the CUREe Symposium in Honor of George Housner

October 27 and 28, 1995
Pasadena, California

1941, "Response of an Oscillator to Arbitrary Ground Motion"
1947, "Correlation of Tension Creep Tests with Relaxation Tests"
"Characteristics of Strong-Motion Earthquakes"
"Ground Displacement Computed from Strong-Motion Accelerograms"
"Report on Research in Engineering Seismology"
1948, "The Estimation of Linear Trends"
1949, "Analysis of Earthquake Records with the Electric Analog Computer"
Applied Mechanics-Static
"Current Practice in the Design of Structures to Resist Earthquakes"
1950, Applied Mechanics-Dynamics
1951, "Spectrum Analyses of Strong-Motion Earthquakes"
1952, "Bending Vibrations of a Pipeline Containing Flowing Fluid"
"The Tehachapi Earthquake of July 21, 1952"
"Response of a Structure to an Explosive-Generated Shock"
"Spectrum Intensity of Strong-Motion Earthquakes"
1953, "A Dynamic Test of a Four-Story Reinforced Concrete Building"
"Ground Shock and Building Motions Produced by a Quarry Blast"
1954, "Earthquake Pressures on Walls of Fluid Containers"
1955, "Properties of Strong-Motion Earthquakes"
"The Design of Structures to Resist Earthquakes"
1956, "Limit Design of Structures to Resist Earthquakes"
1957, "Behavior of Structures in Earthquakes"
"Dynamic Pressures on Accelerated Fluid Containers"
"Interaction of Building and Ground During an Earthquake"
"Le calcul des ouvrages resistant aux tremblements de terre"
1958, " Accelerometer Data from 1957 San Francisco Earthquake"
"Effect of Torsional Oscillations on Earthquake Stresses"
"The Mechanism of Sandblows"
"The Port Hueneme Earthquake of March 18, 1957"
"Destructive Earthquakes and Earthquake Resistant Design"
1960, "White Noise Representation of Earthquakes"
"Design of Nuclear Power Reactors Against Earthquakes"
"The Plastic Failure of Frames During Earthquakes"
1961, "Integrated Velocity and Displacement of Earthquake Ground Motion"
"Vibration Tests of the Encino Dam Intake Tower"
1962, "Effect of Structure and Foundation Interaction"
"Vibrations of Linearly Tapered Cantilever Beams"
"Dynamics," Handbook of Engineering Mechanics
"Fundamentos de Ingenieria Sismica"

"Strong Ground Motion," "Design Spectrum," Earthquake Engineering
1970, " Nuclear Power Plants and Earthquakes"
"Analysis of Ground Motion at San Onofre Generating Station"
"Numerical Model for Tsunami Run-up"
"Some Special Problems in Earthquake Engineering"
"Calculation of Surface Motions of a Layered Half-Space"
"Seismic Events at Koyna Dam, Rock Mechanics-Theory and Practice"
Chapters 4 and 5, Handbook on Earthquake Engineering
1971, "Earthquake Research Needs for Nuclear Power Plants"
"Lessons from the 9 February 1971 San Fernando, California, Earthquake"
1972, "Conclusions," "Ground Motions," Alaska Earthquake of 1964
"Earthquake Ground Motion"
"The San Fernando Earthquake"
1973, "Earthquake-Resistant Design of High-Rise Buildings"
"Summary and Recommendations: Engineering"
"Nukleer Santrallerin Depremlere Karsi Hesab"
Engineering for Earthquakes
"Problems in Seismic Zoning"
1975, "Earthquake Ground Motion and Response of Structures"
"Measures of Severity of Earthquake Ground Shaking"
"Dynamic Responses of 6 Multistory Buildings "
1976, "Engineering Mechanics and Engineering"
"Research for Minimizing the Impact of Earthquakes on Cities"
"Earthquake Damage and Earthquake Protection"
1977, "Oroville Reservoir and the Earthquakes of August 1, 1975"
"Observed Changes Periods of Vibration of a Steel Frame Building"
"The Capacity of Extreme Earthquake Motions to Damage Structures"
"Seismic Design of Dams," Handbook of Dam Engineering
1978, " Ambient Vibrations of Full-Scale Suspension Bridges"
"Statistics of Pulses on Strong Motion"
"A Challenge to Earthquake Research"
"Hydraulic Perpetual Motion Machine?"
1979, "Vibration Tests of Full-Scale Liquid Storage Tanks"
"Earthquake-Resistant Design Criteria for Major Projects"
"Earthquakes and Earthquake Engineering"
"Dynamic Characteristics of Liquid Storage Tanks (I) and (II)"
1980, "The Momentum Balance Method in Earthquake Engineering"
"A Selection of Important Strong Motion Earthquake Records"

CUREe

California Institute of Technology 1891

CALIFORNIA UNIVERSITIES for RESEARCH in EARTHQUAKE ENGINEERING

California Universities for Research in Earthquake Engineering (CUREe) is a non-profit organization established in 1988 to enable the capabilities of its member universities to be efficiently coordinated on earthquake research problems. The university members of CUREe are:

CALTECH STANFORD BERKELEY DAVIS IRVINE LOS ANGELES SAN DIEGO USC

The purposes of CUREe are:

- identify new ways earthquake research can produce solutions to earthquake problems
- promote and perform research related to earthquake engineering and related disciplines
- establish and manage research consortia and cooperative programs
- establish national and global research relationships
- serve the educational needs of faculty and students in the earthquake field, as well as being of service to practitioners and the public.

Recent and current projects include: NSF-funded activities of the US Panel on Active Control; participation in the SAC Joint Venture (SEAOC-ATC-CUREe) Steel Program as the Joint Venture partner responsible for analytical and experimental applied research investigations; FEMA-funded Northridge Research Coordination Project; joint industry/university research with Kajima Corporation on various advanced research; review of research results for the California Seismic Safety Commission.

ACKNOWLEDGMENTS

The Caltech Organizing Committee for this event was:
Professor James Beck
Professor John Hall
Professor Robert Hanson
Professor Wilfred Iwan
Professor Paul Jennings
Professor Ronald Scott
Professor Robin Shepherd.

The CUREe individuals who helped organize the Symposium were:
Prof. Stephen Mahin, President
Wanda Realegeño, Office Assistant
Bob Reitherman, Executive Director
Parshaw Vaziri, Administrative Specialist.

Sharon Beckenbach, along with Denise Brown, of the Civil Engineering departmental office of Caltech, assisted with many Symposium arrangements and with coordination and communication between Caltech and CUREe. The following Caltech students helped staff the registration desk at the Symposium: Anders Carlson, Eduardo Chan, Wenshui Gan, Andrew Gibson, Ching-Tung Huang, Ayhan Irfanoglu, David Polidori, Luo-jia Wang, Chi-Ming Yang, and Weidon Zhu.

The assistance of the following organizations is gratefully acknowledged for locating and providing photographs used in this program: the Earthquake Engineering Research Institute; Institute Archives, California Institute of Technology; Earthquake Engineering Research Library, California Institute of Technology; Public Relations Office, California Institute of Technology.

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Saturday, October 27, 1995

Program Schedule

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INTRODUCTION
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S. Mahin	*Welcome From CUREe*

The Housner Years I
8:50 am

Session Chair: D. Hudson

R. Clough	*The Early Years of Earthquake Engineering*
R. Johnston	*Structural Engineering: Exciting Past, Demanding Future*
N. Nigam	*Inelastic Behaviour of Ductile Structures in Aseismic Design*
T. Paulay	*George Housner and the International Association for Earthquake Engineering*

Morning Break
10:00 am

The Housner Years II
10:30 am

Session Chair: J. Hall

A. Abdel-Ghaffar	*Cable-Supported Bridges and Earthquakes: Recent Developments Toward the 21st Century*
J. Roberts	*The Caltrans Years*
V. Persson	*Earthquake Engineering for the California State Water Project and Safety of Dams*

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T. Heaton	*Near-Source Ground Motions from Large Earthquakes*
I. Idriss	*Are Earthquake Ground Motions Affected by the Local Site Conditions?*

FRIDAY AFTERNOON, OCTOBER 27, 1995

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Simulation of Structural Behavior
2:15 pm
Session Chair: J. Penzien

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N. Priestley	*The Role of Large-Scale Structural Testing in Earthquake Engineering*

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Design and Performance Criteria
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L. Esteva	*Ground Motion and Codes: On the Formulation and Calibration of Site Response Spectra for Seismic Design in Mexico City*
J. Moehle	*Performance Based Seismic Design*
H. Shah	*Seismic Risk Analysis and Seismic Risk Management: Half a Century of Evolution*

Audience Questions and Comments
4:45 pm

FRIDAY EVENING, October 27, 1995

Reception
the Athenaeum, California Institute of Technology
5:45 pm - 9:00 pm

hosted cocktails and buffet, chamber music

buses will circulate between the hotel and the Athenaeum from shortly after 5:00 pm until 9:00 pm

the Athenaeum is located at the corner of California Street and Hill Street

SATURDAY MORNING, OCTOBER 28, 1995

Research into Practice
8:30 am
Session Chair: G. Hart

D. Abrams	*An Assessment of Earthquake Engineering Research and Testing Capabilities in the United States*
S. Mahin	*The SAC Steel Project and Developments in the United States*
H. Krawinkler	*Inelastic Design Considerations: From Research into Practice*

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F. Seible	*Bridge Retrofit Research and Implementation in California*
M. Haroun	*Seismic Analysis of Tanks: From Housner's Pioneering Study to Today's State of Knowledge*
A. Chopra	*Earthquake Analysis, Design and Safety Evaluation of Concrete Dams*
W. Hall	*Nuclear Power Plants and Nuclear Production Facilities*

SATURDAY AFTERNOON, OCTOBER 28, 1995

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Luncheon Speaker: F. McClure

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J. Yao	*Trends and Directions of Civil Engineering Education*
R. Hanson	*Earthquake Response/Recovery or Earthquake Mitigation: What Should Be Done and Who Should Pay For It?*

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2:55 pm

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C. Poland	*SEAOC's Vision 2000: A Conceptual Framework for Performance-Based Seismic Engineering*
R. Wright	*Collaborations for Earthquake Loss Reduction*
K. Toki	*Midterm Report of the International Decade for Natural Disaster Reduction*

Closing
4:35 pm
Session Chair: W. Iwan

	Audience Questions and Comments
G. Housner	*Closing Remarks*

Abstracts and Photos of Speakers and Session Chairs

Session:
Introduction

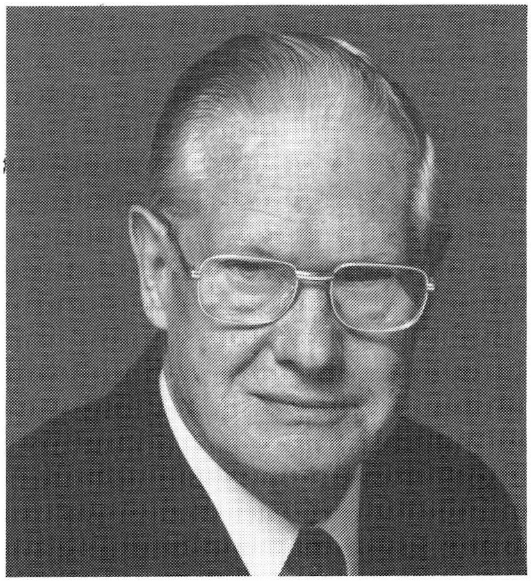
Paul C. Jennings

*Professor of Civil Engineering
and Applied Mechanics
California Institute of Technology*

Professor Jennings will welcome the participants on behalf of Caltech

Professor Stephen Mahin will welcome the participants on behalf of CUREe. His photo and abstract, "The SAC Steel Project and Developments in the United States," appear later in the program under the session "Research into Practice"

Session:
The Housner Years I

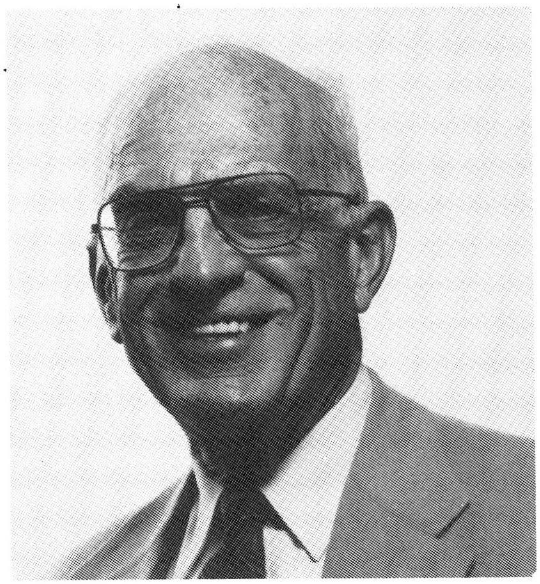


Donald E. Hudson

Professor Emeritus
Department of Mechanical Engineering and Applied Mechanics
California Institute of Technology

The Housner Years: Introductory Remarks

In this presentation, an overview is given of the early career of George Housner in earthquake engineering, starting with his graduate student years, by one who shared these student experiences. The situation at Caltech when Housner began his studies is reviewed, and it is shown that his Ph.D. thesis on "An Investigation of the Effects of Earthquakes on Buildings" was able to combine in a very effective way much of the meager information on the subject which was then available. Housner was able in that 1941 thesis to arrive at a number of far-reaching conclusions about ground motion that have withstood the test of time. The thesis also included a complete mathematical analysis of the response of shear and bending structures with a flexible first story to earthquake excitations, and a study of damping in structures caused by the propagation of elastic waves in the earth produced by foundation movements. An aspect of Housner's early career which is perhaps not well known was his early efforts at developing and deploying strong motion instrumentation. These efforts resulted in the first commercially available strong motion accelerograph, and in the installation of these devices at sites which produced such key accelerograms as the Parkfield array accelerograms, and the Pacoima Dam record during the San Fernando earthquake.



