THE IAEE AT FIFTY: 
A Brief History of the International Association for Earthquake Engineering 

By 

Polat Gülkan and Robert Reitherman 

September 2012
THE IAEE AT FIFTY:
A Brief History of the International Association for Earthquake Engineering

By

Polat Gülkan
Professor of Civil Engineering
Çankaya University, Ankara, Turkey
President, International Association for Earthquake Engineering

Robert Reitherman
Executive Director
Consortium of Universities for Research in Earthquake Engineering
Richmond, California, U.S.A.

September 2012
CONTENTS

Acknowledgments .............................................................................5

1. Introduction .............................................................................7

2. A Half-Century of Perspective .............................................9


4. An Overview of the Establishment and Development of IAEE ...........................................................17

5. World Seismic Safety Initiative (WSSI) and Other Global Programs .....................................................21

6. The World Conferences on Earthquake Engineering .................................................................25

7. Conclusion .............................................................................65

Appendix 1
Prehistory of IAEE (1960 through 1963) ..............................................67

Appendix 2
Officers of IAEE from 1963 ..................................................................71

Appendix 3
Member Countries of IAEE as of 2012 ....................................................73
ACKNOWLEDGMENTS

As noted in the pages that follow, the headquarters of the International Association for Earthquake Engineering (IAEE) has been in Tokyo since the inception of the organization, and the Secretary General there is the key person facilitating IAEE operations. The current Secretary General, Dr. Manabu Yoshimura, provided the documentation on the early years of the International Association for Earthquake Engineering that readers will find in the text that follows and in the appendices.

A number of the photographs were provided by Charles James, the librarian of the National Information Service for Earthquake Engineering (NISEE) library of the Pacific Earthquake Engineering Research Center, located at the Richmond Field Station of the University of California Berkeley.

Research on the content and influential papers of the past World Conferences was greatly facilitated by the digitized collection of the entire set of those papers by the National Information Centre of Earthquake Engineering at the Indian Institute of Technology at Kanpur.

We would also like to thank the Organizing Committee of the Fifteenth World Conference on Earthquake Engineering, headed by Professor Carlos Sousa Oliveira.
But disaster pursues us. It pursues us with a step as steady as time, and an appetite as keen as death.

- Lord Beaverbrook
1. INTRODUCTION

It is fortunate there are always those sincere and motivated few with vision who rally their peers to give serious and scientific attention to solving problems that plague the life and well-being of human beings. These steps are not taken all at once, but must await logical evolution, in keeping with advances in other walks of science and society. The forces of nature can be taken on with our protective tactics, but we must learn from experience, rely on proven theory, and exercise due caution as we fulfill our obligation to our respective communities to provide them with safe facilities of the built environment. These were the sentiments that were expressed in the opening ceremony of the 1956 World Conference on Earthquake Engineering that assembled in Berkeley, California, to mark the fiftieth anniversary of the 1906 Great San Francisco Earthquake.

A half-century has passed since the International Association for Earthquake Engineering (IAEE) was established in 1962, following discussions among leading engineers who had assembled in 1960 during the Second World Conference on Earthquake Engineering in Tokyo. It is an appropriate time to examine its history and achievements in enabling global seismic safety through a network of professionals organized under national associations.

IAEE can rightfully take pride in the enormous surge of accumulated knowledge earthquake engineering research has created toward making a reality its stated objective: the virtual elimination of seismic risk through interchange of knowledge, ideas, research results put into implementation, and sharing of practical experience. Indeed, if we permit a moment of collective pride, we can claim that, for the first time in history, we have the knowledge and the technology (though not necessarily the wealth, human awareness, nor the political will) to create a different world from the seismic safety perspective. And yet, earthquakes continue to batter countries and their economies. During the last one-and-a-half years alone, the world has witnessed some ten major earthquakes, four of which have caused far-reaching consequences of a national scale for Haiti, Chile, New Zealand and Japan. There is some reason to be encouraged by our observations of earthquake effects in some countries, Chile being a case in point, where the application of earthquake engineering knowledge has
made construction more earthquake resistant than in many other countries. Surveying the global situation, however, can be truly depressing and shows that an enormous part of our task still lies unresolved before us. No amount of grandiose speech-making can obscure the stark fact that the earthquake peril remains the most sinister natural disaster for which many countries are still ill-prepared. There is still much to do before we can take comfort in the satisfaction that loss of life and limb and damage to the built environment have been controlled to tolerable levels. Earthquakes continue to occur at their natural pace, but countries and human beings seem to suffer greater losses because of seismic activity. This is a consequence of the increasing exposure of societal assets in today’s world, where urban settlements and increasing population continue to encroach on seismically hazardous areas.
2. A HALF-CENTURY OF PERSPECTIVE

Earthquake science is a global science, indifferent to political or physical boundaries, as evidenced by the Great Indian Ocean Earthquake and Tsunami of 2004, which caused life loss and destruction in a dozen nations. It can therefore best be practiced through effective international cooperation. Through its member national associations that serve as its local branches, the IAEE is a strategically positioned organization to disseminate new knowledge based on research results for the reduction of the seismic risk. Sensible decision-making policies that governments must pursue for that objective will be aided by the theory, experimentation, and experience that earthquake engineers collectively generate. Of course, research is driven by urges other than to inform one’s peers at the quadrennial World Conferences on Earthquake Engineering (WCEE), but that event is the largest gathering of professionals who deal with the broad spectrum of research and implementation aimed at earthquake risk mitigation. They hail from every corner of the world, reflected in the broad geographic range of the locations where the WCEEs have been held (Figure 1).1

---

1. San Francisco
2. Tokyo, Kyoto
3. Auckland, Wellington
4. Santiago
5. Rome
6. New Delhi
7. Istanbul
8. San Francisco
9. Tokyo, Kyoto
10. Madrid
11. Acapulco
12. Auckland
13. Vancouver
14. Beijing
15. Lisbon

**Figure 1.** Locations of Cities That Have Served as WCEE Hosts.

---

1 The complete set of all WCEE papers written to date have been digitized and made searchable by the National Information Centre of Earthquake Engineering at IIT Kanpur at its website, www.nicee.org/wcee, which is also accessible via the IAEE website, www.iaee.or.jp.
This book is not so much a history of earthquake engineering as it is a history of IAEE itself. We have refrained from treating the entire development of earthquake engineering in this narrative because that would require a much broader space than is possible in this book that focuses on the role played by IAEE in the growth of the field. The international story of the development of the scientific and technological aspects of earthquake engineering is described by Bertero and Bozorgnia\textsuperscript{2}, Freeman\textsuperscript{3}, Hudson\textsuperscript{4}, Reitherman\textsuperscript{5}, and Scawthorn\textsuperscript{6}. The quadrennial IAEE-endorsed world conferences on earthquake engineering are now routinely attended by thousands of participants, but the role of those who played key roles in the creation of the Association is not well known. We focus here on the early years and the germination of the ideas through exchanges among those who were present at the first two World Conferences, and who went on to establish IAEE. A half-century after its occurrence, it is not easy to reconstruct on the basis of a few documents and anecdotal stories, the exact path that the Association followed during its formative years, but an informative and lively description is provided by George W. Housner (Figure 2) in the interview he gave for the EERI Oral History series.\textsuperscript{7}


\textsuperscript{5} Reitherman, Robert K. (2012). \textit{Earthquakes and Engineers: An International History}. ASCE Press, Reston, VA.


\textsuperscript{7} Housner, George W., and Stanley, Scott, Interviewer (1997). \textit{George W. Housner}, Connections. the EERI Oral History Series - Earthquake Engineering Research Institute, Oakland, CA.
Just as the Seismological Society of America (SSA) was established in the aftermath of the 1906 San Francisco Earthquake, IAEE can trace its birth to the same earthquake, but in a much delayed timeframe, for it was the fiftieth anniversary of that disaster that served as the catalyst to hold a world conference on earthquake engineering. In the interest of completeness, we should retell the story from its origins more than sixty years ago. Led by Lydik S. Jacobsen (1897-1976), George W. Housner (1910-2008), John A. Blume (1909-2002), and others, the Earthquake Engineering Research Institute (EERI) had been formed in 1948 by a dozen members “dedicated to serving the public welfare in the field of engineering seismology.” Its objective was to promote and sponsor intensive and continuing research on how and why manmade structures failed under the action of earthquake motions and to develop and disseminate increased knowledge and methods for economically minimizing damage and loss of life. Housner was the first vice president and second president of EERI in 1950-1951, following Jacobsen’s one year term in 1949. He then returned to the presidency to serve for eleven years (1954-1965), where one of his first efforts was to help organize the World Conference on Earthquake Engineering in 1956 at the University of California, Berkeley. It was not titled the First World Conference on Earthquake Engineering, for the organizers did not overconfidently assume that it would set in motion a continuing series, and in fact the organizers did not know if the turnout would make the event a success or a failure. During his long term as president, Housner guided the early development of EERI and laid the groundwork for its later transformation from a small, invitation-only organization with a focus on the structural and strong ground motion aspects of earthquake engineering to the large, broad, open, and multidisciplinary association that it is now. In collaboration with Japanese engineers led by Professor Kiyoshi Muto (1903-1989), Professor Housner also was instrumental in the formation of the International Association for Earthquake Engineering (IAEE) in 1962,
and served as its president from 1969 to 1973. He is generally acknowledged to be the “father” of earthquake engineering, though he tended to give the credit of being the father of IAEE to Muto (Figure 3). That judgment is probably correct because it was Muto who pursued the establishment of the Association most vigorously, as described in Chapter 4. Housner’s influence on EERI and IAEE continued long after his presidencies were past. He was involved in IAEE activities for many more years as an elder statesman.

![Figure 3. Kiyoshi Muto](image)

![Figure 4. Ray W. Clough](image)

Our organization sponsors the World Conferences on Earthquake Engineering and encourages the development of earthquake engineering societies in the seismic parts of the world. Additionally, during Professor Housner’s term of office, the journal *Earthquake Engineering and Structural Dynamics* was formed as the official journal of the IAEE, with Professor Ray Clough (Figure 4) as the founding editor. The first issue was published in 1972.

---

3. SEISMIC SAFETY: OUR COMMON, ELUSIVE GOAL

It is now difficult to establish when or by whom the term “earthquake engineering” was first coined. In the name of the Earthquake Engineering Research Institute, the words “earthquake engineering” originally meant, when the organization was incorporated in California as a nonprofit organization in the U.S.A. November 4, 1948 and began operations in 1949, the application of engineering to the earthquake problem. The term in use prior to “earthquake engineering” was “engineering seismology,” and the other discipline besides engineering involved in EERI in its early years was seismology. It was only the small branch of seismology that concerns itself with strong ground motions that was meant by “seismology.” The central interest of many of the seismologists in the world then as well as now is in the information earthquakes provide about the interior of Earth, whereas in the earthquake engineering field, earthquakes are phenomena studied because of their destructive effects at the surface of the planet.

The emergence of the earthquake engineering discipline as a field of technological endeavor as broad as we today know it naturally took several decades and was aided by parallel developments in computer science, information technology, and developments with regard to inelastic behavior, dynamics, and statistics that were sometimes borrowed from aeronautical and mechanical engineering. One of the more important influences on the field has been specific earthquakes that were not only damaging but came at the right time in the right place to offer engineering and policy insights.

