. Tanimoto M. Nishi T. Noda	A Study of Shear Deformation Process of Sandy Soils by the Observation of Acoustic Emission Response	971
W. P. Grant I. Arango D. N. Clayton	Geotechnical Data at Selected Strong Motion Accelerograph Sites	983
Y. Shioi T. Furuya M. Okahara	Recent Earthquake Resistant Design Methods for Different Types of Foundations in Japan	1001
W. F. Marcuson, III R. F. Ballard, Jr. S. S. Cooper	Comparison of Penetration Resistance Values to In Situ Shear Wave Velocities	1013
C. M. Duke G. C. Liang	Site Effects from Fourier Transforms	1025
A. M. Abdel-Ghaffar R. F. Scott	Dynamic Characteristics of an Earth Dam from Two Recorded Earthquake Motions	1037
B. Tucker J. King K. Aki J. Brune I. Nersesov W. Prothero G. Shpilker G. Self	A Preliminary Report on a Study of the Seismic Response of Three Sediment-Filled Valleys in the Garm Region of the USSR	1051
K. W. Campbell	Empirical Synthesis of Seismic Velocity Profiles from Geotechnical Data	1063
S. D. Werner H. S. Ts'ao	Effect of Local Site Conditions on Spectral Amplification Factors	1077
I. Lam C. F. Tsai G. R. Martin	Determination of Site Dependent Spectra Using Non-linear Analysis	1089
M. L. Traubenik J. E. Valera W. H. Roth	Effects of Soil Inertia Forces on Design of Buried Pipelines Crossing Faults	1105
C. B. Crouse B. E. Turner	Analysis of Ground Motion Spectra	1117

Index of Authors

VOLUME III

ENGINEERING MECHANICS AND STRUCTURAL DESIGN SESSION

G. C. Hart C. Rojahn	Selection of Buildings for Strong-Motion Instrumentation Using Zonation Information and Decision Theory	1135
V. V. Bertero S. A. Mahin	Need for a Comprehensive Approach in Establishing Design Earthquakes	1145
A. R. Chandrasekaran D. K. Paul	Velocity Response Spectra for Sites on Rock or Soil	1157
P. C. Chen J. H. Chen	Generation of Floor Response Spectra Directly from Free-Field Design Spectra	1169
T. Hisada Y. Ohsaki M. Watabe T. Ohta	Design Spectra for Stiff Structures on Rock	1187
A. H. Hadjian	On the Correlation of the Components of Strong Ground Motion	1199
T. Iwasaki K. Kawashima	Seismic Analysis of a Highway Bridge Utilizing Strong-Motion Acceleration Records	1211
G. C. Delfosse J. C. Miranda	Buildings on Isolators for Earthquake Protection	1223
W. J. Hall J. R. Morgan N. M. Newmark	Traveling Seismic Waves and Structural Response	1235
R. V. Whitman	Effective Peak Acceleration	1247
B. Mohraz M. L. Eskijian	A Study of Earthquake Response Spectra for Offshore Platforms	1257
J. Petrovski	Influence of Soil-Structure Interaction Effects on Dynamic Response of Large Panel Prefabricated Buildings	1269

OFFSHORE MICROZONATION SESSION

I. M. Idriss L. S. Cluff A. S. Patwardhan	Microzonation of Offshore Areas - An Overview	1281
A. S. Patwardhan	Factors Influencing Seismic Exposure Evaluation for Offshore Areas	1291
R. G. Bea M. R. Akky	Seismic Exposure and Reliability Considerations in Offshore Platform Design	1307
J. A. Fischer C. T. Spiker	Preliminary Microzonation of the Baltimore Canyon Lease Area	1329
L. A. Selzer R. T. Eguchi T. K. Hasselman	Seismic Risk Evaluation of Southern California Coastal Region	1341
J. R. Benjamin F. A. Webster C. Kircher	The Uncertainty in Seismic Loading and Response Criteria	1369
D. Nair J. B. Weidler R. A. Hayes	Inelastic Seismic Design Considerations for Offshore Platforms	1383
H. Kappler G. I. Schuëller	The Influence of Microzonation on the Reliability-Based Design of Offshore Structures	1399
B. J. Watt R. C. Byrd	Aseismic Design Considerations for Concrete Gravity Platforms	1409
Y. Moriawaki E. H. Doyle	Site Effects on Microzonation in Offshore Areas	1433
H. J. Swanger D. M. Boore	Importance of Surface Waves in Strong Ground Motion in the Period Range of 1 to 10 Seconds	1447
J. Kallaby W. W. Mitchell	Guidelines for Design of Offshore Structures for Earthquake Environment	1459

URBAN PLANNING, SOCIO-ECONOMICS AND GOVERNMENT RESPONSIBILITY SESSION

R. A. Olson	The Policy and Administrative Implications of Seismic Microzonation: Toward Logic or Confusion	1475
M. Abolafia A. L. Kafka	Toward a Measure of Socio-Seismicity	1489
E. Kuribayashi T. Tazaki	An Evaluation Study on the Distribution of Property Losses Caused by Earthquakes	1499
H. C. Cochrane	Potential for Inflated Building Costs after Disaster	1511
R. Themptander	Earthquake and Insurance	1525
D. R. Nichols R. A. Matthews	The U.S. Geological Survey's Role in Geologic-Related Hazards Warning	1531

Index of Authors