Ray W. Clough

Nishkian Professor of Structural Engineering, Emeritus

University of California at Berkeley

The Early Years of Earthquake Engineering

It may be argued that earthquake engineering began with the strong-motion instrumentation program of the U.S. Coast and Geodetic Survey. Certainly, effective earthquake-resistant design was dependent on having reliable information about the seismic input to which structures might be subjected. Thus, it is reasonable to designate the Advisory Committee on Engineering Seismology (ACES)—which advised the USCGS on the requirements for instruments to record earthquake motions and on the most appropriate places to locate these instruments—as the group which initiated the earthquake engineering field.

In this paper the successive stages of development of earthquake engineering will be described—from its initiation by the ACES, through the formation of the EERI and subsequently the IAEE, which was responsible for holding the sequence of World Conferences on Earthquake Engineering at four year intervals for the past 40 years.

Roy Johnston

Consulting Structural Engineer
Brandow & Johnston Associates

Structural Engineering: Exciting Past – Demanding Future

The practice of structural engineering has had an exciting past and will have a demanding future. This is particularly true for the seismic design of tall buildings. Through the years, there have been changes in the perception of the magnitude of the earthquake risk and in engineering analysis and procedures, coping with what may be called an acceptable risk. The process includes the representation of the ground motion, a conceptual and schematic plan, mathematical analysis and detailed design, and the observation and verification of the construction.

Navin C. Nigam
Vice-Chancellor and Professor
Goa University, India

Inelastic Behaviour of Ductile Structures in Aseismic Design

In the first World Conference on Earthquake Engineering held in 1956, George Housner introduced the concept of inelastic design based on energy input to a structure during an earthquake and its capacity to dissipate energy while undergoing inelastic deformations. Later, in a seminal paper (ASCE, 85EM4, 1959), Housner explained the anomalies in the response of structures during past earthquakes, and the significance of inelastic deformations in the aseismic design of ductile structures. Housner's pioneering work, the work of his students and other researchers, has formed the basis for the evolution of the present earthquake resistant design philosophy, namely, elastic behavior for frequent small earthquakes, 'limited' inelastic deformation for moderate earthquakes and 'large plastic deformation without collapse' for infrequent large earthquakes. Recent developments and the present status of research on inelastic behavior of structures is reviewed.

Thomas Paulay

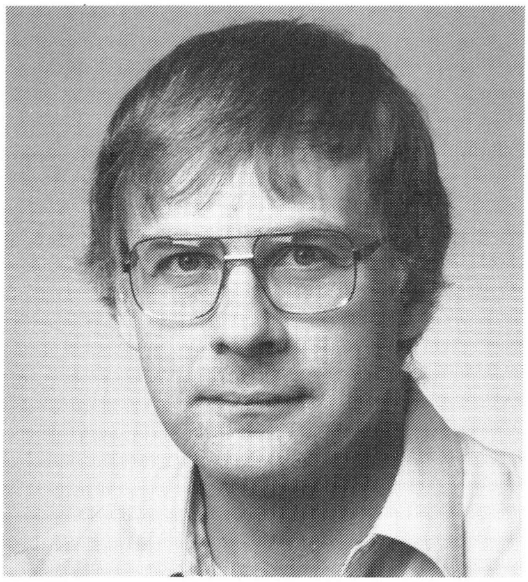
Emeritus Professor of Civil Engineering
University of Canterbury
Christchurch, New Zealand

President of the International Association for Earthquake Engineering

George Housner and the International Association for Earthquake Engineering

A brief record of the role of George Housner in the founding and expansion of the International Association for Earthquake Engineering over close to four decades is presented. A lighthearted description of a unique seismic response control system, a subject known to be of considerable appeal to George Housner, conceived at the Swiss Federal Institute of Technology in Zurich and studied further at the University of Canterbury with respect to its potential for application to reinforced concrete buildings, will be illustrated.

Session: The Housner Years II



John F. Hall

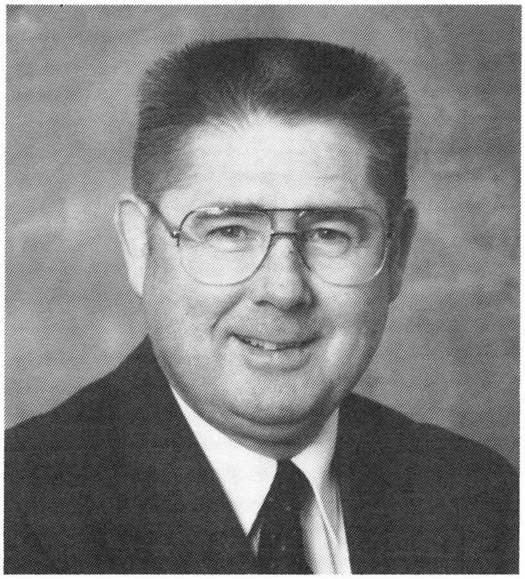
Associate Professor of Civil Engineering
California Institute of Technology

Professor Hall will chair the session: The Housner Years II

Ahmed M. Abdel-Ghaffar
Professor, Department of Civil Engineering
University of Southern California

Cable-Supported Bridges and Earthquakes: Recent Developments Toward the 21st Century

Recent developments and general characteristics of seismic behavior of modern cable-stayed bridges and conventional suspension bridges are presented. Large-scale recently completed or under-construction projects of these long-span bridges are introduced. Parameters affecting their free-vibration and seismic response are discussed. Among these factors are: three-dimensionality, of both the earthquake ground motions at the supports and the structural modeling; nonlinearities; cable-vibration; structural connections; energy absorption (damping augmentation) devices at critical connections; the spatial variation of ground motion; and finally the feasibility and effectiveness of structural control with its passive, hybrid, and active categorization. Examples from Japan, Europe and the U.S. are presented. The American example is the well-instrumented, well-studied and well-shaken (by two moderate earthquakes) suspension bridge (the Vincent Thomas Bridge at Los Angeles harbor which was strongly shaken by the October 1, 1987 ($M_L = 5.9$) Whittier, California earthquake and more recently by the January 17, 1994 ($M_L = 6.8$) Northridge earthquake. Recommendations are made for strengthening and retrofitting of existing bridges; moreover, seismic counter measure devices of some international bridges are shown.



James E. Roberts
Chief Structures Engineer
California Department of Transportation

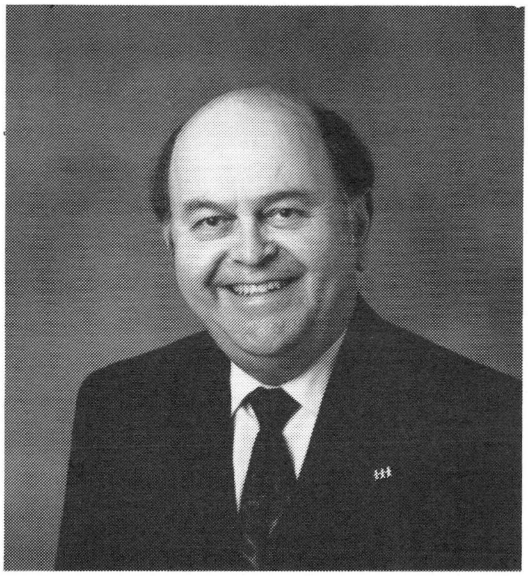
The Caltrans Years

George Housner has had a profound influence on the California Department of Transportation since the San Fernando Earthquake of February 9, 1971. He was already known as a leader in earthquake engineering, and his influence on revised seismic design practice and specifications for bridges helped launch a revolutionary change in bridge seismic design. The first use of improved seismic analysis and design for a major Caltrans bridge was on the high-level crossing of the New Melones Reservoir on State Highway 49. Caltrans designers used "Housner's Response Spectum" in the dynamic analysis of that bridge in early 1971.

The most important contributions made to bridge engineering and to Caltrans occured after the disastrous October 17, 1989 Loma Prieta Earthquake. In early November, 1989, Governor George Deukmejian appointed Dr. Housner as Chairman of the "Governor's Board of Inquiry" to investigate the causes of bridge failures and recommend corrective actions to insure future public safety. The Board of Inquiry issued its final report with the warning title, "Competing Against Time" on June 1, 1990. Since then, Caltrans staff engineers, consulting firms, independent peer review teams, and university researchers have cooperated in an unprecedented program of bridge seismic retrofit strengthening to meet the challenge presented in that report. The State Legislature, the California Transportation Commission, and Department of Transportation Management designated this program the number one priority for budget allocation. Dr. Housner agreed to Chair the Caltrans Seismic Advisory Board, and it has been an invaluable asset in reviewing our criteria, design specifications, and design procedures. In many instances, the Advisory Board has positively influenced management decisions to support a strong research program to support seismic design and retrofit, through its recommendations to the Caltrans

Director. Dr. Housner recently resigned from the Advisory Board after serving for five years as Chairman.

The success of the Bridge Seismic Retrofit program and the success of future seismic design for California bridges is based, to a large degree, on the accelerated and "problem-focused" seismic research program. That program has been supported at a level more than ten times the pre-Loma Prieta level of support for all bridge research. We have been able to sustain the necessary high level of research support over the past five years, and we have a commitment for that level of support for the foreseeable future.



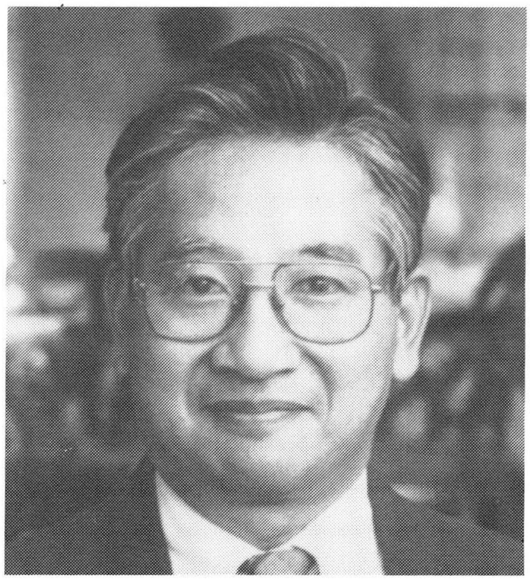
Vernon H. Persson

Chief, California Dept. of Water Resources
Division of Safety of Dams

Earthquake Engineering for California's State Water Project and Safety of Dams

The Department of Water Resources designed and constructed the State Water Project, a major civil engineering work which transfers water from Northern to Southern California, a distance of over 600 miles. Those in charge had the foresight to employ advisors with special expertise. Dr. George Housner served as a consultant to DWR on the Earthquake Analyses Board from its inception in 1962. He and his colleagues provided earthquake engineering oversight to DWR staff during design and construction of the three billion dollar project. Dr. Housner played a major role in reviewing criteria and facility performance after the 1971 San Fernando earthquake and the 1975 Oroville earthquake. DWR's Division of Safety of Dams has a separate regulatory function for providing supervision to California dam owners and their engineers with regard to safe dams. For many years, Division management has used the EAB to advise them on especially difficult projects, the seismic review of Auburn Dam being the most prominent. Dr. Housner and his long time colleagues Dr. Allen and Dr. Bolt served on the EAB from 1962 to 1994 at which time Dr. Housner stepped down from the Board after 32 years of exemplary service to DWR. This presentation will expand on the many important roles he held and the effect of his sound advice on water facilities throughout the State.