Following several destructive earthquakes in the 1960s and 70s (Alaska, 1964; Niigata, 1964; Caracas, 1967; San Fernando, 1971) the objective of the Association was expressed as reducing seismic risk worldwide by promoting international cooperation among scientists, engineers, and other professionals in the broad field of earthquake engineering through interchange of knowledge, ideas, results of research, and practical experience. In this sense, the scope of earthquake engineering has been expanded now to include also the economic and social sciences. From their inception, the proceedings of the World Conferences on Earthquake Engineering have been designed as an authoritative source of information for diverse professionals who deal with earthquake loss reduction. These include practitioners and researchers among engineers (civil, structural,
mechanical, and geotechnical), architects and urban planners, earth scientists (geologists, geophysicists, seismologists), public officials, and social scientists. The range of papers that appear in the World Conference proceedings is very broad. An earthquake’s short- or long-term effects on a society, or how pre-earthquake societal characteristics affected a population’s vulnerability or response to an earthquake, constitute topics that are now firmly included under the banner of earthquake engineering. While there are many journals for academically oriented articles in each disciplinary area, the proceedings of the World Conferences still serve as the primary platform bringing together the latest research and professional practice developments to serve the diverse earthquake safety professions.

3.1 Components of Earthquake Safety
A legitimate question that must be answered now is: has earthquake engineering been able to enhance the level of earthquake safety globally during the last half century? Surely, the network of earthquake professionals enabled partly by IAEE, the tools at their disposal, and the worldwide organizations such as IAEE and governmental action formulated within the Hyogo Framework for Action led by the United Nations, should comfort us all that we are not as vulnerable as our ancestors a century ago were against the earthquake threat. Before jumping to a rash answer, however, let us consider the following hypothetical issues that beg to be answered.

Suppose someone wants to understand how hazardous the city is where they are planning to buy a house. That individual can be better informed now about the decision that may be taken for that investment. Tools have been developed for Internet-based responses to many of the basic questions required for that purpose.

Suppose a geotechnical engineer wishes to calculate the expected seismic motion on bedrock for a given location in order to define the reference motion needed for site effect analysis. Depending on where this need has arisen, reasonably accurate figures may be provided. The amount of information varies widely. In a country like the U.S., geographical coordinates may be entered online to have an answer to that query, as opposed to another country or region where the background studies have not yet been carried out. The same applies to an engineer who is working on the design of a bridge located in a zone with seismic activity, and who wants to perform
a seismic assessment of the hazard of seismic shaking in order to compute maximum spectral intensity within a certain time span, and the probability of occurrence of liquefaction or landslides that could affect the foundation. The amount of extra work that the engineer will need to perform may then be confined to establishing the design parameters of the local site geology so that they may be incorporated into the calculations that will be run to verify the adequacy of the design. Structural engineers can use our contemporary knowledge and computer resources to, in effect, subject a design to several different earthquakes to validate and improve it prior to construction.

Often an urban planner needs to calculate risk maps within a given region for a given building type in order to identify the areas of the city with higher levels of risk. Or a reinsurer wants to calculate the average annual loss and probable maximum loss to the buildings in the company’s portfolio. The tools that we have developed should provide many of the answers needed for a rational decision in that domain. Likewise a civil protection or emergency management officer who wants to see the probable distribution of damage and fatalities within an urban area for a selected scenario earthquake for disaster response planning can, at this time, with much more accuracy and geographical specificity, arrive at first order estimates for such questions.

But are these tools all that are needed for achieving the elusive goal of what is commonly understood as safety from the harmful effects of earthquakes? Post-earthquake images show us fallen buildings, displaced bridge abutments, failed utility systems, and many other types of distressful signs of human misery. Have the tools of earthquake engineering been able to eliminate these for most citizens in the world? Have governments been able to convert the tools that have been developed by earthquake professionals over the past half-century to policies that bring safe roofs above the heads of their citizens? It is impossible to answer such questions positively, not only because absolute safety is not within the reach of any country, but because other societal needs take precedence over contingencies, such as earthquakes, that have remote likelihoods of occurrence. In most instances, the recurrence intervals of destructive earthquakes are longer than human memory, and most of us manage to live our lives, even in seismically hazardous regions, without experiencing strong ground shaking beneath our feet. Tools have been developed for retrofitting deficient structures, but the willingness of individuals to make the sacrifices necessary to procure
the goods and services for enhancing the robustness of their own property is usually lacking. The same applies to anonymous decisions falling in the same category taken by agencies and governments. The replacement of hazardous civil infrastructure elements, hospitals, schools, and other critical facilities is often left to the process of natural replacement at the end of their economic lives, or to the Darwinian weeding out of construction that fails to pass the test of an actual earthquake. Many countries are simply not in a position to assess, survey, and upgrade if necessary the enormous inventory of the built environment. In many instances, it is a more defensible or practical policy to make sure that what is erected today is built in accordance with the requirements of modern earthquake engineering. It is the conviction of many that a seismically quiescent period of fifty years in major cities of the world that live under the potential impact of earthquakes, coupled with the implementation of currently known safe building practices, would help diminish the urban loss potential to only a fraction of its current levels. Much of the world’s future earthquake risk is being built right now in the form of inadequately earthquake-resistant construction.

IAEE cannot alone take credit for all that has been accomplished for improving global seismic safety. Research and development in a particular field of science and technology have their own random dynamics, and progress does not necessarily follow a pre-programmed path. It happens because of the combined talents and curiosities of men and women driven by many different ambitions and motives responding to different stimulating factors. IAEE has been a leading catalyst for this advancement to occur during the last half century. Its mission will not change, but it will take on new dimensions and forms in the coming years, some of which are difficult to forecast now.
4. AN OVERVIEW OF THE ESTABLISHMENT AND DEVELOPMENT OF IAEE

The first conference in recent time held on earthquake engineering was the one that also included blast effects on structures, held in Los Angeles in 1952. Though organized by the Earthquake Engineering Research Institute, blast was included because it was thought that there would be insufficient attendance for a conference devoted solely to earthquake engineering. That pioneering event in 1952 was to be followed in 1956 by a conference devoted only to earthquake engineering and held in the San Francisco area to commemorate the fiftieth anniversary of the 1906 earthquake in northern California. The prescient name given to that conference by its organizers was the World Conference on Earthquake Engineering, because there were foreign participants who had been invited to attend. The 140 delegates presented some 40 papers, and a single commemorative photograph could be taken of all participants as they posed in front of Wheeler Hall of the University of California, Berkeley (see Figure 5), a visual indicator of the difference between that era and today, when thousands attend each World Conference. This 1956 conference has since been retrospectively referred to as the “First” World Conference on Earthquake Engineering.

Figure 5. Delegates to the First World Conference on Earthquake Engineering: June 1956.

9 *Proceedings of the Symposium on Earthquake and Blast Effects on Structures*, Earthquake Engineering Research Institute, Oakland, CA. 1952.
The Japanese delegation in Berkeley was headed by Professor Kiyoshi Muto of the University of Tokyo, who volunteered for his country to host the next conference in Japan. The opinion that there should be an international association was expressed forcefully by Muto (Figure 3), and the delegates at the conference unanimously endorsed the idea that an international organization on earthquake engineering should be established. A Preparatory Committee was organized for this purpose with a representative from each of the 27 participating countries. Muto was elected chairman of this committee. He appointed the delegates from Peru, Portugal, Turkey, U.S.A., U.S.S.R., and Japan to form a Steering Committee to prepare plans for referral to the Preparatory Committee. But should this organization be composed of individuals from many countries, or should it be a federation of national societies? In the end the idea prevailed that it should comprise national societies, because earthquake engineering is different for each country that faces the problem, so they each should have their own group organized in accordance with their own national guidelines. That principle has stayed.

An itemized formal account of the preliminary round of meetings among participants of the Berkeley and Tokyo conferences that led to the formation of IAEE is given as Appendix 1. In May 1961, the draft of the Statutes of the International Association for Earthquake Engineering were prepared and forwarded to the Steering Committee for examination and comment. The amended draft was completed in December 1961. It was approved and adopted by the Steering Committee in February 1962. As stipulated in the Statutes, each country was required to form a National Society or Association and name a delegate and a deputy delegate to represent that country. In order that IAEE could be formally established as soon as possible to carry out its functions, voting for the Executive Committee of the Association took place in January 1963, and the President, Vice-President, Secretary General and eight Directors were named. Officers of the Association from 1963 are listed in Appendix 2. Since its inception, the home base of the Association has been situated in Tokyo. Likewise, the Secretary General has always been from Japan. The Statutes have been amended many times from the original text in 1961. The current Statutes are available at the IAEE website (www.iaee.or.jp). Starting from 2000, the Statutes have been revised to allow the President-Elect to take office at
the midway point between two successive world conferences. From 2010, IAEE has been registered as a not-for-profit organization in Japan.

The Association began to function on February 1, 1963. The Central Office then was located in the International Institute of Seismology and Earthquake Engineering (IISEE), which had been established jointly by the United Nations and the Japanese Government within the Building Research Institute (BRI) in Tokyo. It later moved to Tsukuba. Kazuo (John) Minami (1907-1984), from 1963 to 1977 was the engineer who provided the central point of contact for the International Association for Earthquake Engineering in its Tokyo office.

From the beginning, the aims of the Association have been “to promote international cooperation among scientists and engineers in the field of earthquake engineering through interchange of knowledge, ideas and results of research and practical experience.” These aims are to be accomplished by holding world conferences, through interchange of information, and extending technical cooperation. The Association agreed to cooperate with UNESCO to minimize earthquake damage and loss of human lives by participating in the Intergovernmental Meeting on Seismology and Earthquake Engineering that was convened by UNESCO in 1964, and also through planning the dispatch of Emergency Inspection Teams to affected areas after strong earthquakes.

At present, countries affiliated with IAEE number 56 and are listed in Appendix 3. The Association is administered by its Officers that include the President, Executive Vice-President, Vice-President, President-Elect, Past President and Secretary General. Its Executive Committee is composed of eleven members, eight of whom are elected by the General Assembly and three by the Executive Committee itself.
5. WORLD SEISMIC SAFETY INITIATIVE (WSSI)
AND OTHER GLOBAL PROGRAMS

The original concept of the International Decade for Natural Disaster Reduction (IDNDR) was proposed in 1984 by Frank Press, then President of the U.S. Academy of Sciences, during the Opening Ceremony of the 8th World Conference on Earthquake Engineering (8WCEE) held in San Francisco in 1984. This idea evolved into a United Nations resolution in 1987, and the Decade program started on January 1, 1990.

The International Association for Earthquake Engineering (IAEE), the definitive academic and international engineering organization in the field of earthquake engineering, had been feeling moral responsibility to take an active role in implementing the goals of IDNDR. In Madrid in 1992 at the 10WCEE, IAEE made an important decision to be more strongly involved with IDNDR by creating the World Seismic Safety Initiative (WSSI) as an IAEE undertaking.\(^\text{10}\) An interim Committee of seven members was first established, with Tsuneo Katayama (Secretary General of IAEE) and Haresh C. Shah (Stanford University) as co-chairs.

The WSSI plan was endorsed by the IAEE Executive Committee, and the General Assembly of Delegates adopted resolutions in which the establishment of the WSSI was clearly acknowledged. WSSI was approved by Scientific and Technical Committees of IDNDR as an International and Regional IDNDR Project in January 1993.

To perform such duties as required to establish the WSSI until the members of the Board of Directors were appointed, the WSSI Interim Organizing Committee (WIOC) was formed. The committee included, as of February 1993:

- Giuseppe Grandori (Italy)
- George Housner (U.S.A.)
- Wilfred Iwan (U.S.A.)

