

LEARNING FROM EARTHQUAKES

The EERI Learning from Earthquakes Program: A Brief Synopsis of Major Contributions

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The EERI Learning from Earthquakes Program: A Brief Synopsis of Major Contributions

The Learning from Earthquakes (LFE) Program of the Earthquake Engineering Research Institute has been funded by the National Science Foundation since 1973. At the heart of this program are the multidisciplinary reconnaissance teams that are sent out to damaging earthquakes around the world, bringing back observations and lessons for the professions (see Appendix 1 for a complete listing of the earthquake investigations and reports that have been generated through this program). In these 30+ years, many important advances in engineering, earth sciences, public policy and the social sciences have resulted from initial observations made by these reconnaissance teams. These advances range from increased understanding in the basic science of earthquake ground motions and fault mechanics to fundamental changes in our building codes and construction practices, based on observations of building performance in earthquakes, and to improved procedures in preparedness, response and recovery. The LFE Program is widely appreciated in the broad earthquake science and engineering community. In addition to its direct impact on earthquake engineering practice, it has provided problems, benchmarks, education, and calibration and verification of methods to nearly every earthquake engineering research activity.

Close to 180 reports or dedicated journals on individual earthquakes have been produced as part of this program (Appendix 1), and several other EERI publications summarize or reference many pertinent lessons, for example: *Contributions of Earthquake Engineering* (draft, EERI 2004); *Securing Society Against Catastrophic Earthquake Losses* (EERI 2003); *Practical Lessons from the Loma Prieta Earthquake* (National Research Council 1994); *Reducing Earthquake Hazards: Lessons Learned from Earthquakes* (EERI 1986); and *Lessons Learned from the 1985 Mexico Earthquake* (EERI 1989).

The following nuggets, provided by a broad group of researchers and practitioners representing the many disciplines in the LFE program, summarize some of the LFE Program's recent contributions and address its broader impacts.

Broad Societal Impacts

Continuous growth in knowledge

Over time, the LFE program has produced a systematic, continuous collection of reports, summarizing lessons learned from domestic and international earthquakes, all of which contribute to continuous growth in fundamental knowledge in various disciplinary fields. In developing countries, state-sponsored reconnaissance efforts are often minimal or non-existent. LFE/NSF dispatched teams to the regions often provide the only systematic collection of perishable data in numerous countries throughout the world. In addition, the LFE program has continued to build the knowledge base between U.S. events by turning the horrible losses in earthquakes abroad into lessons for future U.S. research and practice.

Some international earthquakes, most recently Turkey and Taiwan, are seminal scientific and engineering events because they were near the design levels required for most seismic areas of the U.S. In addition, they struck modern industrial areas, allowing evaluation of performance of facilities that have not been tested by such large earthquakes during the last 30 years.

Informed opinion to support public policy on disasters

Many important public policy changes have been based on knowledge gained during reconnaissance investigations, often beginning with changes in California, but ultimately being adopted by other states and the federal government as well. Such policies include stricter requirements for the construction of public schools and hospitals in California. Reconnaissance reports on damage to unreinforced masonry buildings in the Coalinga earthquake were used by the California Seismic Safety Commission when it worked with the legislature to develop SB 547, requiring identification of all such buildings in high seismic zones in the state. Reconnaissance reports on liquefaction failure in the San Francisco Marina District were used in support of the Seismic Hazards Mapping Program authorizing legislation.

Support for sustained and substantial retrofit program

The substantial retrofit of many older buildings and lifelines throughout the west is often based on documented findings from earthquake reconnaissance. Reconnaissance allows for the documentation of building failures and data with which to develop compelling arguments for building owners to engage in retrofits.

Maintenance of internationally competitive position; U.S. leadership in science and engineering

The LFE program provides the basic knowledge that U.S. scientists and engineers present to international forums and develop into further research activities. Establishing high visibility through reconnaissance teams after earthquakes is important to maintaining an internationally competitive position, particularly as other countries such as Japan aggressively support international reconnaissance teams.

Training for research and design professionals

Design is a process in which intuition is developed with experience. Unfortunately, intuition is only as good as the breadth of experience it is founded on. Design and research professionals who visit earthquake sites come away with a greatly enriched foundation for their intuition. Field reconnaissance is the most powerful teacher in earthquake engineering. Unfortunately, without funding, many research and design professionals will not be exposed to such a teacher. Their intuition will lead them to do what they have always done, missing the verification or negation provided by field observations. LFE provides an incentive to travel and gain the field experience. The subsequent improvement in intuition is automatic.

LFE is a mid-career professional training program. Prior to this program, only a few highly motivated professionals (Karl Steinbrugge, John Blume, Henry Degenkolb) who lived in San

Francisco within living memory of the 1906 earthquake, were motivated and knowledgeable enough to pursue field reconnaissance. Because earthquakes are infrequent, the research community must maintain societal and institutional memory between events. We have a responsibility to ensure that future generations have access to this knowledge and experience.

When younger professionals lack field experience, it can lead to a deterioration in seismic design and construction practices, perhaps acceptable in a country with infrequent earthquakes, but intolerable given the seismic risk faced by the U.S.

Building and maintaining a global network and promoting international collaboration

Successful reconnaissance investigations require the cooperation of local engineers, scientists, and policymakers in order to understand the context within which the earthquake, the emergency response, and the recovery are taking place. Over the years, EERI has become more widely known throughout the world for improving international collaboration of scientists and engineers. The resulting reports are rich in scientific context and depth, and the relationships that have been established will be critical in future earthquakes.