Session: Ground Motion



Hiroo Kanamori

John E. and Hazel S. Smits Professor of Geophysics
California Institute of Technology

Professor Kanamori will chair the session: Ground Motion

Clarence Allen

Professor of Geology and Geophysics, Emeritus
California Institute of Technology

Seismic Hazard In Southern California

During the George Housner years, publicized estimates of seismic hazard in Southern California have varied markedly. Statements by eminent scientists have ranged from "the region is one where long accumulations of strain are probably prevented by frequent, slight releases" to "in southern California there will be a severe shock which is more likely to come in three years than in ten." George Housner himself has often joked about the diverse and confusing meanings of "active fault" as promulgated by various investigators, but he has actively encouraged geological and geophysical seismic hazard studies, particularly those of practical use to engineers.

In actuality, there has been a relatively steady progress in our understanding of the earthquake potential in Southern California, starting with studies of the 1906 earthquake, which recognized that its culprit, the San Andreas Fault, also extended through Southern California. Geodetic observations over the years, although sometimes misinterpreted, have been particularly important in establishing the rates of tectonic deformation and in identifying the principal seismic source areas. If one had to name the four most significant advances in seismic hazard assessment in Southern California during the Housner years, I would judge them to be (1) the development and use of paleoseismic techniques in identifying the times and natures of prehistoric earthquakes and in determining long-term fault slip rates, (2) the innovative use of seismological data, particularly from a new generation of wide-band instruments, in understanding the physics of the fault-rupture process, (3) the recognition of blind thrusts as significant seismic sources, and (4), the use of a new generation of geodetic instruments, the Global Positioning System (GPS), in quickly and cheaply delineating the ongoing crustal deformations that cause earthquakes.

Our greatest challenges at the present time are twofold: In a specific sense, it is critical to understand the seismogenic potential of the numerous blind thrusts that underlie many urbanized parts of Southern California. And in a more general sense, we must work to better quantify seismic hazard for effective and realistic use by engineers, planners, and public officials who must balance the costs, benefits, and priorities of earthquake mitigation.

Thomas Heaton

Faculty Associate in Geophysics

California Institute of Technology

Near-Source Ground Motions from Large Earthquakes

Ground shaking is often quite violent close to large earthquakes; of more than 30 recordings at distances of less than 5 km from earthquakes with magnitudes of 6.5 or greater, the median peak acceleration and velocity are 0.85 g and 105 cm/sec, respectively. Unfortunately, near-source ground motions have not yet been recorded for really large earthquakes ($M \geq 7.5$); the 1992 M 7.3 Landers earthquake and the 1978 M 7.4 Tabas, Iran, earthquake are the largest earthquakes for which near-source records are available. The Lucerne recording of the Landers earthquake was taken at a distance of 1 km from the fault rupture and the peak acceleration, velocity, and displacement were 0.90 g, 142 cm/sec, and 255 cm. The Tabas recording was at a distance of 3km from the rupture and the peak acceleration and velocity were 0.92g and 125 cm/sec.

Near-source peak displacements are often comparable to the slip that occurs on faults. As earthquake magnitude grows, the average fault slip grows and so does peak displacement. It is very difficult to put an upper limit on displacement; slip on the San Andreas fault reached as much as 10m in the 1857 earthquake. Fortunately, it seems unlikely that peak acceleration continues to grow in the same way that displacement does. Nevertheless, it seems likely that the peak accelerations in very large earthquakes will be at least as large as the already strong values recorded in smaller earthquakes, but they will last longer. Near-source peak velocities for very large earthquakes will almost certainly exceed 100cm/sec, but it is not known just how large they can become for a really large earthquake.

I.M. Idriss

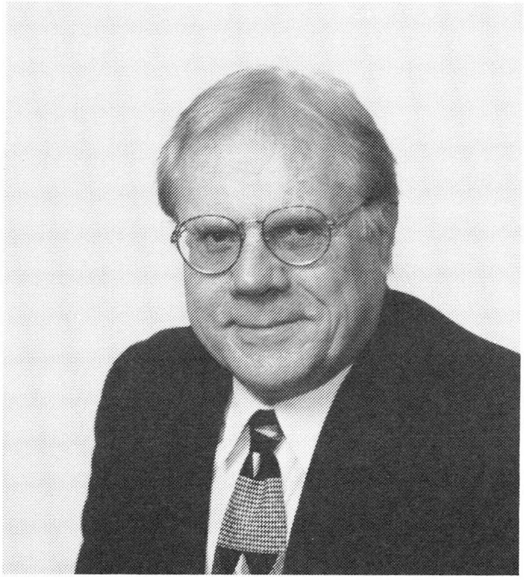
Professor, Department of Civil Engineering
University of California, Davis

Are Earthquake Ground Motions Affected by the Local Site Conditions?

The damage resulting from earthquakes may be influenced in a number of ways by the local site conditions in the affected area. Where the damage is related to a gross instability of the soil, resulting in permanent movements of the ground surface, association of the damage with the local site conditions is readily apparent. The influence local site conditions may exert on the characteristics of earthquake ground motions, however, is not as apparent. Examination of motions recorded during earthquakes over the past 30 years indicates that local site conditions can have varying effects on these motions. The earthquake ground motions recorded during numerous earthquakes (such as Parkfield, San Fernando, Imperial Valley, Coalinga, Palm Springs, Whittier, Loma Prieta, Landers, Big Bear and Northridge) are used to assess these effects on accelerations, velocities, displacements, and spectral ordinates.

The results of these assessments will by summarized at this symposium.

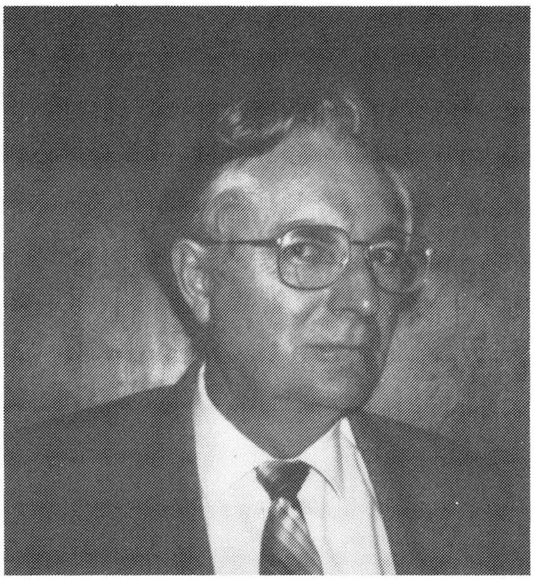
Session: Simulation of Structural Behavior



Joseph Penzien

Professor of Civil Engineering, Emeritus
University of California at Berkeley

Professor Penzien will chair the session: Simulation of Structural Behavior

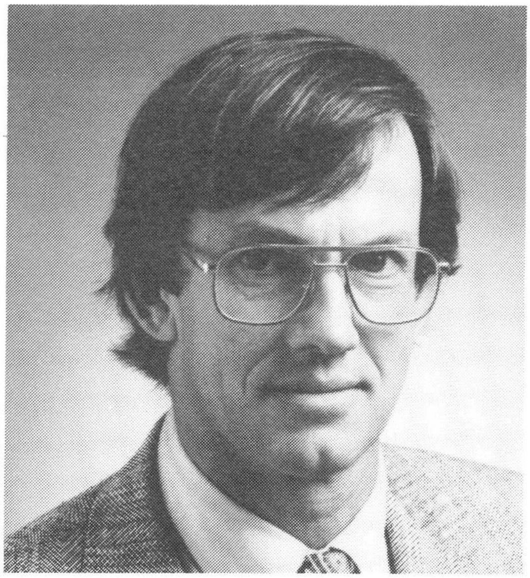


Edward L. Wilson

T.Y. and Margaret Lin Professor in Engineering, Emeritus
University of California at Berkeley

Linear and Nonlinear Seismic Analysis of Three Dimensional Structural Systems

The development, during the past forty years, of computational methods for the simulation of the dynamic behavior of complex structural systems will be summarized. In the early days of earthquake engineering, the Rayleigh-Ritz method of dynamic analysis was used extensively to calculate approximate solutions. With the development of high-speed computers, the use of exact eigenvectors replaced the use of Ritz vectors as the basis for seismic analysis. It will be illustrated that Load-Dependent Ritz vectors can be used effectively in modern seismic analysis of both linear and nonlinear structures. The new modified Ritz method produces more accurate results, with less computational effort, than the use of the exact eigenvectors. In addition, the importance of creating realistic computer models and the need for experimental verification will be emphasized.



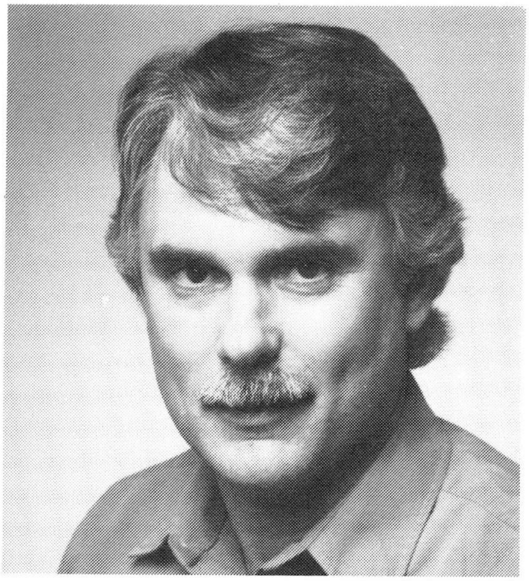
M.J.N. Priestley
Professor of Structural Engineering
Department of AMES
University of California, San Diego

The Role of Large-Scale Structural Testing in Earthquake Engineering

Proof tests have always had a special place in structural design, and are routinely employed in Japan as an adjunct to the design process. The advantages of experimental research at as large a scale as possible would seem to be obvious, and following a decline in the perceived significance of experimental tasks in the 1960s and 70s, there is now a resurgence of interest in large-scale seismic testing in the USA, with many large structural testing laboratories being constructed in recent years.

The paper will examine this trend, which has applied not only to the research field, but also to proof testing for both new and existing designs. Reasons will be examined with reference to analytical developments which might have been expected to make structural testing less attractive. The paper will be illustrated by recent examples from seismic research, design, and assessment projects, and some of the efforts to improve load simulation will be emphasized.

Session:
Design And Performance Criteria



James L. Beck

Associate Professor of Civil Engineering
California Institute of Technology

Professor Beck will chair the session: Design and Performance Criteria

Luis Esteva
Institute of Engineering
National University of Mexico

Ground Motion and Codes: On the Formulation and Calibration of Site Response Spectra for Seismic Design in Mexico City

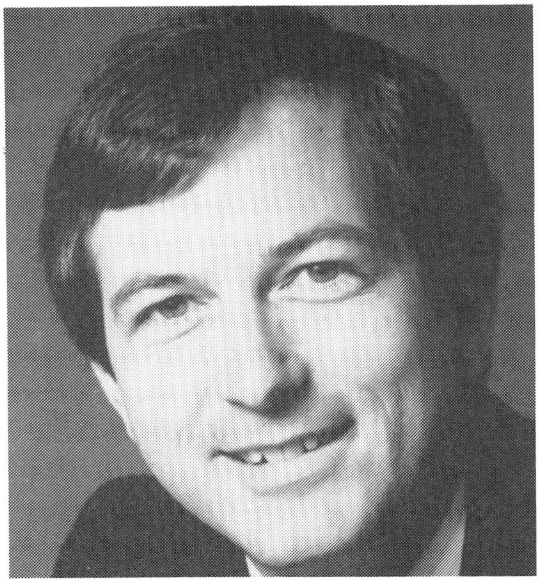
A critical account is presented of the revision process of seismic design response spectra in Mexico City after the 1985 Michoacan earthquake. Two parallel lines of development are studied, within the probabilistic framework of structural reliability and seismic risk analysis: a) the formal mathematical approach, and b) the semi-empirical approach, in a great measure relying on expert opinions based on the observed behavior of a large number of structures in different parts of the city during the earthquake.