• Tsuneo Katayama, Co-chair and Secretary General, IAEE; (Japan)
• Roberto Meli (Mexico)
• Haresh Shah, Co-chair; (U.S.A.)
• Charles Thiel (U.S.A.)
• Kenzo Toki (Japan)

The philosophy of WSSI is not to embark upon unrealistic and unmanageable projects but to work on well-defined regional projects that include experts who are dedicated to the ideals of IDNDR and to the goals of WSSI. Self-help is the foundation on which WSSI builds its programs. The organization must keep its focus on increasing awareness and helping people protect their lives and property due to future earthquakes. It is obvious that current knowledge that could save lives and property is not getting to where it is most needed and where it could do the most good. WSSI’s promise is that it will bring this need into focus and will do what it can within its available resources to help communities around the world to understand their risk reduction options. WSSI will need everyone’s help in achieving this modest goal. WSSI is currently headquartered at the Nanyang Technological University in Singapore.

Another global program in which IAEE is involved is the Global Earthquake Model (GEM), which has the ambitious objective of making the current state-of-the-art in earthquake risk models widely accessible via the Internet (www.globalquakemodel.org). The GEM Foundation is a public-private partnership that drives a collaborative effort aimed at developing and deploying tools and resources for earthquake risk assessment worldwide. Hundreds of organizations and individual experts, professionals, and practitioners are working together on uniform global databases, methods, tools and open-source software. GEM pursues its objectives through a combination of global components and regional programs.
Originating further back in the history of IAEE is its series of *Regulations for Seismic Design: A World List*, updated ten times since it first publication in 1960. *Figure 6* shows the growth in number of countries that have adopted a seismic code, as measured by those in the World List editions. In 1980, IAEE published *Basic Concepts of Seismic Codes*, and in 1986 that was revised and published as *Guidelines for Earthquake Resistant Non-Engineered Construction*, authored by Anand S. Arya.

*Figure 6.* Number of countries with seismic codes.  
6. THE WORLD CONFERENCES ON EARTHQUAKE ENGINEERING

The tools of earthquake engineering have been greatly improved from the mid-1950s and earlier, and this development and sophistication of the discipline are traceable from an examination of the contents of the 14 sets of World Conference on Earthquake Engineering proceedings published to date. As noted above, all of the many papers in those proceedings are available at www.nicee.org/wcee. While it is logical to outline the progress of the overall field from a survey of the WCEE proceedings, that exercise is certain to be incomplete. Doing justice to that task would require many years of work, because there have been tens of thousands of papers that have been published in those proceedings on topics that range far and wide (see Figure 7). No scientific measure is attempted to quantify the impact of a given paper in any of the conferences in terms of the effect it had on subsequent developments or its durability in terms of the citations it drew subsequently. Because we can only mention a few of the milestone papers that have appeared in the proceedings, we may appear to do injustice to many others that are not mentioned. The brief survey here must come with the caveat that any selection as an outstanding or historic paper is certain to

![Figure 7. The Rapid Rise in the Number of WCEE Papers.](image)
be on weak ground for several reasons. First, World Conference proceedings are not the only publication platform for research or development results. Over the years, a number of archival journals were created in the earthquake engineering field. Second, one or more papers that preceded the ones cited here may deserve to take the real credit but are not mentioned because they have slipped through the poorly woven net that we have cast. Finally, the rankings or citations here are not necessarily a unique set, and other combinations are plausible. In the interest of impartiality we will refrain from naming names unless it becomes absolutely necessary to do so, and also avoid specific volume and page number citations, or citations to papers in electronic format, that are inappropriate in this brief overview. So the picture we draw of the development of the trade called earthquake engineering through the prism defined by the proceedings of the World Conferences is at best suggestive. The broad outline for the listed important thresholds of earthquake engineering as reflected through the papers in the World Conference Proceedings of any vintage should be viewed with the same skepticism that is attached to a list that purports to contain the best paintings of all time, or most significant novels, or greatest achievements of political leaders.

**IWC EE: BERKELEY (1956)**

Based on the limited number of observations of the performance of buildings or other structures that had been subjected to strong ground motions, Housner was prompted to write that if limited plastic deformations were accepted, it would be possible to design buildings safely for strengths much less than what the observed spectral acceleration would require them to have. Thus the seed of inelastic design principles was sown. Rosenblueth identified the random character of the chain of successive wavelets of earthquake disturbances arriving at structures, and stated that probability theory was the ideal tool to compute the response they would demand. Participants from many countries reported on their seismic codes, strong motion
instrumentation programs, laboratory experimentation, and theoretical developments about earthquake-resistant construction, along with commentary on the social aspects of implementing earthquake engineering. While these topics do not span all those that the much larger field and more voluminous WCEE proceedings cover today, the Proceedings of the first of the World Conferences is nonetheless a representative sample of the scope of earthquake engineering today.

**Historic Context: The Technology of 1956**

In what kind of world did the earthquake engineers of this time live and work? Their minds often used many of the same concepts in use today, as indicated by the broad scope of the Proceedings of the World Conference that year. Compared to today, however, the civil engineers and seismologists did their calculations by hand, using pencil and paper to add up figures, using graphic statics, manipulating a slide rule for many of the computations with larger figures, and perhaps using a calculator such as the Curta, a mechanical device the size of a pepper grinder that also had a similar crank. The era when most engineers would have ready access to a powerful computer, or to any computer, was not to arrive until the 1970s. As of 1956, computers were massive, centralized machines usually available only to some government bureaus, the military, and large banks. Seismic design is an iterative and creative process, and only much later were individual engineers able to use desktop computers as an extension of their thought process. The transistor radio had been brought to market in 1954, and only a few specialized research calculating machines had substituted transistors for vacuum tubes. A commercially available magnetic storage product was produced by IBM in 1956, with a then-impressive capacity of 5 million bytes. Two years before, IBM issued the first mass-produced computer (IBM 650), “mass-produced” meaning that 450 were produced. It was only in 1956 that researchers at the Massachusetts Institute of Technology introduced “direct input,” the now mundane process of typing instructions to the computer on a keyboard rather than manually setting switches and plugging in wires.

Indicative of the fact that the leading engineering minds were producing conceptual breakthroughs that were not to wait till the 1970s when computer technology became powerful and accessible, it was in 1956 that
the historic paper on the finite element method was published. One of the co-authors, Ray Clough, was later to give the method its famous name, and his name became famous in the history of earthquake engineering as well. As was the case with several other innovations, earthquake engineering borrowed from fields such as aeronautical and mechanical engineering. Clough worked with Turner and others at the Boeing Aircraft Company in developing the finite element method to analyze jet airplane wings, not to solve an earthquake engineering problem.

The reading lists and class handouts of professors as of 1956 appeared on paper as purple type, reproduced via Mimeograph; the Xerox process was still an expensive luxury. The slide projector that could be pre-loaded with a group of slides had recently been invented, but most instruction used the educational technology invented in 1801 – the black slate blackboard and white chalk.

**Historic Context: The Earthquakes**

What earthquakes had recently occurred that provided engineers with lessons and data? The 1952 Kern County Earthquakes in California provided the Taft strong motion record (Figures 8 and 9), which joined the 1940 El Centro, California record as one of the most useful for researchers up to then, though the modern shake table was not yet on the scene to “play back” these recordings. The reconnaissance report by Steinbrugge and Moran on that 1952 earthquake had a scope that is comparable to today’s reports that are produced by a dozen people, covering seismology, emergency response, utilities and infrastructure, and detailed building performance statistics. In the four years prior to the first WCEE, there had been earthquakes killing

---


one thousand or more people in Turkey (1953), Afghanistan (1954), and Algeria (1954). Such grim statistics must be acknowledged in earthquake engineering, whose primary purpose is to prevent such disasters. Compared to some later time periods, there were relatively few earthquakes of the scale of a large disaster. The efforts of the organizers of the first of the World Conferences to make that gathering a successful and well-attended event were not aided by much front-page earthquake news.

Figure 8. 1952 Taft accelerogram, Kern County Earthquakes.  
- NISEE-PEER, University of California, Berkeley

Figure 9. 1952 Kern County Earthquakes. Good performance of seismically designed schools provided an early verification that earthquake engineering was on the right track.  
- photo by Karl Steinbrugge, NISEE-PEER, University of California, Berkeley
2WCEE: TOKYO AND KYOTO (1960)

The Conference proceedings and participants increased suddenly to some 2,000 pages and 500 participants, confirming that earthquake engineering had been a discipline on the verge of a growth period. It saw a vigorous debate of perhaps one of the most fundamental concepts in earthquake structural engineering: the elastic-plastic idealization of individual frames, and later, of framed buildings with many stories. Engineers had realized that the elastic capacities of the structures they had been designing could be surpassed during earthquakes, so the old design philosophy of keeping structures elastic would mean that their capacities would need to be very large. The obvious compromise was to allow structures to go inelastic, because in the dynamic environment they could oscillate back and forth while still performing satisfactorily. Papers by Veletsos and Newmark, Housner, Blume, and Penzien ushered in the new way of thinking that realized that, unlike during sustained static loading as for gravity loads, the brief inelastic deformations induced by earthquakes would not necessarily cause failure if they could be controlled. To date, this concept has been broadened to include other systems such as soil structures, and it is what anchors the active research area of performance-based engineering. Geologic and geotechnical topics that were then new included a discussion of the hazard of fault rupture (Tocher), and the strength of soils during earthquakes under shear reversals (Seed).

**Historic Context: The Technology of 1960**

At this time, the computer was steadily developing, but it was still too underpowered, too much the preserve of elite usage, to be of use to most earthquake engineers. Clough can be cited again to benchmark the progress of the era, who observed in 1958 that “with few important exceptions, the application of electronic computers in the design and analysis of civil engineering structures has been very limited....”\(^{14}\) Not only the finite

element method, which he co-developed, but the response spectrum method had been conceptualized by this time, but they were not widely applied because the necessary computer capability was not available to the engineer. A larger archive of ground motion records was also needed. Both Kiyoshi Muto and Nathan Newmark (1910-1981), major figures in earthquake engineering for their other accomplishments, were involved in the development of advanced computer centers. At the University of Tokyo, Muto led the development of the Strong Earthquake Response Analysis Computer, SERAC. SERAC was an “electric analog computer capable of calculating the elasto-plastic response of up to a five-mass spring system. This analog computer was replaced as the result of the development of digital computers approximately five years later.” At the University of Illinois at Urbana-Champaign, Newmark was the chair of the Digital Computer Laboratory and played a role in the development of the ILLIAC II computer.

Although the Soviet Union had demonstrated in 1957 that it was possible to put an object in orbit, the practical applications of satellites for communications, picturing Earth’s surface in the visible and invisible ranges of the spectrum, and surveying (such as GPS) were far in the future.

A number of nuclear power plants were constructed in the 1960s in seismic areas, as were some large dams and high-rise buildings. These new types of constructed technologies merited the use of the most advanced analysis methods for both ground motion and structural response calculations, sophisticated methods that slowly worked their way into more widespread earthquake engineering practice.

It was still true in this era that funds for earthquake engineering research were very rare. Clough can again be cited as a benchmark, who noted that after the 1956 World Conference, “I had no opportunity for further study of the FEM until 1956-57, when I spent my first sabbatical leave in Norway…” (where he worked at the Norges Skipstekniske Forskningsinstitutt, now MARINTEK, doing naval architecture research on ship structures). If one

---


of the most prominent names in earthquake engineering as of then could not find funding to pursue research in that field, imagine how daunting it was for everyone else.

**Historic Context: The Earthquakes**

Between the first of the World Conferences and the 2WCEE, it was again a time span of moderate seismicity, at least in terms of earthquakes causing fatality tolls of 1,000 or greater: Iran (two in 1957, one in 1962), one in Morocco (1960), and one in Chile (1960). The 1960 Agadir, Morocco Earthquake still holds the sad record of causing the greatest number of fatalities (over 13,000) for the small size of its magnitude (M 5.9). The event that stands out in engineering terms in the years since the first of the World Conferences, and which also still holds first place in seismology for the largest recorded magnitude (M 9.5), is the 1960 Chile Earthquake. It is a remarkable and lamentable fact that our field failed to obtain a single strong motion record near to this great earthquake, which is also the case for three magnitude 9 earthquakes that have occurred in Alaska as well as the 2004 Sumatra Earthquake.

![Figure 10. The Hotel Saada, a luxury hotel in Agadir, Morocco, pictured before and after the 1960 earthquake.](image)

- U.S. Geological Survey, NISEE-PEER, University of California
3WCEE: AUCKLAND AND WELLINGTON (1965)

With IAEE firmly established, this was the first endorsed conference when the Association’s ubiquitous symbol Ruaumoko, the Maori god for earthquakes and volcanoes, emerged and was adopted. This woodcarving is present at the opening ceremony of each World Conference. Karl Steinbrugge, then President of the Earthquake Engineering Research Institute, saw the Ruaumoko carving in the national museum in Wellington, the Dominion Museum, now called Te Papa, and commissioned a replica by master Maori wood carver Charles Tuarau. Steinbrugge later gave it to the University of Canterbury in Christchurch, New Zealand to be kept there in between its appearance at World Conferences. The current carving is a replica of that original, which disappeared during an event at the 14WCEE.

Prompted by the experience in El Centro (1940) and perhaps Alaska (1964), though no strong motion records were obtained from the latter large earthquake, and driven by a need to answer the intriguing question of how large the peak value of the ground acceleration measured in the near vicinity of a fault trace might be, it was again Housner who applied basic mechanics to venture an answer: 50 percent of the gravitational acceleration would not be an unreasonable limit. We now have amassed many records from different parts of the world surpassing that value, but his observation that the ground motion in the immediate vicinity of the fault rupture during a large magnitude earthquake is not necessarily as severe as might be assumed, and may be somewhat less than that at a greater distance depending on wave paths and local soils, is supported by measurements and observations. Following the concept of inelastic dynamic response of certain systems, Iwan described the dynamic response of one-degree-of-freedom bilinear hysteretic systems, and Clough and his co-workers extended the basic premise to earthquake response of tall buildings. Blume’s reserve energy concept can be seen in retrospect as sowing the seed of reducing elastic response with a factor that varies with the attained ductility, now a central concept of displacement-based engineering.
**Historic Context: The Technology of 1965**

There were several building construction trends in the early 1960s that affected earthquake engineering. Buildings relying only on their reinforced concrete moment-resisting frames, without extensive structural walls, became common, not only for one- or two-story structures but in some cities for many apartment buildings about ten stories tall. The Portland Cement Association, anxious to provide engineers with a textbook to assist them in their design of reinforced concrete buildings in seismic areas, commissioned Blume, Newmark, and Corning to prepare their seminal book.\(^{17}\) Tilt-up concrete panel construction in the western United States became very popular. Steel bridges and buildings, and industrial structures with steel frames, had been built up of riveted structural shapes since the turn of the nineteenth-twentieth century, with building frames often encased in concrete. By the time of the 3WCEE, welded and bolted connections were supplanting the use of rivets, and lightweight fireproofing replaced concrete or masonry protection of steel members. Architectural styles in many countries for centuries had made columns a central aesthetic feature, but from this era on, the column began to be minimized to free up floor plans, resulting in longer spans, larger members, and less redundancy. Building booms in many countries led to rapid development, sometimes too rapid for the earthquake engineering field to stay ahead of the trends and produce reliable designs.

A new trend began in the world of computers: networks of connected computer devices, rather than stand-alone machines. In 1963, the SABRE reservation system, running on IBM 7090 computers, connected up 2,000 terminals in 65 cities for an American airline.

**Historic Context: The Earthquakes**

Since the 2WCEE, only two earthquakes occurred that resulted in 1,000 or more fatalities: Iran (1962), and Skopje (1963). Again, earthquake engineers toiled in a field that had few news headlines to boost its cause. There were two other earthquakes that provided significant learning opportunities to the geotechnical study of earthquakes in this period, as discussed later,

---

because of what was learned about liquefaction: Alaska and Niigata in 1964. Because these earthquakes occurred near to the time of the 3WCEE in New Zealand, papers were not yet written on liquefaction and included in the 3WCEE Proceedings. Every WCEE proceedings since then, however, has given extensive coverage to the liquefaction topic.

![Image](image-url)

**Figure 11.** Liquefaction-caused loss of soil bearing strength in the 1964 Niigata Earthquake.
- Joseph Penzien, NISEE-PEER, University of California, Berkeley

4WCEE: SANTIAGO (1969)

Seismic ground shaking hazard assessment, and earthquake occurrence probability and seismic risk (outcome of the hazard), constitute an important range of activities that began developing in the 1960s to meet the design needs of critical facilities, preparedness, and insurance. They now constitute a major part of the earthquake engineering portfolio of research and implementation. Risk and hazard currently are clearly differentiated, but these terms were used synonymously initially. The 4WCEE papers by some of the pioneers of the field (Esteva and Vanmarcke) are a good measure of the degree of development that had been achieved thus far. The velocity of the ground
motion is convincingly identified as being a good index for its damage-causing capacity by Kanai. The stochastic analysis of inelastic systems attracts increasing interest, and it is argued by Ambraseys that the maximum ground velocity for an earthquake must be of the order of 100 cm/s, but high frequency accelerations that exceed 1 g are possible. This conference showed that the use of the shaking table as a research tool in earthquake structural engineering was becoming a reality (Sozen, Bouwkamp, Clough, Rea), and the trend in large-scale structural testing as a way of verifying the applicability of analytical models was enabled by modern testing equipment and data capture technology (Umemura, Aoyama, Bertero, Bresler, Paulay, Park). Papers by Idriss and Seed, and Whitman, brought the dimension of earthquake dynamics into the response of soil deposits.

**Historic Context: The Technology of 1969**

Computer capabilities had not yet been made available to most earthquake engineers. Not only had the technology of computers not begun its remarkable growth phase, when each year a desktop computer was on the market with even more impressive capabilities and at a lower price. In addition, the 1960s and even the 1970s, were eras when the computers were usually run by technicians, not directly by the user. Cards with holes punched in them by a device resembling a typewriter were stacked to provide the programming instructions to the main-frame computer, and only later did paper printouts come back across the counter to give the engineer results that could be used to refine an analysis or design. One had to learn a computer language and programming techniques, analogous to having to learn a foreign language. Some of the inventions needed to make the powerful personal computer of the 1970s a reality were in place, but not yet fully applied. The graphical user interface going by the name of the mouse was invented in 1964. In that year, at the World’s Fair, Sony unveiled a desktop calculator running on transistors. Its name, SOBAX, stood for solid-state abacus, and by comparison with today, it seems more related to the abacus than to today’s hand-held calculators, let alone desktop computers, though it was advanced in its day. Researchers at Bell Labs produced the UNIX computer language this year, but it was a little early for the development of structural analysis software, which became prevalent shortly after. ARPAnet, the forerunner of the Internet, was developed in 1969, a primitive version of the Internet today, but a working prototype nonetheless.
The first high-rise buildings were designed with the benefit of computerized seismic analysis in the late 1960s in three countries that were leaders in earthquake engineering innovations: the 36-story Kasumigaseki Building in Tokyo, Japan; the 20-story Civic Administration Building in Auckland, New Zealand; and the 43-story Wells Fargo Building in San Francisco and 40-story Union Bank Building in Los Angeles, in the U.S.A.

The modern shake table earthquake simulator began its evolution in these years, with one in use at the University of Illinois at Urbana-Champaign in 1967, and a smaller one at ISMES in Italy in 1968. This branch of the family tree of earthquake engineering experimentation extends back to the University of Tokyo in 1893 and Stanford University in 1906. The modern shake tables that date from the 1960s were not only more powerful than earlier ones, they were more refined with respect to the fidelity with which they could simulate earthquake motion. In Japan in 1967, construction of Tsukuba, the Science City, began, which in the 1970s included major earthquake engineering facilities that are still a center for experimental research today.

**Historic Context: The Earthquakes**

Three earthquakes that had fatality tolls of 1,000 or greater occurred since the previous WCEE: Turkey (1966), Iran (1968), and China (1969). While the life loss was small in these events as compared to previous or later earthquakes in these countries, the recurrence of earthquake disasters in some countries such as these points out the risk posed by the co-location of seismicity and extensive populations, a problem that can continue for generations until earthquake engineering risk reduction measures are implemented. The 1967 Caracas Earthquake was perhaps the most instructive event in this period, because it gave the structural engineers lessons regarding the collapse of mid-rise reinforced concrete frame buildings, while the geotechnical engineers studied soil effects that caused amplification of ground motion.
Figure 12. Complete collapse of an 11-story building, 1967 Caracas Earthquake.
- NISEE-PEER, University of California, Berkeley

Figure 13. Correlation of damage to taller buildings in Caracas with soil depth.
- NISEE-PEER, University of California, Berkeley
**5WC EE: ROME (1974)**

The dynamic properties of structural systems can be identified from recordings made during their oscillations. This knowledge is necessary for control of the response, and is obtained by a successive optimization procedure that reduces the difference between computed and measured response. Among papers presented in Rome we see the signs of this research area developing. Seismic response of storage tanks with flexible walls was examined by Veletsos, and inelastic response of complex systems was the focus of several papers by Powell, Wilson, and Bathe. Whitman introduced the damage probability matrix to earthquake engineering, an early probabilistic development for loss estimation studies.

**Historic Context: The Technology of 1974**

The ubiquitous “at” symbol (@) we see in email everyday made its debut in 1971, though for most, email was only to be available in the 1980s or early 1990s, and the personal computer that was needed to make email and the World Wide Web practical tools for most engineers as well as others was not to be mass produced till the 1980s. In 1972, MIT students invented SpaceWar!, merely a computer game, not a useful tool, but it demonstrated that a person and a computer could interact instantly, without the “priesthood process” of punch cards being handed off to be processed by technicians in another room. 1970 is a convenient benchmark in the history of computer software in the earthquake engineering and civil engineering field in general, for that was when SAP was introduced by Edward Wilson, who commented that it “is one of the most powerful and efficient programs for the linear elastic analysis of complex structural systems that has been developed to date. Nevertheless, I am sure it will be obsolete within five years.” True, the original SAP became obsolete, but versions on through to today have kept it an up-to-date tool for the engineer. Other computer programs for structural analysis in the early 1970s included DYNA – STARDYNE, EASE, ELAS, FRAN-HOUSEM, DYNAL, STRUDL, NASTRAN, SAMIS, and STRESS.

---

The large (6.1 m x 6.1 m) shake table at the University of California at Berkeley was in use in 1972, relatively briefly holding the record for the largest and most sophisticated such device in the world. Japan soon established several that were even more impressive. Geotechnical research using small-scale soil models and centrifuges was pioneered at Cambridge University and by the late 1970s was being applied to earthquake engineering problems. In 1970, the steel plate shear wall was invented, resembling somewhat ship construction. In 1972, the eccentric braced frame was added to the vocabulary of the earthquake engineer’s kit of structural parts, the first structural system designed from inception to be earthquake-resistant. Pause for a moment to reflect on the fact that the other basic systems -- the moment-resisting frame, the shear wall, and the braced frame -- had all been introduced in building construction many years before, and all without thought of earthquakes. In this era, earthquake engineers began to invent their own devices and systems rather than to, in effect, retrofit the ones that had been designed with only gravity loading in mind.