After revising the microzonation of the city, a set of design response spectra were proposed, consistent with those calculated from the ground motion records obtained in 1985 at different sites in the Valley of Mexico, on different soil conditions, as well as with some theoretical results produced by the simple 1d model of vertically traveling shear waves on stratified deposits.

Following the installation of strong ground motion recording instruments or arrays at a large number of sites in the Valley, a substantial number of records for a wide variety of soil conditions have been obtained during the last few years. Those records have been used to obtain transfer functions from Fourier amplitude spectra on firm ground in the Valley of Mexico to their counterparts on soft soil. In spite of the significant inconsistencies between observed and calculated ground motion on soft soil, in particular regarding the duration of the intense phase of the motion, linear response spectra derived from the recorded ground motions are not very different.

from those derived from theoretical models. With a few exceptions, the empirical transfer functions are not very sensitive to earthquake magnitude and source distance nor to the azimuth of the arriving waves. To what extent the differences in duration between observed and theoretically derived records affect the nonlinear response spectra has not been established yet.

The availability of sets of several records at many locations in the city, on different soil conditions, has stimulated interest in the development of criteria for determining site specific response spectra for seismic design, which make use of the empirical transfer functions mentioned above. This has created the need for criteria and methods to determine consistent-reliability design spectra, as well as to account for the uncertainties associated with the structural parameters. The discussion of this problem ends the presentation.



Jack Moehle

Professor, Civil Engineering Department,
University of California, Berkeley

Director, Earthquake Engineering
Research Center

Performance Based Seismic Design

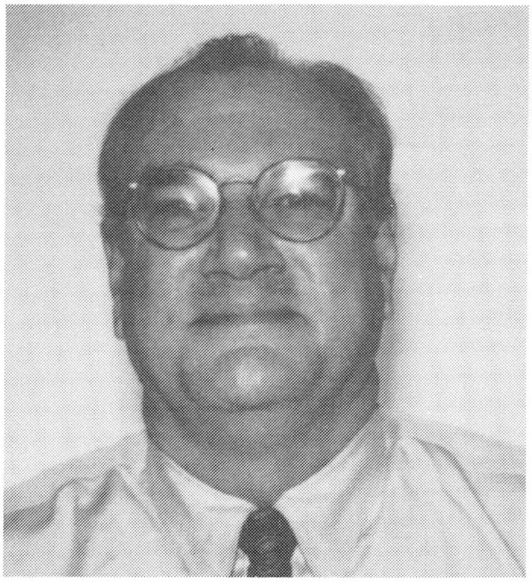
Current seismic design codes and practices were written to achieve a loosely defined objective of providing life safety. While this objective appears to have been reasonably well achieved, two major shortcomings are recognized. The first shortcoming lies in the realization, made clear by recent earthquakes, that structures designed to provide basic life safety may suffer extensive structural and non-structural damage, often resulting in huge economic losses for the owner and the community. The second shortcoming is that our seismic design measures are very unevenly applied; some structures are subject to costly over-design, while others suffer large losses because designs are not properly related to performance needs and expectations. Recent years have witnessed a surge in organized efforts to develop performance based seismic design procedures, including ATC-32 for bridges, SEAOC Vision 2000 and FEMA/EERC Performance Based Design for new buildings, and ATC-33 and ATC-40 for existing hazardous buildings. Writing provisions is one thing. Writing provisions that are demonstrably effective and that will be used by the public is another. This paper investigates a range of issues surrounding the holy grail of performance based seismic design.

Haresh C. Shah
Obayashi Professor of Engineering
Department of Civil Engineering
Stanford University

Seismic Risk Analysis and Seismic Risk Management: Half a Century of Evolution

In this presentation, we will review the evolution of philosophy and methods for assessing and managing seismic risk during the past fifty years. Major accomplishments of science and engineering toward understanding this problem during this period will be highlighted. Recent contributions from social sciences in understanding the complex interplay of nature, technology, socioeconomic development, and human activities toward increasing or mitigating seismic risk will be discussed. We will present the contributions of Professor Housner and his students in this discipline. Finally, some shortcomings of current work and future challenges in this field will be summarized.

Session:
Research Into Practice



Gary C. Hart

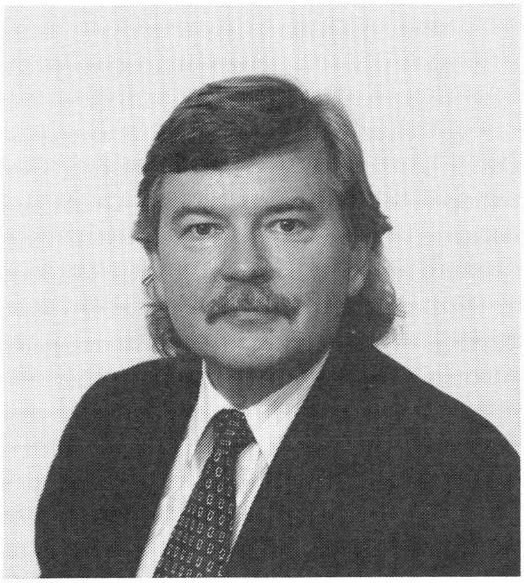
Professor of Civil Engineering
University of California at Los Angeles

Professor Hart will chair the session: Research into Practice

Daniel P. Abrams
Professor of Civil Engineering
University of Illinois at Urbana-Champaign

An Assessment of Earthquake Engineering Research and Testing Capabilities in the United States

Recommendations made over the last twenty-two years for improving experimental capabilities in the United States are briefly summarized as a preface to a presentation of findings from a recent workshop on the subject. The workshop was held in response to a need expressed in the NEHRP Reauthorization Act of 1994 for the President to conduct an assessment of earthquake engineering research and testing capabilities in the United States. With sponsorship of the National Science Foundation and the National Institute of Standards and Technology, the Experimental Research Committee of the Earthquake Engineering Research Institute held a meeting of the nation's top experimental researchers and earthquake engineers to offer their ideas and opinions on (a) the present state of research facilities, (b) the need for new facilities, (c) options for multinational cooperation, (d) projected costs for construction, (e) operation and maintenance of new research facilities, (f) options for funding of future experimental earthquake engineering research, and (g) the feasibility of developing a comprehensive national research program. Recommendations from the workshop on each of these topics are presented.



Stephen A. Mahin

Byron L. and Elvira E. Nishkian Professor of Civil Engineering
University of California at Berkeley

President, California Universities for Research in Earthquake Engineering

The SAC Steel Program and Guideline Developments in the U.S.

Many steel frame buildings suffered brittle fractures in their welded beam to column connections during the January 17, 1994 Northridge earthquake. Damage varied in intensity, from micro-cracking to complete fractures of beams or columns. Damaged structures were observed throughout the epicentral region, in old and new structures, in tall and short ones, both privately and publicly owned.

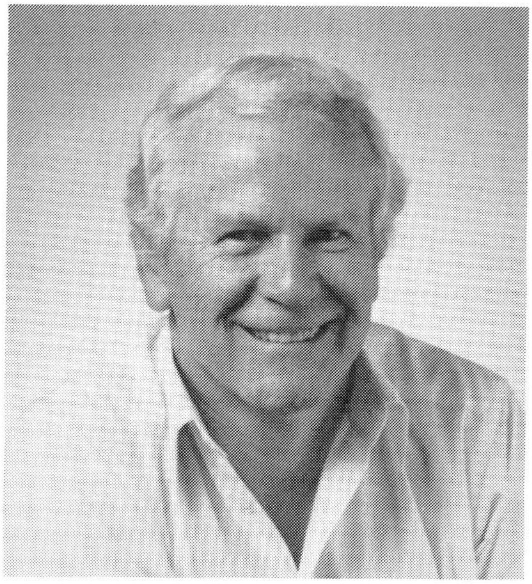
In the immediate aftermath of the earthquake, the California Office of Emergency Services initiated a program to reduce earthquake hazards in steel frame structures. The program was carried out by the SAC Joint Venture, comprised of the Structural Engineers Association of California, the Applied Technology Council, and the California Universities for Research in Earthquake Engineering. The Federal Emergency Management Agency (FEMA) significantly expanded the scope of this effort to include surveys of the performance of steel buildings, detailed analytical and experimental investigations of damaged and undamaged steel buildings, and assessment of the state of the art. In addition, a preliminary experimental investigation of full-size beam to column connections was conducted to examine the behavior of conventional pre-Northridge details and to validate the reliability of various recommendations for repairing or upgrading damaged connections and for constructing new ones.

The topical investigations conducted to date have been reviewed and used to develop *Interim Guidelines*. The *Interim Guidelines* contain:

- Information on damage to steel buildings during the Northridge earthquake
- A unified classification system for reporting damage
- Procedures for inspecting and evaluating structures to determine appropriate post-earthquake actions
- Procedures for repair and modification of damaged steel frames
- Procedures for design and construction of new steel frames
- Information on materials, welding, inspection and quality control

The *Interim Guidelines* suggest that historic practices used in the design and construction of welded steel moment frame structures do not provide adequate levels of reliability and safety and should not continue to be used. Following strong earthquake ground shaking, welded steel moment frames should be subjected to rigorous evaluations to determine the extent and implications of any damage sustained. Risk to public safety associated with continued occupancy of existing undamaged welded steel moment frame buildings is probably no greater than that associated with many other types of existing buildings with known seismic vulnerability.

A second three-year phase is about to begin with additional FEMA funding. It will enable the SAC Steel Program to conduct further investigations leading to more reliable and cost effective solutions to the steel problems revealed by the Northridge earthquake.



Helmut Krawinkler

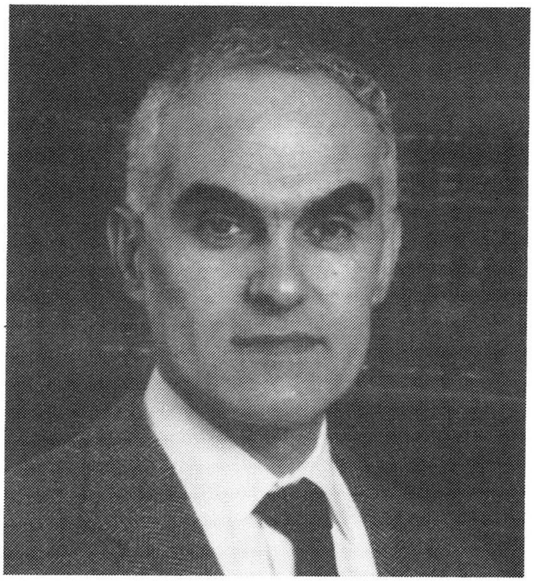
John A. Blume Professor of Engineering
Department of Civil Engineering
Stanford University

Inelastic Design Considerations: From Research Into Practice

Seismic design has been, and in most cases still is, based on purely elastic concepts. A few basic principles combined with much judgment are being used to define seismic design loads for which an elastic design is performed based on member forces (or stresses) and elastic stiffness. In parallel with elastic design go more than 30 years of research on inelastic behavior of structures, which has provided fundamental as well as detailed knowledge on dynamic and cyclic response characteristics of structures and their elements. As this knowledge finds its way into practice, and as the public, regulatory agencies, and the engineering profession request, or focus on, fulfillment of explicit performance objectives, the need is being recognized for a more realistic representation of actual physical phenomena in the seismic design and evaluation process. In severe earthquakes, in which life safety and collapse prevention become overriding performance objectives, inelastic considerations control seismic performance in most structures. In many cases, these considerations can not be represented adequately in elastic models.

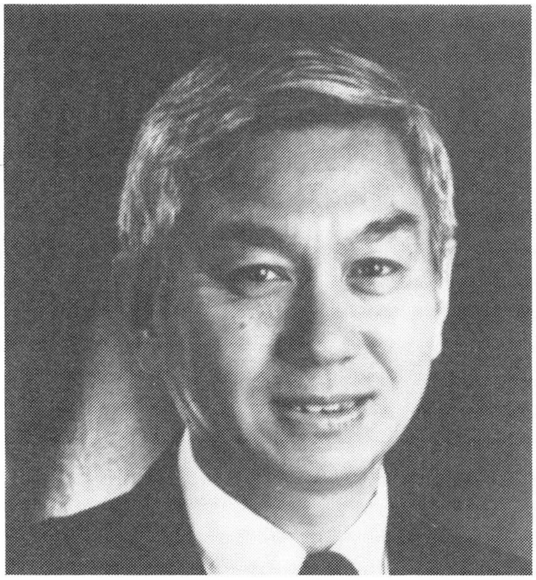
The presentation focuses on the following three related issues: (1) it summarizes research that provides the foundation for inelastic design considerations, (2) it summarizes ongoing professional efforts that focus on the explicit incorporation of inelastic concepts in the design process, and (3) it paints a subjective picture of the potential of a design methodology in which inelastic concepts are considered explicitly and comprehensively.