**Historic Context: The Earthquakes**

The earthquakes with fatality tolls of 1,000 or more that had occurred since the last WCEE were: China (1969, 1970, and 1974), Turkey (1970 and 1971), Peru (1970), New Guinea (1970), Iran (1972), Nicaragua (1972), and Pakistan (1974). The greatest life loss (67,000) was from the Peruvian earthquake, with much of the devastation caused by a completely natural hazard, that is, the natural environment rather than collapsing buildings and other construction. Massive landslides on steep and very tall Andean mountain slopes completely buried some towns and all their residents. From a structural engineering standpoint, the Nicaragua earthquake was well-studied and provided lessons, some of the construction there having been designed using current seismic design codes from California and thus providing a test of those provisions.

With regard to strong ground motion records, the 1971 San Fernando Earthquake in California singlehandedly boosted the worldwide archive: 241 records were obtained. The number of records from this one earthquake was ten times the world total as of 1940 when the El Centro record had been obtained, and instruments had improved in quality as well over those decades. One of the 1971 accelerograms, obtained from the instrument at Pacoima Dam, had a 1¼ g peak ground acceleration. Engineers were
forced to re-calibrate their concepts of how hard the ground shook, and also how much earthquake resistance could be mobilized by their structures: in many cases, both were greater than had been assumed in previous decades. Rationalizing the demand and capacity sides of the equation to make the basis of seismic design more explicitly revealed to the engineer, as well as increasing the accuracy of results, was to remain a continuing challenge in the field.

Figure 14. The cylindrical metal shed in foreground housed the accelerograph at Pacoima Dam where over 1g of acceleration was measured in the 1971 San Fernando Earthquake.
- NISEE-PEER, University of California, Berkeley

6WCEE: NEW DELHI (1977)

It has been confirmed that, in addition to the influence of site geology, the azimuth also plays a role in shaping the ground motion. Arnold and Vanmarcke identified the phenomenon from records from the 1971 San Fernando event. Two companion 6WCEE papers dealing with different aspects of the ATC 3 Project by its leading researchers explained a substantially innovative way of quantifying ground shaking hazard in the U.S., and bring about an innovative approach to seismic design. The summaries given in the papers have served as the basis of much code development in the world since that time, especially with respect to the
so-called response modification or $R$ factors. Consistent hazard response spectra were discussed by Der Kiureghian and Ang, while Shibata and Sozen introduced the substitute structure concept as an equivalent linearization procedure for multistory systems.

Unique among the World Conferences, a prime minister was very personally involved in the event. Donald Hudson recalled that Prime Minister Indira Gandhi “gave the opening address. We had a very elegant tea party at her house for the conference officials where she thanked me very much on behalf of her father for starting the laboratory.” The laboratory Hudson referred to was at the University of Roorkee, and during its development, yet another prime minister, Indira Gandhi’s father, Jawaharlal Nehru, personally visited there to lend his support to the earthquake engineering program.

**Historic Context: The Technology of 1977**

The computers that were to be routinely used by engineers as of the end of the twentieth century were not quite yet available in recognizable form. The latest external storage device for small computers was the 5¼ inch diameter “floppy” magnetic diskette, storing 100 KB. Kilobytes was a term destined to soon become arcane, to be replaced by megabytes, and later by gigabytes and terabytes. At the time of the previous WCEE in 1974, hand-held electronic calculators had just been introduced, and in 1977, many engineering students could afford to buy one. A mere chronology of the development of computer technology in the 1970s might lead one to believe that engineers routinely used them as of this time, but a survey of structural engineering firms in 1975 found that the only computer or computer-like device widely used was the Olivetti Programma P101, limited to arithmetic operations and square roots, with 240 bytes of memory, which in year 2012 dollars cost $43,000.

---


**Historic Context: The Earthquakes**

Earthquakes with fatalities of 1,000 or greater since the previous WCEE were: China (1974 and 1976), Pakistan (1974), Turkey (1975 and 1976), Guatemala (1976), Indonesia (1976), and Romania (1977). Many of the lessons concerning the need for ductile design were learned and applied at least in initial form in codes in this decade. The 1976 Tangshan Earthquake in China was to cause the century’s greatest earthquake life loss. It coincided with the beginning of a new economic era in China, which led to that country’s construction boom and related rapid growth of earthquake engineering research and practice.

*Figure 15*. Computer Center, Bucharest, 1977 Romania Earthquake.  
- NISEE-PEER, University of California, Berkeley
7WCEE: İSTANBUL (1980)
The decade began with renewed vigor in our understanding and in analytically duplicating ground motion time series. The stochastic source model proposed by Joyner and Boore is now considered as the classic paper in synthetic ground motion generation. The propagation of elastic waves in layered media was reduced to a formulation analogous to structural analysis by Kausel and his colleagues, while Newmark and Riddell formalized inelastic design spectra on the basis of exhaustive studies of many different ground motion records. How well will existing buildings respond in a future earthquake? This question requires us to address issues of vulnerability and is challenging to answer. Umemura’s 7WCEE paper is one of the most consistent early approaches. Structural systems are subjected to the effects of two simultaneous horizontal ground motion components, so just how well do uniaxial load tests or computational models represent this reality? Two papers, one by Otani and his colleagues who tested column stubs under statically applied displacement trajectories, and the other by Oliva and Clough on a reinforced concrete frame model tested on a shake table, reach the same conclusion: under biaxial loading, rectangular columns showed decreased capacity and more rapid stiffness degradation. A marked degree of response interaction occurs when nonlinear motion involving changes in the section stiffness takes place. If there existed distinct weak and strong axes, the biaxial coupling occurred predominantly in the form of a significant strong axis influence on weak axis response.

Earthquakes cause damage to cultural property as well as the ordinary building stock, and much of this damage can be prevented by prior inspection and strengthening. Feilden wrote that historic buildings should be identified and fully documented before a possible earthquake using photogrammetry techniques. After an earthquake it is essential that an architectural conservator should be involved to prevent unnecessary destruction of what cultural property remains.
**Historic Context: The Technology of 1980**

The first of the desktop computers were now on the scene, though the introduction of the IBM PC slightly later in 1981 was the definitive early event in the popularization of that technology. In 1980, a then-impressive 5 MB hard drive was made available for desktop computers. Some important methods of earthquake engineering analysis had been conceptually developed back in the 1930-1950 era, such as the response spectral approach historically benchmarked by California Institute of Technology doctoral theses by Maurice Biot\(^1\) and George Housner\(^2\), and the finite element method developed by Clough and others. Only in the 1980s did these methods become practical tools for many civil engineers, because of computing advances.

**Historic Context: The Earthquakes**

Only one earthquake since the previous WCEE caused at least 1,000 fatalities: Iran (1978). That earthquake in Tabas provided a near-fault strong motion record that was to be often used in the future when a record was desired that induces large demands on structures. The life loss (20,000) in that earthquake demonstrated once again that some countries’ territories unfortunately coincide with high seismicity, subjecting them to the risk of repeated disasters.

\[\text{Figure 16. Displacement history, Tabas, Iran Earthquake strong motion record.}\]

**8WCEE: SAN FRANCISCO (1984)**

After 28 years, the World Conference returned to the San Francisco Bay Area in a well-attended assembly. The seven heavy volumes for the proceedings showed the incredible range of topics that earthquake engineering had then come to embrace. In recognition of the need to base seismic hazard


assessment on earth science parameters, Schwartz et al. collected empirical information anchored to earth science to allow reliable estimates of the maximum magnitude. A strong motion array had been established in Lotung, in the northern part of Taiwan, for purposes of both ground motion and structural studies. Records obtained from the array allowed strong motion measurements that were useful for judging coherence of the ground shaking over short distances, among other properties. The Lotung experimental site had been established as a joint research program between Taiwan and the U.S., with Bolt as one of its leading scientific coordinators. Such systematic measurements of ground motions during strong ground motions were important in understanding the intricacies of earthquake ground motion propagation. Setting up geometrically arrayed strong motion stations had been one of the key recommendations that came from an International Workshop on Strong-Motion Instrument Arrays that was convened in May 1978 in Hawaii. The recommendations and conclusions of this workshop included the following:

*Earthquake-threatened countries (should) individually and collectively initiate the immediate installation of minimal arrays of 10-20 strong-motion instruments at the sites identified by this workshop.*

The Lotung array yielded data that was used by many researchers for many years, providing a fresh insight to the intricacies of seismic waves and their interaction with the built environment. We now routinely use the shear wave velocity of the topmost 30 m layer of soil deposits as the index that characterizes sites. Joyner and his colleagues presented an 8WCEE paper that explained the justification of the approach. The Spectral Analysis of Surface Waves (SASW) technique was among new developments that were discussed in San Francisco. Also in focus were the performance of buried

---

pipelines and similarly extended infrastructure systems. Under the heading of Urban Vulnerability Studies, the determination of monetary losses and casualties for use in earthquake mitigation and response planning was included. Fires following earthquakes, and reconstruction planning in the urban context, were included as was human response in spontaneously organized community groups following disasters.

**Historic Context: The Technology of 1984**

Earthquake engineering laboratories in several countries now had high-quality shake tables for structural and geotechnical testing, as well as large strong walls for imposing simulated earthquake displacements on structures. Digital strong motion accelerographs came into use, debuting in the SMART-I array in Taiwan in 1980.

With regard to computers, the 1980s distributed the benefits of access to a computer to many more engineers than in the 1970s. The personal computer had arrived, and earthquake engineers now could do with great speed and capability what they had done with slide rules: make a trial design or analysis assumption, quickly get results and ponder them, and then refine their work in a creative process of iteration. Engineers did not farm out their complex calculations to centralized service companies or take their punch cards to the central university computing center and wait for results, which was as significant an advance as the increase in computing power the new computers brought.

**Historic Context: The Earthquakes**

In the time since the 7WCEE, earthquakes causing at least 1,000 fatalities occurred in Algeria (1980), Italy (1980), Iran (1981), Yemen (1982), and Turkey (1983). In most cases, the building stock affected was predominantly of reinforced concrete or masonry construction, or a combination thereof, demonstrating that especially with those kinds of materials, inadequate implementation of seismic design can be deadly.
9WCEE: TOKYO AND KYOTO (1988)

The development of stochastic wave models to simulate earthquake ground motions, and the use of empirical Green’s functions (data from small magnitude earthquakes combined to represent larger events), became products of synthetic ground motion studies. With still a decade to go for a comprehensive and computer-based urban seismic loss estimate tool to be available, reliable tools needed to be developed for building performance assessment. The N2 method of Fajfar for that purpose made a debut during this conference. These studies were to be building blocks for assessing the likely performance of urban building groups in scenario studies. One corollary of this development was the increased attention paid to repair and strengthening techniques for the existing building stock. The hysteretic nature of structural response can be identified from response measurements, so that more accurate computational models can be developed. Increased sophistication in experimentation (centrifuge tests on soils in the laboratory to simulate field conditions, hybrid test techniques requiring real-time on-
line control of the experiment) and greater emphasis on urban seismic risk modeling for tsunami hazard areas were among principal steps forward in the conference. The 1988 conference was noticeable also for evidence on the spreading use of base isolation devices for structural response control. Another novelty was the comprehensive Session or State-of-the-Art Reports that had been prepared by leading experts to put a perspective on the overall discussions. Socio-economic aspects and human behavior were now considered routine headings for conference themes, broadening and re-defining the frontiers of earthquake engineering.

**Historic Context: The Technology of 1988**

The Internet had now arrived in an accessible form for engineers, at least for email communications, especially if they worked in an academic environment. The World Wide Web was still a few years off in the future. The most demanding of computations, such as running a structure through a number of simulated earthquakes with the response history method, were now within the reach of a larger number of professors and their students, as well as some practitioners.

**Historic Context: The Earthquakes**

In the four years since the 8WCEE, there were four earthquakes causing at least 1,000 fatalities: Mexico (1985), El Salvador (1986), Ecuador (1987), and Nepal-India (1988). The earthquake that struck Mexico City was the most devastating, and it demonstrated in frightening form the phenomenon of dynamic response: ground motion with relatively small amplitudes but with a semi-harmonic character that tuned into the natural frequencies of mid-rise buildings and excited a number of them until they collapsed.
**10WCEE: MADRID (1992)**

The state-of-the-art summaries were given importance in the 11-volume printed 10WCEE proceedings in 1992. This was to be the last time delegates needed to carry with them the heavy books when the conference ended. When even a six-page length limit that had been placed for the papers still led to that many volumes, it was clear that the World Conferences needed to resort to other forms of information storage in the future.
Invited papers and Special Theme Reports were combined effectively for authoritative overviews on a broad range of topics that constituted focused research areas:

- B. A. Bolt: The state of the art in synthesis of strong ground motion for earthquake engineering
- W. D. Liam Finn: Effect of foundation soils on seismic damage potential
- J. M. Kelly: The implementation of base isolation in the United States
- A. Der Kiureghian: Structural reliability methods for seismic safety assessment
- M. Watabe, K. Dan, T. Sato and T. Okumura: Microzonation and disaster mitigation
- O. C. Zienkiewicz and M. Pastor: Computational mechanics and earthquake engineering
- F. Darve: Constitutive relations for dynamic soil behavior
- T. Katayama: Recent developments in lifeline earthquake engineering
- A. Giuffrè: Seismic safety and strengthening of historical buildings and urban fabrics
- P. E. Pinto: Earthquake resistant design: Research developments in basic and in normative research

The Madrid conference provided much evidence of the burgeoning field of structural control. Research and development for the control of structures and equipment during wind and earthquake through arrays of smart sensors and control mechanisms had been given a head start by the National Science Foundation in the U.S.A., and cooperative organizations were crafted as a result of collaboration with Japan. Consequently the IAEE Journal of Earthquake Engineering and Structural Dynamics was for a number of years also the official publication of the International Association for Structural Control. Other papers dealt with the identification of previously liquefied sites from Spectral Analysis of Surface Waves (SASW) measurements, understanding the behavior of ultra-high-strength concrete structural components, replacement of the force-based seismic design paradigm with
a displacement-based one, prediction of mortality in building collapses, and portfolio dispersal for earthquake insurance.

**Historic Context: The Technology of 1992**
The World Wide Web was a tantalizing possibility in the minds of some computer scientists as of then, with HyperText Markup Language (HTML) developed in 1990, but the Web was still a few years off in the future as a benefit routinely used by engineers and the general public. The portable document format (pdf) was introduced in 1991, though it was not widely used till the mid 1990s.

**Historic Context: The Earthquakes**
The earthquakes since 9WCEE with at least 1,000 deaths were Armenia (1988), Iran (1990), Philippines (1990), and India (1991). The Armenia earthquake demonstrated that a single earthquake could cause a truly national impact, with the losses of life and property representing a large percentage of the nation’s resources. Proportional measures of earthquake loss are as important as absolute measures, and some countries are faced with the “all the eggs in one basket” national scale of earthquake risk.

![Figure 19. Collapsed 3-story precast concrete building in Leninakan; collapsed 9-story building at right, 1988 Armenia Earthquake. - C. J. Langer, U.S. Geological Survey](image)
This conference followed two major urban earthquakes in modern cities (Northridge near Los Angeles in 1994 and in Kobe near Osaka in 1995) that left a large imprint on the course of earthquake engineering. It was also the first time when delegates were handed a small box with several CDs that contained the conference papers in electronically stored format. Yet, no sooner does technology solve one problem (replacing the heavy books) than it creates another (the CDs now require computer geniuses to search through and read them due to changes in hardware and data retrieval software).

The conference heard the following state-of-the-art papers that had become a unique feature of the conferences, and each delivered by an acknowledged authority, capturing the spirit of the time:

- C. Arnold: Architectural aspects of seismic resistant design
- J. L. Beck: System identification methods applied to measured seismic response
- V. V. Bertero: State-of-the-art-report on: Design criteria
- A. K. Chopra and J. C. de la Llera: Accidental and natural torsion in earthquake response and design of buildings
- E. Faccioli: On the use of engineering seismology tools in ground shaking scenarios
- W. T. Holmes: Seismic evaluation of existing buildings
- G. W. Housner and S. F. Masri: Structural control research issues arising out of the Northridge and Kobe earthquakes
- R. Riddell and J. C. de la Llera: Seismic analysis and design: current practice and future trends
- S. K. Singh: Advances in seismology with impact on seismic hazard estimation
• M. Tomazevic: Recent advances in earthquake-resistant design of masonry buildings: European prospective
• R. Villaverde: Earthquake resistant design of secondary structures
• D. E. Geis: Developing seismic resistant communities
• T. P. Tassios: Advances in earthquake-resistant design of concrete structures
• T. D. O’Rourke: Lessons learned for lifeline engineering from major urban earthquakes

Borcherdt discussed implications for site-specific design factors from strong ground motions generated by the Northridge and Hanshin-Awaji (Kobe) earthquakes, which occurred a year apart. Improvements in site-dependent design spectra for code provisions were then underway, and records from a variety of site conditions from both events provided a useful calibration opportunity. We also see that the use of GIS technology for hazard mapping and insurance industry purposes had become firmly emplaced. Increased sophistication of models for nonlinear dynamic analysis, use of confined masonry as an effective way of improving the performance of masonry buildings, and seismic isolation were among the highlights of the conference. The economic consequences of earthquakes are notoriously difficult to assess. Using data from the first ten weeks following the Kobe disaster, Chang focused on lifeline disruption to come up with a figure to describe its economic impact.

**Historic Context: The Technology of 1996**
The advent of the Netscape World Wide Web browser in 1994 can be taken as the beginnings of the current era in which the Web is so functional and accessible that it is taken for granted. Earthquake engineers began to access their literature via the Web, and papers and reports were commonly being published as pdf electronic documents. Going to a library in person to look at an article in a journal was no longer necessary. One could work far from an engineering library, search rapidly to find relevant literature, and begin to read it within a minute – a utopian dream only a few years before.
Historic Context: The Earthquakes

Since the 10WCEE, earthquakes with at least 1,000 fatalities occurred in Indonesia (1992), India (1993), Japan (1995), and Russia (1995). The earthquake in India had the greatest toll, another instance of a large population living in relatively non-earthquake-resistant construction. The event in Japan, the Great Hanshin Earthquake, which focused its destructive energy on the large city of Kobe, showed that even in a nation that had long played a leading role in earthquake engineering research and practice, losses could be great. Severe damage even occurred to some construction with vintages as late as the 1970s and early 1980s, recent enough to have been built according to modern seismic code provisions that had been updated every few years, a class of construction which was often assumed to be earthquake-resistant. The damage to the port of Kobe, one of the world’s largest, showed the need to apply the knowledge of earthquake engineering geotechnical and infrastructure experts to those facilities. The Northridge Earthquake in California, while having a small number of fatalities, also pointed out that there were vulnerabilities even in recent, code-conforming construction, such as welded moment-resistant steel frames.

Figure 20. Collapse of Ferry Port in Kobe, 1999 Great Hanshin or Kobe Earthquake, caused by underlying soil failure.
- NISEE-PEER, University of California, Berkeley
The state-of-the-art presentation on performance-based design confirmed the drastic reappraisal that had taken place over the last ten years that preceded this conference. A shift was underway toward displacement-based design provisions. From the inception of the equivalent static lateral force method that began to evolve in Italy and Japan around 1900, and on through many decades, the force-based approach was the standard one. The displacement-based approach also was becoming commonly used as a realistic way to assess building risk and decide how, or whether, to retrofit them. Many countries are burdened with substandard buildings due to a variety of reasons, and governments are under pressure to reduce that risk by committing themselves to massive urban renewal schemes. Many aspects of earthquake engineering are directly related to risk assessment and retrofit, including performance-based engineering, characterization of the seismic hazard of ground shaking, performance of nonstructural systems, costs of retrofit, and public policy. The scope of this activity is broad and is intimately interlinked with our everyday lives. Methods for rapidly and systematically evaluating earthquake damage were being developed. GPS technology was becoming increasingly more accurate, so real-time monitoring of their oscillations was suggested as an attractive way of reaching a decision on the safety of continued use. Research focus had once again shifted to the effects of strong earthquakes in the near field where long-period velocity and displacement pulses tend to blur conventional thinking that had been shaped by “El Centro-like” ground motion records. Dense deployment of strong motion monitoring transducers was suggested as one approach for quick assessment of earthquake losses, and a model system for Yokohama was described. The design of urban space is critical for evacuation following disasters and was an urban planning topic discussed.

Historic Context: The Technology of 2000
The instrumentation used in earthquake engineering laboratories became more sophisticated, though two basic kinds of instruments, to measure strain (electric resistance strain gauge) and displacement (linear variable
differential transformer, LVDT) had been in existence since the late 1930s. The strain gauge that replaced mechanical measurement was co-invented by an earthquake engineering researcher, Arthur Ruge, while conducting shake table research on a scale model of an elevated water tank, while the LVDT came from the aircraft industry. Though both instruments operated electrically, it was not till the last decades of the twentieth century that the electronic revolution had matured to the point where laboratories could directly feed data from sensors to computers and make that information easily available to be archived and manipulated. Earlier analog-based laboratory apparatus, such as shake tables, came to be controlled by digital systems, and with digitized ground motion records providing the instructions to make the shake tables perform their motions, the hand-off of data from one setting to another was seamless.

**Historic Context: The Earthquakes**
In the four years since the 11WCEE, there were a large number of earthquakes that had fatality totals of 1,000 or more: Iran (two in 1997), Afghanistan (two in 1998), Colombia (1999), Turkey (1999), and Taiwan (1999). The last two earthquakes, occurring in major metropolitan areas with modern construction, were as instructive as they were destructive. Though both were large disasters for their countries, they were only indications of how much greater the loss would be if similar earthquakes occurred closer to their nation’s capital cities and largest urban regions, Istanbul and Taipei.

**Figure 21.** A transformer on rails overturned clockwise, 1999 Izmit or Kocaeli Earthquake.
- NISEE-PEER, University of California, Berkeley
The nonlinear static analysis procedures (of which the capacity spectrum is one) had developed rapidly in the 1990s as a practical way of assessing the likely performance of building frames when subjected to a certain level of ground motion hazard. Yet, it had been acknowledged that the methods lacked precision because some were graphical while others had been derived from studies on a limited number of variables or records, and might not converge to the correct target displacement under adverse conditions. The ATC 55 project that culminated in the FEMA 440 report was designed to address these shortcomings, and Comartin and his colleagues reported a preliminary description of the improvements. In the United States, the Network for Earthquake Engineering Simulation (NEES) supported by the National Science Foundation provided extensive test facilities at over a dozen university laboratories, and remote-presence was enabled for tests. Fault rupture hazard maps made an entry into the proceedings in this conference. The ultimate state of development in strong motion seismology would be when we can accurately simulate rupture processes of future earthquakes, including propagation path and site amplification effects on ground motion, and then, following the relation between ground motion and damage, arrive at an all-inclusive picture for mitigation. It follows that strong ground motion prediction is a key factor for mitigating disasters for future earthquakes. Irikura examined this intriguing prospect. For most engineering applications, it is not necessary that we know the exact time series for earthquakes that are yet to occur, but have some inkling about their amplitudes, durations and frequencies. A related question, examined by Strasser and her co-workers, is the need to establish upper bounds on seismic ground motion so that the statistical scatter-driven estimates for extreme ground motions with long recurrence periods can be capped.