Session: Special Structures and Systems



Sami F. Masri
Professor of Civil Engineering
University of Southern California

Professor Masri will chair the session: Special Structures and Systems

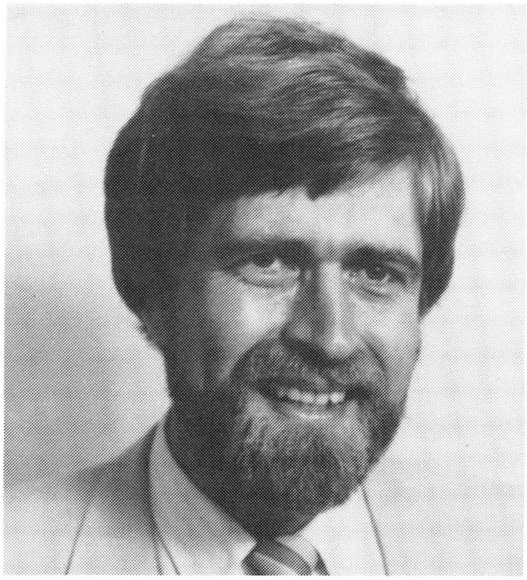


Tsu T. Soong

Professor, Department of Civil Engineering
State University of New York at Buffalo

Energy Concepts and Structural Control

This talk touches upon two areas of Professor Housner's contributions to earthquake engineering that have had a major impact on the earthquake resistant design and seismic retrofit of structures. These two areas are energy-based design concepts and structural control. Energy-based design philosophy has been largely responsible for the development of innovative structural control technologies and, as a result, considerable attention has been paid to passive and active structural control research in recent years. Passive control systems encompass a range of materials and devices for enhancing damping, stiffness, and strength and can be used both for new design and for rehabilitation of aging or deficient structures. In recent years, serious efforts have been undertaken to develop the concept of energy dissipation, or supplemental damping, into a workable technology. Active systems and some combinations of passive and active systems, so-called hybrid systems, are force delivery devices integrated with real-time processing evaluators/controllers and sensors within the structure. They must react simultaneously with the hazardous excitation to provide enhanced structural behavior for improved service and safety. Remarkable progress has been made in both areas of research and implementation. This talk presents an overview of some of the basic control concepts as applied to civil engineering structures and provides examples of current full-scale applications of these technologies.



Frieder Seible

Professor of Structural Engineering
Department of AMES
University of California, San Diego

Bridge Retrofit Research and Implementation in California

In direct response to recommendations in the Governor's Board of Inquiry report following the 1989 Loma Prieta earthquake, Caltrans has significantly expanded seismic retrofit research programs and accelerated bridge retrofit implementations over the past six years. The problem-focused research efforts that resulted from these Board of Inquiry recommendations are discussed by means of examples of experimental and analytical research, the resulting retrofit technology development, and examples of field installations. Examples presented will include, but not be limited to, the bridge column retrofit with steel and advanced composite jackets, the footing retrofit with reinforced concrete overlays and additional piles, the retrofit of the San Francisco Double Deck Viaducts, and the retrofit of flared bridge columns. The emphasis in the presentation will be on problem-focused research and retrofit technology development based on analytical models, laboratory component testing, and large scale prooftesting.

Medhat A. Haroun

Director, University of California Study Center in Cairo, Egypt

Professor, Department of Civil and Environmental Engineering University of California, Irvine

Seimic Analysis of Tanks: From Housner's Pioneering Study to Today's State of Knowledge

George Housner, as he has often done in many fields of earthquake engineering, has laid the foundation for the advancement of the seismic analysis of liquid storage tanks. In his pioneering work, some forty years ago, Housner developed a simplified method for the seismic analysis of rigid tanks which recognized that these systems have two distinct response characteristics: the impulsive (short period) components and the convective (long period) components. His method has formed the basis for the design of storage tanks for many years to follow and has served as the cornerstone for future advancements in the field. In the late seventies, the so-called Haroun-Housner mechanical model was developed to take into consideration the wall deformability of anchored tanks. Since Housner's original work, numerous enhancements of the analysis of tanks have been made, most notably, by Veletsos, Clough, Haroun, and their associates, to include explicitly tank flexibility, support effects, and various nonlinearities.

The most recent advancement in the seismic analysis of tanks has dealt with the nonlinear time-dependent response of unanchored ground-based tanks. For these tanks, the overturning moment caused by the hydrodynamic pressure tends to lift the shell off its foundation. Computer models capable of simulating this complex seismic behavior were developed taking into consideration large amplitude liquid sloshing and the geometric, material and contact nonlinearities of the tank shell and the base plate using the finite element method. The computer simulation included the following features: a variational principle that forms the basis for the numerical discretization of nonlinear fully-coupled liquid-structure interaction problems with free surface sloshing; an up-to-date finite element technique for the linearity; potential flow modeling using an efficient Eulerian finite element; free surface of the contact/uplift analysis by a Lagrange multiplier technique employed to enforce both displacement compatibility and force transmissibility constraints along the unknown contact surface; and an efficient time integration technique developed specifically to solve liquid-structure interaction problems.

The presentation includes a summary of the historical development of the seismic analysis of liquid storage tanks since Housner's pioneering work and it highlights the most recent advances in the field and their implications on enhancing seismic design procedures.

Anil K. Chopra

Johnson Professor of Civil Engineering
University of California at Berkeley

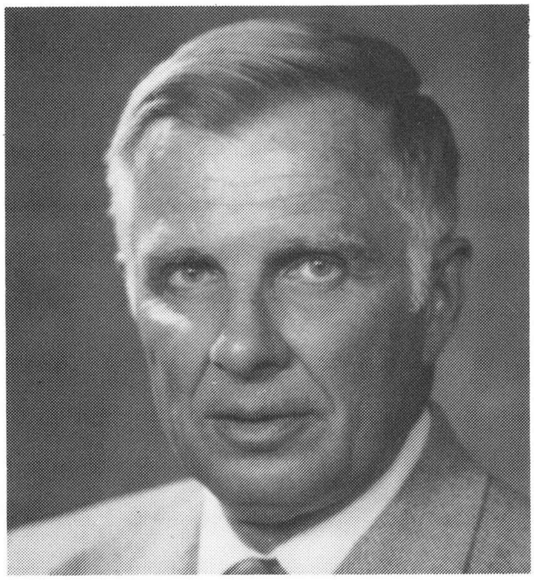
Earthquake Analysis, Design and Safety Evaluation of Concrete Dams

Progress in earthquake engineering can often be traced back to the damaging effects of earthquakes. Alarmed by the damaged school buildings during the 1933 Long Beach earthquake, the California Legislature passed the Field Act. The spectacular damage to the Olive View Hospital during the 1971 earthquake led to the stringent code for design of hospitals. The damage to freeway structures during the same earthquake prompted Caltrans to revise its design procedure and to develop retrofit concepts. These design and retrofit schemes were improved again after the experience with the performance of freeway structures during the 1989 Loma Prieta earthquake. Finally, the 1994 Northridge earthquake brought to the fore the concern about blind thrust faults and surprised the profession in that steel frame buildings are not as earthquake-resistant as we had presumed.

The 1967 Koyna earthquake was a watershed event in the history of earthquake engineering for concrete dams. A dam designed by standard procedures of the time had been structurally damaged during the earthquake, which surprised the dam engineering profession. This event inspired serious research on earthquake engineering for concrete dams. In 1970 George Housner wrote about the significance of the seismic events at Koyna Dam. Since then, over the past twenty-five years, earthquake analysis of dams has come a long way, advancing from rule-of-thumb methods to very simple pseudostatic analyses to procedures that recognize the dynamics of the dam-water-foundation rock system. It is the story of this progress that will be presented in this talk.

The current state of knowledge about earthquake response analysis of concrete dams will be summarized, along with its application to the earthquake-resistant design of new dams and to the seismic safety evaluation of existing dams. The limitations of the traditional analysis procedures will be identified, the factors that should be considered in dynamic analysis of dam-water-foundation rock systems will be discussed, and linear analysis procedures for simplified response spectrum analysis and refined response history analysis available to the profession will be summarized. The presentation will include examples of the application of these analysis procedures to seismic design and safety evaluation of dams.

Linear analyses of dams subjected to the very intense ground motions expected in highly seismic areas may indicate that the computed tensile stresses exceed the available tensile strength of concrete, indicating that the dam is likely to crack. Similar analyses of an arch dam may show that the tensile stresses in the arch direction exceed the compressive arch stresses prior to the earthquake, implying cyclic opening and closing of the vertical contraction joints during vibration. For these reasons nonlinear response of concrete dams has been a subject of increased research activity during recent years. However, the interpretation of the results of such analyses to predict the damage to a dam and to evaluate its safety remains a challenge, especially for government agencies responsible for dam safety. Additional research is needed to develop reliable methods for predicting damage to dams that experience intense earthquakes with spatial variability in ground motion along the canyon, as was the case at Pacoima Dam during the 1994 Northridge earthquake.



William J. Hall
Professor Emeritus of Civil Engineering
University of Illinois at Urbana-Champaign

Nuclear Power Plants and Nuclear Production Facilities

This talk begins with a brief description of George Housner's key role in the seismic design of special and commercial nuclear power plants, as well as nuclear production facilities. This "road map" of George's leading part in this effort is based on the speaker's personal knowledge, as well as deductive research on the matter. George Housner was the pioneer in developing seismic design criteria for such facilities, and in making the case for the importance of such design considerations.

There follows a brief history of the development of such facilities and systems, with particular emphasis on the advances that have been made in the field in the relatively short time it has been in existence. This section of the presentation leads naturally into some observations about current technical efforts in the United States directed toward reduction of cost of new commercial nuclear power plants, with the goal of bringing about a resurgence of interest in nuclear power as a major energy source. The talk concludes with some brief comments about the importance of interrelationships between technical and societal issues as they relate to nuclear matters.

Session: Looking To The Future I

Mihran S. Agbabian

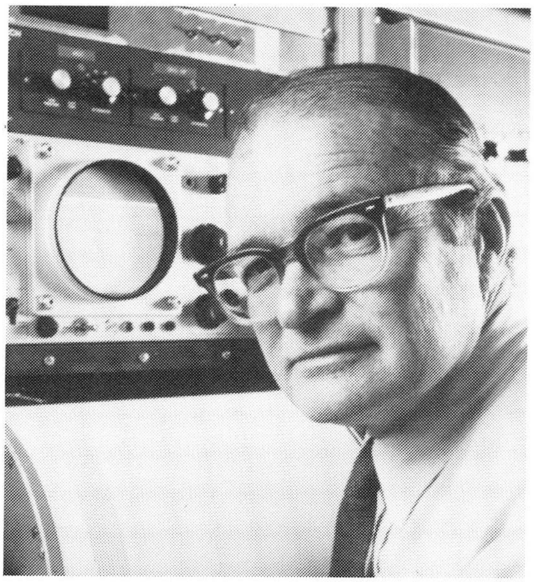
Professor Emeritus of Engineering
Civil Engineering Department
University of Southern California

Professor Agbabian will chair the session: Looking to the Future

Looking back at the Housner years is the way to chart the future of Earthquake Hazard Mitigation. "Back to the Future" is the best way to describe what we are discussing at this Symposium that honors George Housner.

Dr. Housner was a co-founder of the Earthquake Engineering Research Institute in 1949, with the goal of "the advancement of the science and practice of earthquake engineering, and the solution of national earthquake engineering problems." He has personally fulfilled this challenge and developed the state of the art more than anyone else in the scientific community. He took the leadership role in organizing the California Universities for Research in Earthquake Engineering, and in recent years became the principal advisor on the new technology of structural control. His publications, starting with "Characteristics of Strong-Motion Earthquakes" in 1947, have laid the foundation of the science of earthquake hazard mitigation.