**Historic Context: The Technology of 2004**

Though not the only useful kind of earthquake engineering laboratory apparatus, the shake table remained central to experimental research.
A sampling of 39 of the most significant shake table earthquake simulators at the end of the twentieth century found that three-fourths had at least two-degree-of-freedom or even six-degree-of-freedom capability, whereas two decades or more before, platforms translating along a single axis were more common.24

**Historic Context: The Earthquakes**
Earthquakes since the 12WCEE causing 1,000 or more deaths occurred in India (2001), Afghanistan (2002), Algeria (2003), and Iran (2003), countries listed many times above in previous time spans between the World Conferences. While earthquake engineering knowledge as of the end of the twentieth century was adequate to prevent most instances of collapse, applying that expertise to vast building stocks and where building code enforcement is minimal is a continuing challenge.

![Image of a damaged building](image)

*Figure 22. 2003 Boumerdes and Algiers, Algeria Earthquake.
  - Djillali Benour, University of Bab Ezzour*

---

14WCEE: BEIJING (2008)
This was the most populsously attended conference up to that time, with some 3,500 people in attendance, and with 3,041 published papers. The range of subjects that the papers and posters covered showed the increased sophistication of research in earthquake engineering. For example, how does a bridge engineer consider the effects of a rupture that occurs when the bridge traverses a fault line? Goel and Chopra examined the effects of statically imposed rupture displacement and dynamic displacements caused by ground shaking. A continuing debate among geophysicists and engineers has been about whether the extreme ground motions predicted for very long return periods are in fact physically achievable, or whether they stem from the residuals at the upper end of the lognormal distribution. This has far-reaching consequences for hazard studies for a class of critical structures.

A group of papers examined topics that later gained grim reality in Japan when the March 11, 2011 M 9.0 earthquake struck off the Tohoku coast. One paper by Iwabuchi et al. looked at the tsunami run-up database in Japan and tsunami risk for nuclear power plants. Motosaka and co-workers examined warning time availability in Sendai in the event of a subduction zone earthquake offshore.

The Beijing conference also heard papers on seismic risk assessment and its management: more than one hundred papers were devoted to the subject. Enough time had passed since the earthquake engineering field had begun to evolve for the 14WCEE to feature for the first time a special session devoted to papers written on the history of the field.

Historic Context: The Technology of 2008
In 2005, the E-Defense shake table in Miki City, near Kobe, was opened. By far the world’s largest and most powerful earthquake simulator, no facility of similar size and capability, and cost, has yet been planned to surpass it. While analytical capabilities in the field have grown greatly since 1956 when the first of the World Conferences was held, earthquake engineers
still rely on experimental research, or actual earthquake performance, to verify their computer modeling and calculations.

**Historic Context: The Earthquakes**
The most devastating (fatalities of 1,000 or more) earthquakes occurred in Indonesia (2004, 2005, and 2006), Pakistan (2005), and China (2008). The last two caused the most fatalities, over 80,000 each. The 2004 Indonesian Earthquake’s losses were predominantly due to the massive tsunami caused by the seafloor displacement of the event, and the effects caused damage and life loss in several countries of the Indian Ocean. The tsunami warning system that had been begun in 1946 for the Pacific had no counterpart in the Indian Ocean, pointing out the need for a more global application of earthquake engineering capability.

![Figure 23. 2004 Sumatra, Indonesia Earthquake and Tsunami.](image)
- *Herman Fritz, Georgia Institute of Technology*
Over 3,400 papers were written for this World Conference, a continuing sign of the growth of the earthquake engineering field. Set in Lisbon, the conference celebrated the 50th anniversary of the World Conference series and also had a historic connection extending much further back, for the 1755 earthquake there was one of the earliest to attract scientific attention to this natural hazard.

Historic Context: The Technology of 2012
While several earlier World Conferences were electronically based with respect to registrations, submission of abstracts and papers, and publication of the proceedings, the 15WCEE set a new mark in use of information technology to facilitate the international meeting. Information technology was likewise featured in the papers, such as data acquired via satellite to assemble construction inventories for pre-event hazard reduction or assessment of damage in the post-event emergency response phase. Web-based ways of quickly looking at an earthquake from a variety of topical standpoints had become more comprehensive as well as more seamless and easy to use as of 2012. The International Association for Earthquake Engineering as of 2012 was more actively engaged in using World Wide Web and other communication means to facilitate sharing of information.

Historic Context: The Earthquakes
Since the 14WCEE, earthquakes causing 1,000 or more fatalities occurred in Indonesia (2009), Haiti (2010), China (2010), and Japan (2011). The Japanese disaster was primarily a tsunami disaster, which was the cause of the damage at a cluster of nuclear power plants on the northeast coast of Honshu. The state of the art of forecasting the earthquake effects to be used in design proved fallible. Tsunamis had not been neglected in Japanese earthquake engineering, for there had been studies of that hazard, but the estimates proved to be under-scaled so significantly that the power plant seawalls were overwhelmed coastal defenses. In another country with advanced earthquake engineering, New Zealand, a similar cautionary point was made, when Christchurch was hit in 2010 and 2011 with much stronger shaking from a nearby earthquake and aftershocks than had been
estimated in the building code. Increasingly sophisticated probabilistic techniques were used in earthquake engineering to intelligently manage uncertainty about future earthquake shaking and other earthquake effects, but the Japanese and New Zealand earthquakes were reminders that uncertainty was nonetheless present in large amounts. In Chile in 2010, although a very large magnitude (M 8.8) caused moderate to strong shaking over a large area, losses were relatively small, demonstrating that the country’s implementation of earthquake engineering was on the right track. The strategy of combining architectural needs (acoustic separation, fire resistance, and durability of materials) with the structural goal of ample earthquake resistance, the latter in the form of extensive reinforced concrete walls, proved valid. Also as in past earthquakes, configuration irregularities such as soft stories were sometimes able to defeat the good intentions of seismic design.

Figure 24. Port-au-Prince, 2010 Haiti Earthquake, collapse of residential district.
- Marko Kokic, International Federation of Red Cross and Red Crescent Societies
7. CONCLUSION

The earthquake engineering field has grown greatly since the first of the World Conferences convened in Berkeley in 1956 with the rather modest aim of commemorating the fiftieth anniversary of the 1906 San Francisco Earthquake. The next conference in Tokyo in 1960 led to the formation of IAEE, the global home of national societies composed of individual professionals who collectively pursue the immodest aim of making the world better protected against the seismic threat. This means a continuous contest between humankind and nature, an unceasing effort to understand the effects of the sudden paroxysms in the crust of the earth that release the accumulated strain energy. Even if scientific and technological advances would enable us to construct the built environment such that we would be confident of its good performance during earthquakes in places where they are expected to occur, there remain daunting obstacles against achievement of that happy state of affairs. Economic or social constraints, human apathy or misunderstanding, unexpected occurrences of nature, or emergence of more pressing needs of growing urban societies make it impossible to throw a protective cloak of seismic safety over all the communities at risk. In many ways, we work today in this field with many more conveniences and technologies, and with well-established programs providing educational and research opportunities that the small number of people in the field in the early years could enjoy. It leads us to pause to pay our respects to our visionary predecessors who led the way, and to be thankful for advances in the field that they initiated that are sometimes taken for granted.

Also evident from the brief review here of devastating earthquakes is the fact that earthquake losses in many countries are far from being controlled to reasonable levels. The International Association for Earthquake Engineering continues to strive to achieve two complementary goals: an increase in earthquake engineering knowledge and capability, and more effective implementation of that expertise around the world. IAEE cannot do it alone, because research, development and clever ideas for a safer human environment are meaningless unless they are transformed into reality by governments at all levels. International organizations such as the United Nations and international financial institutions can lead programs that urge
governments to design and finance policies for disaster protection, but top-down programs are known to fall prey to shortages of funds, absence of technical capacity, divergent societal priorities, human conflict, and other manifestations of our non-ideal existence.

It is difficult to foretell what the next fifty years will mean for the role of IAEE. An elevated international profile, and closer cooperation with its member countries and other international associations that pursue the goal of better seismic safety, will guide its actions. Ultimately, IAEE is an association of professionals who perform their diverse responsibilities with perseverance toward their common objective. They are aware that with increased populations and rapid increases in construction in seismically hazardous regions, there are simply more assets in harm’s way. In many ways, we work today with the benefit of many more conveniences, technologies, and educational and research programs than were available to the pioneers in the earthquake engineering field. It leads us to pay our respects to our visionary predecessors who led the way. It is what we owe our successors.
APPENDIX 1
Prehistory of IAEE (1960 through 1963)

1. The Draft for the Recommendations for the Formation of an International Organization on Earthquake Engineering was circulated by mail prior to the Second World Conference held during July 11 through 18, 1960, in Japan.

2. The revised Draft, based on comments reached on the originally distributed draft, was distributed at the first Business Meeting held July 12, 1960. (Annex 1 to Appendix 1)

3. Recommendations for the Formation of an International Organization on Earthquake Engineering were adopted at the fourth Business Meeting held July 18, 1960. There were three important motions made during this Meeting. These were:

   (1) The Preparatory Committee of the Organization to consist of temporary members from each country who attended the Meetings.

   (2) It was resolved that K. Muto of Japan should serve as the Chairman of the Preparatory Committee.

   (3) A small (Steering) committee to be selected from the Preparatory Committee members to prepare a proposed draft for the International Organization on Earthquake Engineering and that members of the steering committee be selected by the Chairman of the Preparatory Committee.

4. K. Muto appointed the Delegates from Peru, Portugal, Turkey, U.S.A., U.S.S.R., and Japan to form a Steering Committee to prepare plans to be referred to the Preparatory Committee.
5. In May 1961, the Draft of the Statutes for the International Association for Earthquake Engineering (note the name was changed at some time between July 1960 and May 1961) was prepared and referred to the Preparatory Committee for study and comments. The amended draft of the Statues was completed in December 1961, which was approved and adopted in February 1962 by the Preparatory Committee.

6. As stipulated in the Statutes, each country was requested to form a National Committee and name a Delegate to represent that country. In order that IAEE be established as soon as possible to carry out its functions, voting for the Executive Committee members of the Association took place in January 1963. The President (K. Muto, Japan), Vice-President (J. Rinne, U.S.A.), Secretary General (K. J. Minami, Japan) and eight Directors (N. Ambraseys, United Kingdom, R. Flores, Chile, G. Housner, U.S.A., J. Krishna, India, V. Murphy, New Zealand, E. Rosenblueth, Mexico, C. Turner, New Zealand, and K. Zavriev, U.S.S.R.) were elected.

7. The Association formally began functioning on February 1, 1963. The number of countries affiliated with the Association as of May 15, 1963 were thirty one: Argentina, Austria, Brazil, Canada, Chile, El Salvador, France, Germany (East), Germany (West), Ghana, Greece, India, Indonesia, Iran, Italy, Japan, Lebanon, Mexico, New Zealand, Pakistan, Panama, Peru, Philippines, Portugal, Republic of China, Romania, Turkey, United Kingdom, U.S.A., U.S.S.R., and Venezuela.