There are now thousands of scientists and engineers who are building on the pioneering work of Housner. These persons are Housner's children. I say this by quoting a Russian scientist during the Soviet years who was visiting the United States in 1979 as the leader of the delegation of exchange scientists on "Construction in Seismic Regions." I heard him say to Dr. Housner, "We are all your children." There is no better testimony in honoring our father of earthquake engineering.



Bruce A. Bolt

Professor of Seismology (Emeritus)
Departments of Geology and Geophysics and Civil Engineering
University of California, Berkeley

Future Earthquake Education in the Earth Sciences

Geology and geophysics enter into earthquake hazard reduction (and hence earthquake engineering) because there is the need to specify earthquake source location, size, activity rate, mechanism, rupture process and so on. Seismology further has the responsibility of providing ways to construct appropriate seismic ground motions for structural design and hazard assessment. Many recent inferences, field measurements, and estimation procedures on these topics have not yet been worked through in the classroom. In the future, additional attention in text books and courses must be given to three-dimensional seismic wave propagation properties, including lateral refraction and scattering, together with better explanations of nonlinear wave interactions at the source and site.

New educational emphasis must be given to forensic earthquake studies so that more quantitative correlations can be made in practice between recorded seismic motions and observed intensity (in both surficial geology and engineered structures). Better understanding of formulating and working inverse problems is needed. Closer integration of courses in strong motion seismology and earthquake engineering must emerge if the full promise of cost-efficient damage minimization is to be achieved.

James T.P. Yao

Professor of Civil Engineering
Texas A&M University

Trends and Directions of Civil Engineering Education

To date, many workshops and conferences have been held to discuss engineering education. During this past decade, the National Science Foundation has been supporting projects to further improve engineering education including the eight Engineering Education Coalitions. These Coalitions involve approximately 60 institutions of higher learning. They are pursuing various approaches with such common goals as (a) to develop innovative and integrated curricula, (b) to incorporate new technologies in teaching, and (c) to increase the number of engineering graduates from underrepresented groups. The American Society of Civil Engineers (ASCE) held a Civil Engineering Education Conference in Denver, Colorado on 8-11 June 1995. In preparation for this conference, a workshop was held in Dallas, Texas on 22-25 September 1995 with 23 educators and 23 practitioners. In addition, more than 200 position papers were circulated to 400 interested members and friends of ASCE from 1992 through Spring 1995. These efforts resulted in the following four educational initiatives:

- Faculty Development
- Integration of Technical Subjects, Communication, Leadership Training, Management and Teamwork into Curricula, and Implementation of Results of NSF Coalitions
- Practitioner Involvement in the Education Process
- Professional Degrees (Post-baccalaureate)

In this paper, current trends and future directions of civil engineering education will be presented and discussed in honor of Professor George Housner as a leader and role model of engineering educators.

Robert D. Hanson

Professor of Civil Engineering
University of Michigan

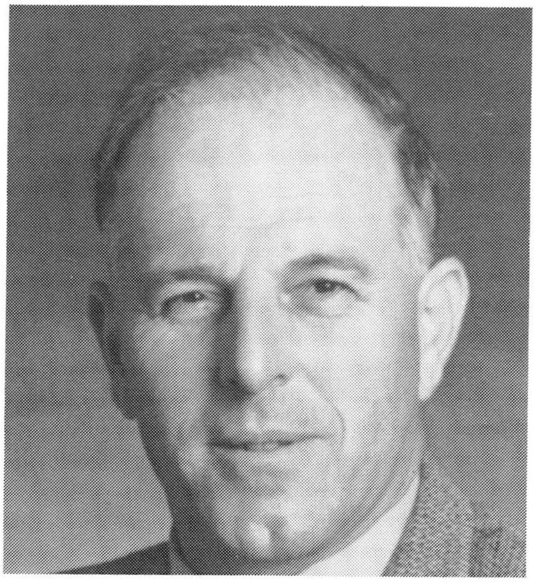
on IPA assignment with the
Federal Emergency Management Agency

Earthquake Response/Recovery or Earthquake Mitigation: What Should be Done and Who Should Pay for It?

Recent earthquake experiences in California, namely the Loma Prieta earthquake of 1989 and the Northridge earthquake of 1994, have created a new climate of expectations from the public, building owners, local and state public officials, and the federal government. Many of these expectations are based on a misunderstanding of the purposes of earthquake resistant design codes and the resulting construction. They expected earthquake-proof buildings and received damaged buildings.

For the private sector this has increased interest in techniques to minimize damage, to assure post-earthquake operation, and to control construction or rehabilitation costs. For the public sector this has increased efforts to mobilize the maximum amount of federal dollars to repair damaged buildings, to upgrade damaged buildings to new building earthquake resistant design levels, and to rehabilitate undamaged buildings (mitigation) to new building design levels. This extraordinary demand for federal dollars is causing a serious consideration of revisions to the Stafford Disaster Relief Act to reduce the federal exposure in the next earthquake disaster. This paper focuses on the impact of building officials' interpretations of codes and legislative actions to maximize federal disaster relief through earthquake damage upgrade triggers, and some actions being considered for revision of federal disaster relief legislation regarding response/recovery and mitigation.

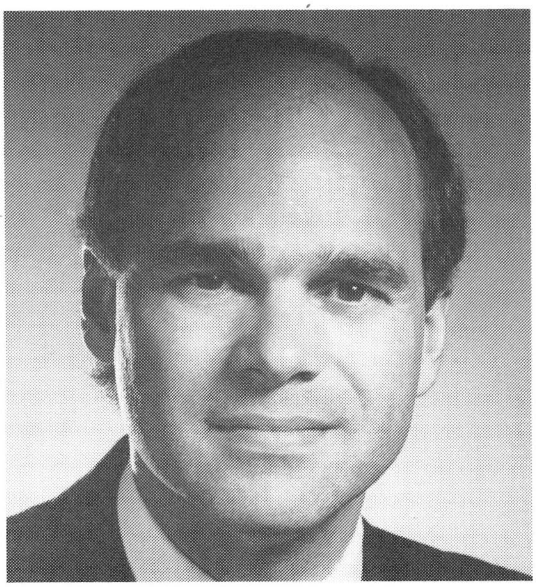
Session: Looking To The Future II



Robin Shepherd

Professor of Civil Engineering, Emeritus
University of California at Irvine

Professor Shepherd will chair the session: Looking to the Future II



Chris D. Poland

Chairman, SEAOC Vision 2000 Committee

President, Degenkolb Engineers

SEAOC's Vision 2000:
A Conceptual Framework for Performance-Based Seismic Engineering

The Recommended Lateral Force Requirements of SEAOC (Structural Engineers Association of California) have historically targeted a limited set of design objectives and focused chiefly on the design of the primary structural system. Recognizing that this is no longer sufficient, SEAOC has begun the development of a new generation of performance-based engineering provisions embracing a broader scope of design and construction quality assurance issues and yielding more predictable seismic performance over a range of earthquake demands. These procedures will address a broad range of performance objectives considering life-safety, structural and nonstructural damage control, and maintenance of function over a range of earthquake hazards. The performance-based procedures will embrace new design and analysis approaches to more directly address the inelastic response of structures and to provide alternative procedures to better achieve defined seismic performance objectives. To date, SEAOC has developed a conceptual framework for this new generation of design guideline.

Performance-based engineering begins with the selection of performance objectives and identification of seismic hazards; continues with conceptual, preliminary and final designs, design acceptability checks and design review; and concludes with quality assurance during construction and building maintenance after construction. Each step is pursued to a greater or lesser extent, depending on the rigor of design required to meet the selected performance objectives. Abbreviated methodologies can be used for simple structures with modest performance objectives.

The "design" and "acceptability check" steps vary depending on the design approach selected and the performance objectives. Building design approaches have been defined and include Comprehensive Design, Displacement, Energy, General Force/Strength, Simplified Force/Strength, and Prescriptive Approaches. Acceptability analysis procedures outlined include the General Elastic Analysis Procedures, Component-Based Elastic Analysis Procedure, Capacity Spectrum Procedure, Pushover Analysis Methods, Dynamic Nonlinear Time History Analysis, and the Drift Demand Spectrum Analysis. Other methods will be considered and added as they are identified and shown to be usable.

The conceptual framework thus far defined must next be developed into guidelines and then into code provisions, before it can be uniformly applied in building design. Some of the concepts are easily developed; others will require considerable research and trial design applications before they can be developed into a usable form. In the transitional phase from current seismic design practice to performance-based engineering design, it is anticipated that new provisions will be incrementally developed from the existing provisions to assure that a smooth transition is made.

Richard N. Wright

Director, Building and Fire Research Laboratory
National Institute of Standards and Technology

Collaborations For Earthquake Loss Reduction

George Housner and his colleagues have long warned the earthquake community and the nation of the need for actions to reduce catastrophic potential earthquake losses. Recent earthquakes in California and in Japan have shown that even "well prepared" areas are vulnerable to severe losses of life and property, and to catastrophic secondary economic losses. Indeed, nowhere in the nation are we well prepared for earthquake loss reduction. The Federal government is addressing the needs for loss reduction efforts in major policy studies: Administration Policy Proposals, The National Mitigation Strategy, the National Earthquake Strategy, the Plan for Development and Adoption of Seismic Standards for Lifelines, and Recommendations for Large Scale Testing Facilities. The recommendations and status of these studies is reported. An important feature of each is the dependence on collaborations between the private sector and federal, state and local governments. These include collaborations between earth scientists, social scientists, and engineers concerned with research, practice and education. Success in earthquake loss reduction requires understanding, commitment of resources, and partnership among all these groups.

Kenzo Toki

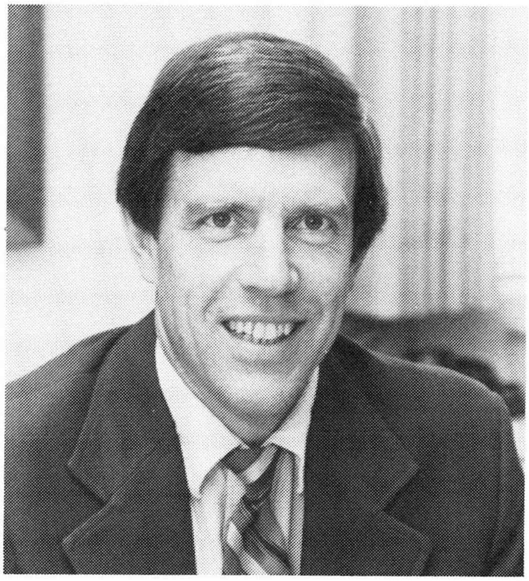
Professor, School of Civil Engineering
Kyoto University

Midterm Report of the International Decade for Natural Disaster Reduction

The International Decade for Natural Disaster Reduction (IDNDR) was first proposed by Dr. Frank Press, then President of the National Academy of Sciences, in his keynote address to the 8th World Conference on Earthquake Engineering held in San Francisco in 1984. The International Association of Earthquake Engineering immediately endorsed the proposal to promote the IDNDR in the earthquake engineering community and related fields. In 1986, the Advisory Committee on the IDNDR was organized and chaired by Prof. G.W. Housner under the auspices of the National Research Council, the National Academy of Sciences and National Academy of Engineering. The Committee published a booklet entitled "Confronting Natural Disasters" in 1987. This was the first concrete activity taken by the US organization. In 1988, Dr. Press called 31 specialists from various countries to discuss how to promote the IDNDR in the world. Professor Housner was representing the United States, and in this way, the United States was the leading country in the beginning of the IDNDR. After the United Nations adopted the resolution to support the IDNDR, however, the activities of the United States were not influential for worldwide promotion of the IDNDR, even though the national committees for the IDNDR were organized by the federal government and academia.

Professor Housner had been waiting patiently for something to happen in the developed countries of the world and under the auspices of the United Nations. Nothing happened except the holding of many meetings that produced no active action for reducing natural disasters of the world. Then Prof. Housner suggested that something be done only in the earthquake engineering community. The World Seismic Safety Initiative has been organized and accepted during the 10th World Conference on Earthquake Engineering held in Madrid in 1992. Only WSSI has mounted continuing efforts to promote the IDNDR in the world, particularly in developing countries.

Session:
Closing



Wilfred D. Iwan

Professor of Civil Engineering
California Institute of Technology

Director, Caltech Earthquake Engineering Research Laboratory

Professor Iwan will chair the session: Closing

George W. Housner

C. F. Braun Professor of Engineering,
Emeritus
California Institute of Technology

Professor Housner received his BSCE degree from the University of Michigan in 1933 and his MSCE (1934) and Ph.D. (1941) degrees from Caltech. From 1934 to 1939 he worked as a practicing engineer in the Los Angeles area. In World War II, he served with the US Army Engineer Corps from 1941 to 1942, and from 1943 to 1945 as Chief of the Operations Analysis Section, Ninth Bomber Command in North Africa.

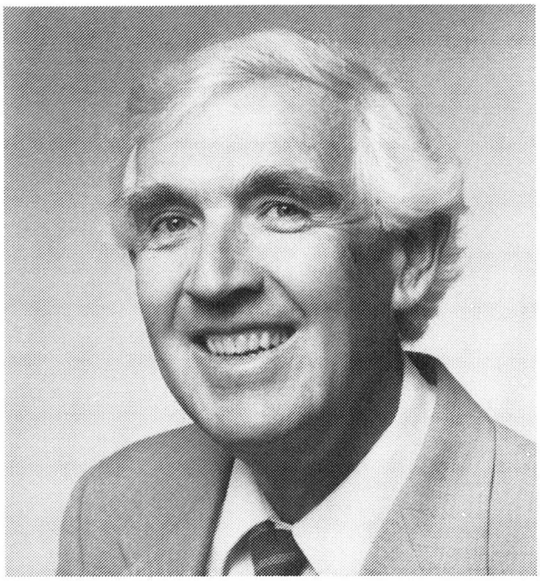
Professor Housner has been on the faculty at Caltech since beginning as an assistant professor in 1945, later serving as Professor of Civil Engineering and Applied Mechanics.

He is the recipient of the Vincent Bendix ASCE Award for Research, ASCE Von Karman Medal, Seismological Society of America Society Medal, ASCE Nathan Newmark Medal for Research, National Medal of Science, EERI George W. Housner Medal (first awardee), National Academy of Engineering Founders Award, and the Alquist Award. He has been named a Member of the National Academy of Engineering, National Academy of Sciences, and Indian National Science Academy; Fellow of the American Association for the Advancement of Science and of the American Academy of Arts & Sciences; Honorary Member of the International Association for Earthquake Engineering, Earthquake Engineering Research Institute, American Society of Civil Engineers, Japan Engineering Academy, Japan Academy, Japan Society of Civil Engineers, Architectural Institute of Japan, Institute of Engineering Mechanics of China, and of the State Seismological Bureau of China.

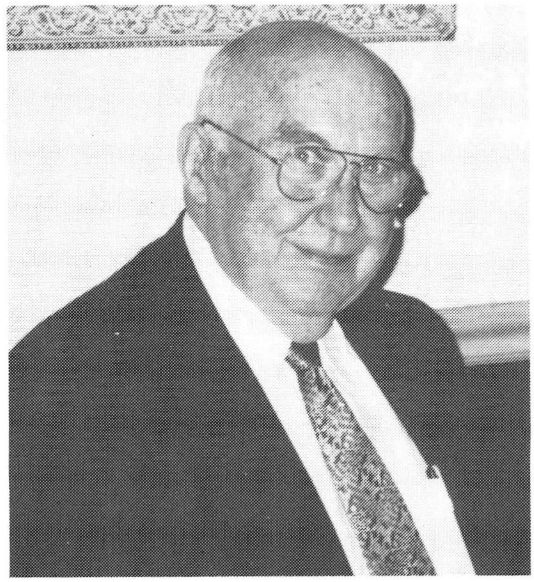
Professor Housner has served as Chairman of the following commissions and panels: National Academy of Sciences panels on the Alaska Earthquake and on Earthquake Engineering; National Research Council committees on Earthquake Engineering, Safety Criteria for Dams, International Decade of Hazard Reduction, and US-China Cooperative Research in Earthquake Engineering; National Academy of Engineering Committee on Earthquake Engineering Research;

Panel on Aseismic Design and Testing of Nuclear Facilities, International Atomic Energy Agency; Committee on Earthquakes, US Committee on Large Dams; US Earthquake Engineering Delegation to Peoples' Republic of China; Governor's Board of Inquiry on the Loma Prieta Earthquake; International Association for Earthquake Engineering Committee on the International Decade for Natural Disaster Reduction; Consulting Board for Earthquake Problems, California Dept. of Water Resources; Consulting Board for Earthquake Design of Auburn Dam; Seismic Advisory Board, Caltrans; US Panel on Structural Control Research, California Universities for Research in Earthquake Engineering.

In lieu of a lengthy list of Professor Housner's publications, the reader is referred to *Selected Earthquake Engineering Papers of George W. Housner* in the American Society of Civil Engineers Classics Series, 783 pp., published in 1990.



Ronald F. Scott
Professor of Engineering and Applied Science
California Institute of Technology



Frank E. McClure
Consulting Structural Engineer

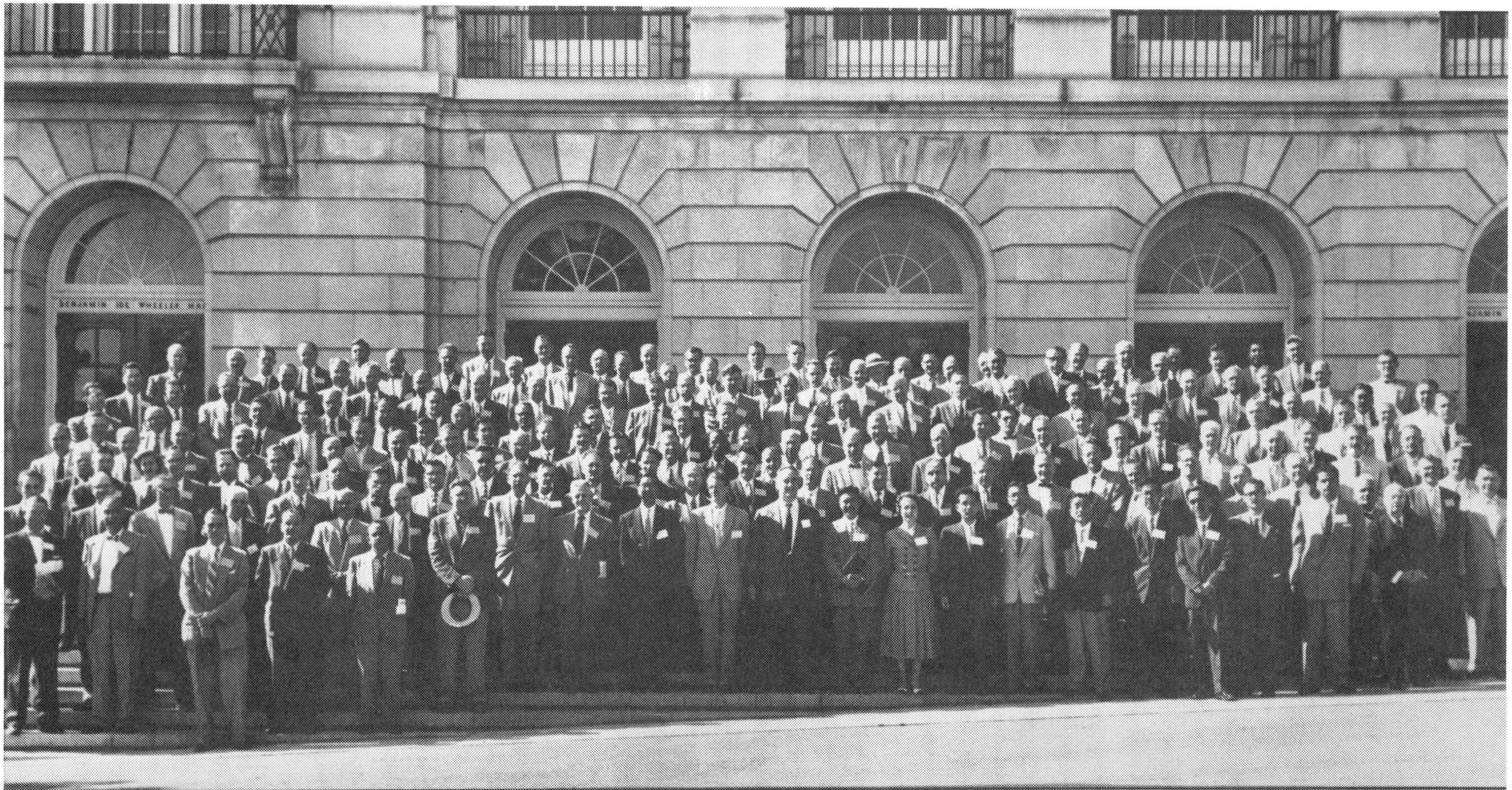
Professor Scott and Mr. McClure will be the Luncheon Speakers

Photographs

Professor George Housner in a Caltech earthquake engineering laboratory, 1955
photo courtesy of Public Relations, California Institute of Technology

First World Conference on Earthquake Engineering, group picture of participants on the steps of Wheeler Hall, UC Berkeley, June, 1956

photo courtesy of the Earthquake Engineering Research Institute



WORLD CONFERENCE ON EARTHQUAKE ENGINEERING
BERKELEY, CALIFORNIA

June 12 - 16, 1956

Conference sponsored by the Earthquake Engineering Research Institute with attendance of four hundred from twelve nations.

Professor George Housner addressing the Symposium on Earthquake Engineering, Roorkee, India, 1959

photo courtesy of the Earthquake Engineering Research Library, Caltech

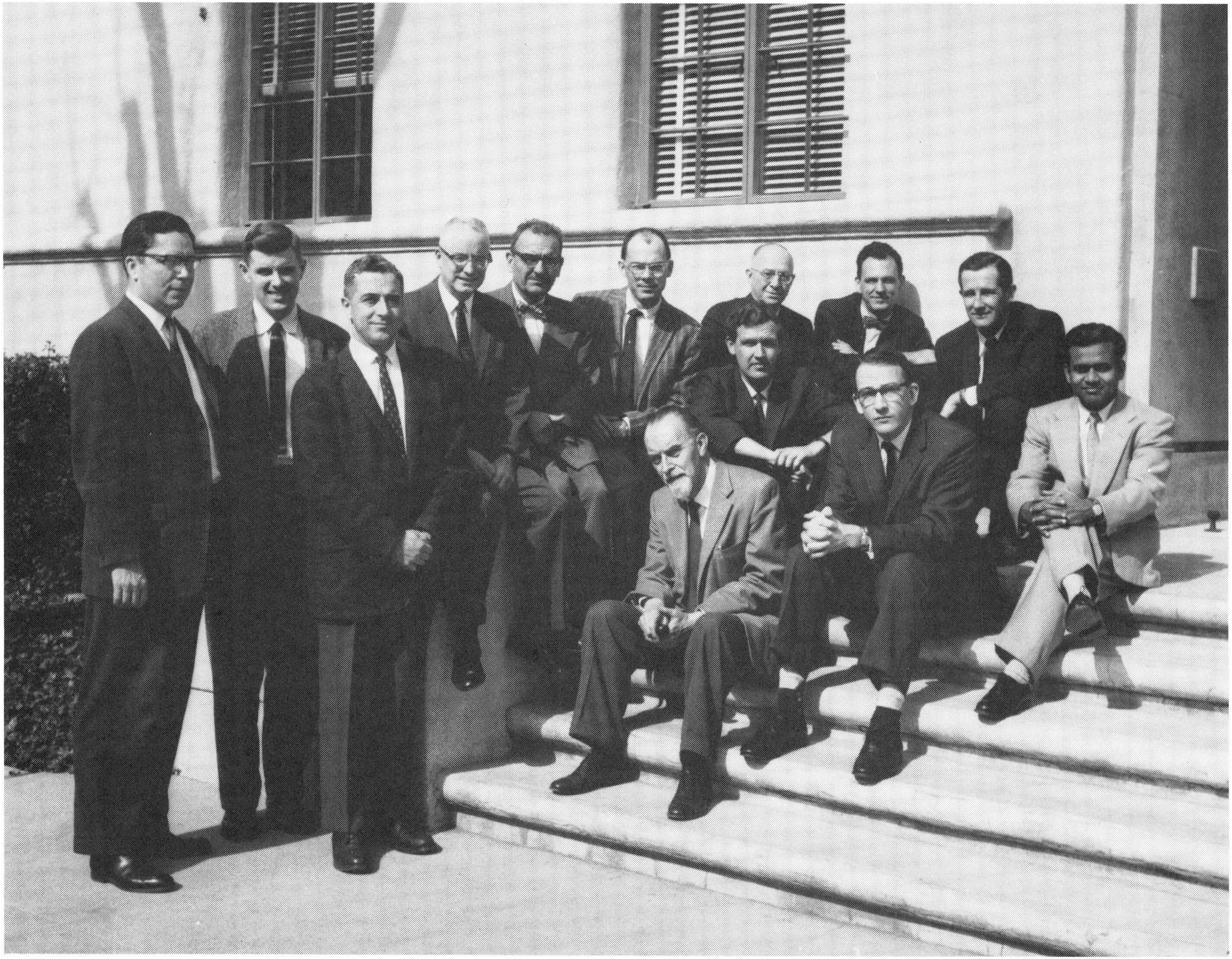

1st Technical Session – Feb 10
11:30 – 13:00 hours
Chairman: DR. D N WADIA
SPEAKERS