NOTE:
*About in April 1962, the Preparatory Committee decided to hold the Third World Conference in New Zealand in February 1965.*
Annex 1 to Appendix 1
(Circulated by mail prior to conference for consideration and comment.)
Distributed at first business meeting of July 12, 1960 for discussion.

D R A F T

SECOND WORLD CONFERENCE ON EARTHQUAKE ENGINEERING

Tokyo and Kyoto, Japan – July 11 through 18, 1960

1. In view of the importance and bearing of Earthquake Engineering and the brilliant success of the First World Conference on Earthquake Engineering in Berkeley, California, June 1956, the participants of the Second Conference recommend unanimously the following procedure to be used in future international cooperation within the field of Earthquake Engineering:

2. An international standing committee for Earthquake Engineering should be established as soon as possible.

3. The object of this Committee should be to encourage international cooperation on research, development, and practical application of the Earthquake Engineering and to facilitate inspection of earthquake damage.

4. Every country, within which there has been established a national committee or a similar group for Earthquake Engineering, should have the right to nominate one delegate to this International Committee.

5. The national committees or groups should have the full right at any time to nominate, replace or withdraw their delegates on this International Committee, but when elected, the national delegates should be given powers to act in an authoritative manner on behalf of their national committees or groups.

6. The functions of this International Committee should in all normal cases be performed by correspondence, and no regular Committee meeting should be contemplated.
6. This International Committee should meet during future international conferences on Earthquake Engineering, but no decisions should be taken at such meetings, unless all delegates on the Committee have had ample opportunity to submit their written opinions or votes on the questions under consideration.

7. No decisions of a binding nature for the national committees or groups should be taken by this International Committee, except the decisions expressly stated below under 8 and 9.

8. This International Committee should receive and consider all invitations from the national committees or groups for future international conferences on Earthquake Engineering, and should thereafter decide upon the place and time of such conferences by consultation among all members of the Committee.

9. When the place and time of the next international conference has been decided upon in this manner, the national delegate from the host country of that conference should take over the chairmanship of the International Committee, relating this office until the conference in question has taken place or, if necessary, until a new chairman has been elected in connection with the following international conference.

10. The national delegates on the International Committee should function at all times as a focal point of contact between the national committees or groups. They should promote and encourage initiatives on international cooperation within their own countries and should also distribute to all other national delegates as much information as possible on research, education, development, and practical application of Earthquake Engineering, on the coming national conference, etc. At the same time they should receive similar information from the other national delegates and be responsible for the widest possible distribution of this information within their own country.

NOTE ON ART. 3

It is recommended that if a committee does not exist within a country capable of selecting a delegate fully representative of all interested societies or organizations, such a committee be organized.
APPENDIX 2
Officers of IAEE from 1963

2010-2012
President: **Polat Gülkan** (Turkey)
Past President: Tsuneo Katayama (Japan)
Executive Vice-President: Sudhir Jain (India)
Vice-President: Carlos S. Oliveira (Portugal)
Secretary General: Manabu Yoshimura (Japan)

2008-2010
President: **Tsuneo Katayama** (Japan)
President-Elect: Polat Gülkan (Turkey)
Executive Vice-President: Sudhir Jain (India)
Vice-President: Carlos S. Oliveira (Portugal)
Secretary General: Manabu Yoshimura (Japan)

2006-2008
President: **Tsuneo Katayama** (Japan)
Past President: Luis Esteva (Mexico)
Executive Vice-President: Polat Gülkan (Turkey)
Vice-President: Xie Lili (China)
Secretary General: Hirokazu Iemura (Japan)

2004-2006
President: **Luis Esteva** (Mexico)
President-Elect: Tsuneo Katayama (Japan)
Executive Vice-President: Polat Gülkan (Turkey)
Vice-President: Xie Lili (China)
Secretary General: Hirokazu Iemura (Japan)

2002-2004
President: **Luis Esteva** (Mexico)
Past President: Sheldon Cherry (Canada)
Executive Vice-President: Hiroyuki Aoyama (Japan)
Vice-President: Donald L. Anderson (Canada)
Secretary General: Hirokazu Iemura (Japan)

1996-2002
President: **Sheldon Cherry** (Canada)
President-Elect: Luis Esteva (Mexico)
Executive Vice-President: Hiroyuki Aoyama (Japan)
Secretary General: Tsuneo Katayama (Japan)

1992-1996
President: **Thomas Paulay** (New Zealand)
Executive Vice-President: Jose Grases (Venezuela)
Vice-President: Roberto Meli (Mexico)
Secretary General: Tsuneo Katayama (Japan)
1963-1965  President: Kiyoshi Muto (Japan)
Executive Vice-President: John E. Rinne (USA)
Secretary General: John K. Minami (Japan)

1965-1969  President: John E. Rinne (USA)
Executive Vice-President: Charles W. O. Tumer (New Zealand)
Secretary General: John K. Minami (Japan)
Secretary: Reuben W. Binder (USA)

1969-1973  President: George W. Housner (USA)
Executive Vice-President: Rodrigo Flores (Chile)
Vice-President: Giuseppe Grandori (Italy)
Secretary General: John K. Minami (Japan)
Secretary: Paul C. Jennings (USA)

1973-1977  President: Emilio Rosenblueth (Mexico)
Executive Vice-President: Jerry F. Borges (Portugal)
Vice-President: Jai Krishna (India)
Secretary General: John K. Minami (Japan)

1977-1980  President: Jai Krishna (India)
Executive Vice-President: Donald E. Hudson (USA)
Vice-President: Rifat Yarar (Turkey)
Secretary General: Yutaka Osawa (Japan)

1980-1984  President: Donald E. Hudson (USA)
Executive Vice-President: Hajime Umemura (Japan)
Vice-President: Joseph Penzien (USA)
Secretary General: Yutaka Osawa (Japan)

1984-1988  President: Hajime Umemura (Japan)
Executive Vice-President: Jakim Petrovski (Yugoslavia)
Vice-President: Keizaburo Kubo (Japan)
Secretary General: Yutaka Osawa (Japan)

1988-1992  President: Giuseppe Grandori (Italy)
Executive Vice-President: Luis Esteva (Mexico)
Vice-President: Alfonso Lopez-Arroyo (Spain)
Secretary General: Tsuneo Katayama (Japan)
APPENDIX 3
Member Countries of IAEE as of 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>Japan</td>
</tr>
<tr>
<td>Argentina</td>
<td>Korea</td>
</tr>
<tr>
<td>Armenia</td>
<td>Macedonia</td>
</tr>
<tr>
<td>Australia</td>
<td>Mexico</td>
</tr>
<tr>
<td>Austria</td>
<td>Montenegro</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Myanmar</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Nepal</td>
</tr>
<tr>
<td>Canada</td>
<td>New Zealand</td>
</tr>
<tr>
<td>Chile</td>
<td>Nicaragua</td>
</tr>
<tr>
<td>China</td>
<td>Norway</td>
</tr>
<tr>
<td>Colombia</td>
<td>Pakistan</td>
</tr>
<tr>
<td>Croatia</td>
<td>Peru</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>Philippines</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Portugal</td>
</tr>
<tr>
<td>Egypt</td>
<td>Romania</td>
</tr>
<tr>
<td>El Salvador</td>
<td>Russia</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Singapore</td>
</tr>
<tr>
<td>France</td>
<td>Slovenia</td>
</tr>
<tr>
<td>Germany</td>
<td>Spain</td>
</tr>
<tr>
<td>Ghana</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Greece</td>
<td>Chinese Taiwan</td>
</tr>
<tr>
<td>Hungary</td>
<td>Thailand</td>
</tr>
<tr>
<td>Iceland</td>
<td>Turkey</td>
</tr>
<tr>
<td>India</td>
<td>Ukraine</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Uganda</td>
</tr>
<tr>
<td>Iran</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Israel</td>
<td>United States of America</td>
</tr>
<tr>
<td>Italy</td>
<td>Venezuela</td>
</tr>
</tbody>
</table>
Pavia Risk Centre (PaRC, www.paviariskcentre.org) refers to a knowledge hub located in the North-Italian city of Pavia, where several organisations with various areas of expertise work within the same vicinity on a common aim: profound understanding of different types of risk, natural and man-made, in order to develop approaches, technologies, systems and solutions to reduce the overall consequences of these events.

Amongst PaRC core institutions there are:

The Eucentre Foundation (www.eucentre.it) has the scope of promoting, supporting and sustaining research and education in the field of seismic risk mitigation. Key target activity areas include:

- Applied research in the field of earthquake engineering, aiming at improving existing practise in assessment and reduction of seismic vulnerability and risk;
- Support work towards the development of guidance documents for both practising engineers and governing bodies, bringing international state-of-the-art into national design codes and regulations;
- Training of engineers and technicians in the field of earthquake engineering, with specialisation in areas such as seismology, geology, geotechnical engineering, material response, structural analysis and design, vulnerability assessment and emergency management;
- Scientific and technological consultancy, at both national and international levels, always in the field of earthquake engineering.

Eucentre runs the high performance experimental laboratory TREESLab, allowing both dynamic and static experimental research to be conducted on full-scale prototypes.
Reliable risk assessment tools and data are out of reach in many areas of the world and there is a lack of global best practice that would allow us to compare risk and risk assessment approaches, whereas recent events have taught us that we need to work together globally to better understand the behaviour and consequences of earthquakes. The Global Earthquake Model (GEM) was created to bridge this critical gap, and thereby support risk awareness and actions that increase resilience. GEM is a global collaborative effort with the aim to provide organisations and people with tools and resources for transparent assessment of earthquake risk anywhere in the world. The non-profit and independent GEM Foundation drives the GEM effort through a public-private partnership; its headquarters are in Pavia, Italy (www.globalquakemodel.org).

UME Graduate School
understanding and managing extremes

The UME School (www.umeschool.it) provides a system within which Masters and Doctoral candidates can study, understand and deal with extreme events. The UME interdisciplinary programmes focus on three main areas:

• **Disaster risk assessment**, focusing mainly on natural hazards such as earthquakes, hurricanes, fires, landslides and floods;

• **Extreme situation management**, which includes topics of statistics and probability, law, economics, resource management, finance, insurance, sociology, ethics and medicine;

• **Engineering for risk mitigation**, which includes topics on engineering to increase the capacity of buildings and infrastructure to withstand the demands from extreme events.

At the UME School, each course is intensively taught in English over a period of one to four weeks, during which the respective lecturer is able to fully dedicate his/her time and efforts exclusively to the scholastic activities at the School, thus ensuring teaching and research training at the highest possible levels of quality. The teaching body consists of international experts representing a large number of top academic institutions from all over the world, also perfectly reflecting the multidisciplinary and international nature of the School.

Since 2002, the IUSS Press has published state-of-the-art works in the field of research and education related to extreme events, risk mitigation as well as engineering solutions and technologies. Books, manuals, research reports and journals are printed in the most efficient way and are distributed worldwide through the e-commerce website www.iusspress.it. The journal “Progettazione Sismica”, devoted to different aspects of seismic design, focuses on the Italian reality and publishes special issues in English on topics of worldwide interest such as the 2009 L'Aquila and the 2012 Emilia Earthquakes.

Authors, all of which are international renowned experts, publish with the IUSS Press in order to see their manuscripts publically available in a short time, with very high quality. Furthermore, the IUSS Press provides a higher royalty to authors compared with standard practice.