Faculty of the Department of Civil Engineering, group picture on the steps of Thomas Laboratory, Caltech, 1962

top row, left to right: George Housner, Norman Brooks, August Rossano, Vito Vanaoni, William Samples, Frederick Converse, Harold Wolf, Caleb McCormick

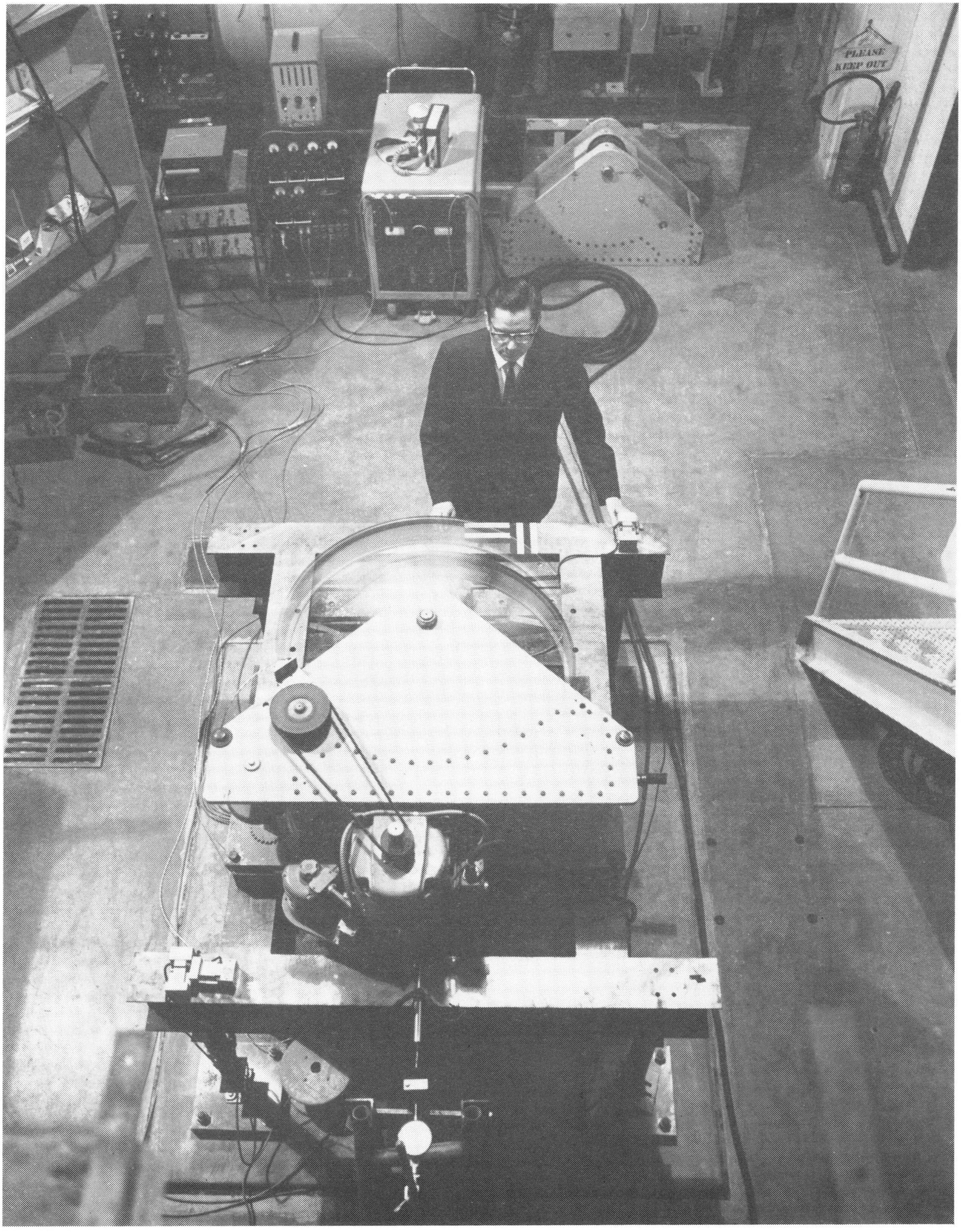
seated on stairs, left to right: R. R. Martel, Ronald Scott, John Kennedy, G.I. Mohanrao

photo courtesy of the Department of Civil Engineering, Caltech



Professor George Housner in a Caltech earthquake engineering laboratory, 1966

photo courtesy of Public Relations, California Institute of Technology

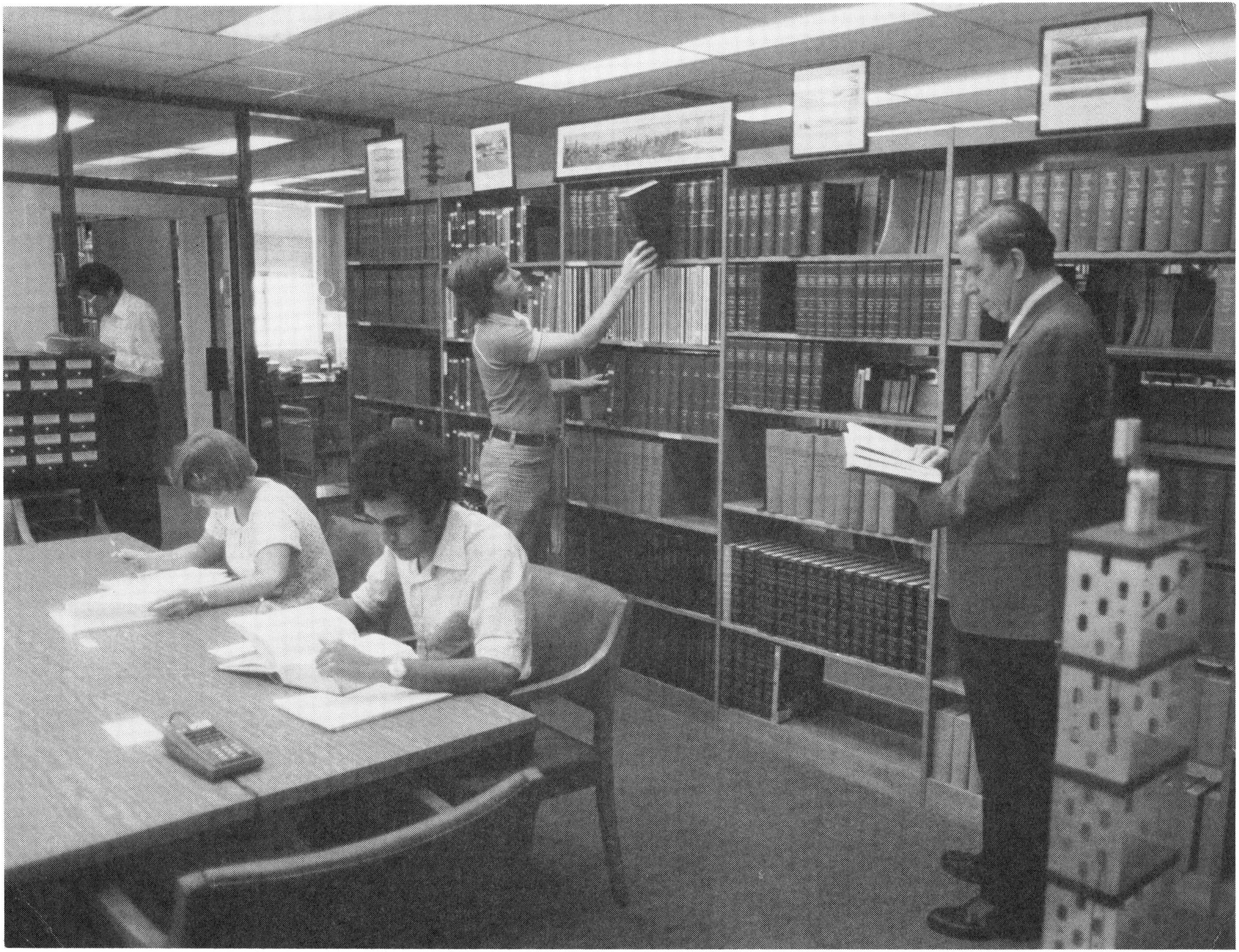

PLEASE
KEEP OUT

Professor George Housner in a Caltech earthquake engineering laboratory, 1969

photo courtesy of Public Relations, California Institute of Technology

Professor George Housner in the Earthquake Engineering Research Library, Caltech, 1975

photo courtesy of the Earthquake Engineering Research Library, Caltech



the CUREe Symposium in Honor of George Housner

Presentations by leading experts from the United States and other countries on the progress that has been achieved in areas pioneered by Professor Housner, as well as thoughts and discussion on what the future may hold.

FRIDAY, OCTOBER 27, 1995

Welcome
P. Jennings, *Caltech Welcome*
S. Mahin, *CUREe Welcome*

The Housner Years I
D. Hudson, *Session Chair*
R. Clough, *The Early Years of Earthquake Engineering*
R. Johnston, *Structural Engineering: Exciting Past, Demanding Future*
N. Nigam, *Inelastic Behaviour of Ductile Structures in Aseismic Design*
T. Paulay, *George Housner and the International Association for Earthquake Engineering*

The Housner Years II
J. Hall, *Session Chair*
A. Abdel-Ghaffar, *Cable-Supported Bridges*
J. Roberts, *The Caltrans Years*
V. Persson, *The California State Water Project and Safety of Dams*

Ground Motion
H. Kanamori, *Session Chair*
C. Allen, *Seismic Hazard in Southern California*
T. Heaton, *Near-Source Ground Motions from Large Earthquakes*
I. Idriss, *Are Earthquake Ground Motions Affected by the Local Site Conditions?*

Luncheon Speaker
R. Scott, *Luncheon Speaker*

Simulation of Structural Behavior
J. Penzien, *Session Chair*
E. Wilson, *Linear and Nonlinear Analysis Of Three-Dimensional Structural Systems*
N. Priestley, *The Role of Large-Scale Structural Testing in Earthquake Engineering*

Design and Performance Criteria
J. Beck, *Session Chair*
L. Esteva, *Site Response Spectra for Seismic Design in Mexico City*
J. Moehle, *Performance Based Seismic Design*
H. Shah, *Seismic Risk Analysis and Management: Half a Century of Evolution*

SATURDAY, OCTOBER 28, 1995

Research into Practice
G. Hart, *Session Chair*
D. Abrams, *Research and Testing Capabilities in the United States*
S. Mahin, *The SAC Steel Program and Development of Guidelines in the United States*
H. Krawinkler, *Inelastic Design Considerations: From Research into Practice*

Special Structures and Systems
S. Masri, *Session Chair*
T. Soong, *Energy Concepts and Structural Control*
F. Seible, *Bridge Retrofit Research and Implementation in California*
M. Haroun, *Seismic Analysis of Tanks*
A. Chopra, *Earthquake Analysis, Design and Safety Evaluation of Concrete Dams*
W. Hall, *Nuclear Power Plants and Nuclear Production Facilities*

Looking to the Future I
M. Agbabian, *Session Chair, Looking to the Future*
B. Bolt, *Future Earthquake Education in the Earth Sciences*
J. Yao, *Trends and Directions of Civil Engineering Education*
R. Hanson, *Response/Recovery or Mitigation: What Should Be Done And Who Should Pay For It?*

Looking to the Future II
R. Shepherd, *Session Chair*
C. Poland, *SEAOC's Vision 2000*
R. Wright, *Collaborations for Earthquake Loss Reduction*
K. Toki, *Midterm Report of the International Decade for Natural Disaster Reduction*

Closing
W. Iwan, *Session Chair*
G. Housner, *Closing Comments*