Such cooperative reconnaissance efforts often lead to longer-term international collaboration, a stated goal of the National Science Foundation. For example, a Peruvian reconnaissance team member is now studying for a doctorate at Drexel University under the direction of a U.S. reconnaissance team member. Upon completion of his degree, the Peruvian will return to his country and share the state-of-the-art understanding of earthquake engineering he obtained in the U.S. Similar relationships exist between researchers in Turkey, Italy, Mexico and India, and their U.S. colleagues. As noted by one U.S. reconnaissance team member:

"I attended a workshop-style program to enhance collaboration with researchers in Turkey, which turned out to be fruitless. The difference? Introductions during a twoday workshop cannot rival the intensity and trust that develops between researchers who are thrust into a collaborative reconnaissance environment."

Capacity-building in developing countries

Capacity-building is an indirect consequence of reconnaissance collaborations, particularly in developing countries. India is a good example of the broader benefits of the U.S.-based LFE program. Indian structural engineers were involved in joint reconnaissance with U.S. investigators after earthquakes in their country in 1991, 1993, 1997, 1999 and 2001. Each of these field visits resulted in reports that met EERI's high standards. Participating in the earlier reconnaissance provided many Indian engineers with the needed experience to play a lead role in reconnaissance after the major 2001 earthquake. The team also produced a special journal issue. Perhaps most importantly, these engineers are now playing major roles in developing the earthquake risk reduction policies and training programs for their country.

Future directions and societal benefit

In addition to sending teams to damaging earthquakes and collecting data in as many disciplines as feasible, there are several new opportunities for the LFE program that will enhance its value further.

Potential field calibration of experimental models

NSF has invested significantly in the Network for Earthquake Engineering Simulation (NEES), developing nationally linked laboratories to share experimental data. The LFE program complements NEES by documenting field observations that capture real-world complexity (ground motion effects, effects of construction procedures, societal response). Understanding what actually happens in the field during real earthquakes is important in calibrating the experimental models and theories developed in the laboratory.

Need for more systematic approaches to data collection

In the last few years, the earthquake engineering community has vigorously embraced the concept of performance-based earthquake engineering (PBEE). Not only will structures need to be safe enough to withstand rare events, but also they must perform well from a serviceability standpoint for smaller, more frequent events. PBEE will have a large impact on design codes in the years to come. The LFE program is working to ensure that post-earthquake damage data are collected in a consistent manner.

In addition, an organized collection of damage and loss data after earthquakes, one of the tasks of the LFE program, is essential for loss estimation studies that are critical to stakeholders such as owners, renters, financial organizations, and insurance and reinsurance companies. Decisions affecting the public at large, including the earthquake insurance rate structure, are based on these studies. The accuracy of these studies is completely tied to the input of systematic damage and loss data.

Need to investigate smaller events

With NSF support, future reconnaissance teams can investigate smaller earthquakes, documenting the effects more systematically. Over time, a larger database of reconnaissance observations--including good performance and performance in different types of moderate events--will be critical in calibrating experimental tools and in understanding the effects of all kinds of earthquake forces on the environment.

Longitudinal studies

In 1998, EERI initiated the Lessons Learned Over Time (LLOT) series under the LFE program. The intent was to fund continuing investigations of earthquakes that could note important developments some years after an event, or re-evaluate what was originally observed in the light of new understanding and knowledge. In the three funding cycles, ten proposals were funded; the studies have contributed to our understanding of the dynamics of recovery and reconstruction. The complex, multidisciplinary and interdisciplinary challenges to recovery in India after the Maharashtra and Bhuj earthquakes, and in California after the Loma Prieta and Northridge earthquakes, have been chronicled and analyzed. The studies have been published in a series of reports by EERI. Prior to the LLOT program, this field of inquiry had received scant attention from the research community.

Structural Engineering

Basic engineering knowledge

Over the past 30 years, field reconnaissance has resulted in advances in basic engineering knowledge which, in turn, have influenced many aspects of structural design. Among the lessons we have uncovered are the following:

- Designing to code does not always safeguard against excessive damage in severe earthquakes.
- Well-designed, well-detailed, and well-constructed buildings resist earthquakeinduced forces without excessive damage.
- Poor construction practice and lack of quality control can lead to severe damage or collapse.
- Ground failures and large ground movements can cause severe damage and even collapse of otherwise well-built structures.
- Buildings that experience successive earthquakes may suffer progressive weakening or eventual collapse.
- Detailing for ductility and redundancy provide safety against collapse.
- An earthquake will find weak links in a structure and the lateral force resisting system must have a complete load path properly designed for seismic forces.
- Stiff elements that are not considered in design strongly affect the seismic response of a building.
- Horizontal diaphragms are essential for the distribution of seismic forces and diaphragms must be properly designed for all required load transfers to and from vertical elements.
- The stiffness of the lateral-load-resisting system has a major effect on structural and nonstructural damage.
- Irregularities in plan and elevation require special care in design.
- Soft stories create hazardous conditions.
- Inadequate distance between buildings can, but does not always, result in pounding damage.
- Elevators and stairways may suffer severe damage that blocks excavation.
- The weakest links in building systems are often the connections between structural elements.
- Collapse may result if the strength of nonductile elements is insufficient.
- Corner columns are vulnerable.
- Exterior panels and parapets need strong anchoring to protect life safety.
- Unreinforced masonry buildings usually perform very poorly.
- Reinforced masonry buildings usually perform well.
- Precast and prestressed concrete elements must be well tied together.
- The performance of cast-in-place reinforced concrete buildings depends on the type of structural system and the quality of the detailing.

• The intrinsic toughness of wooden buildings can be relied upon only when unsuitable configurations and undesirable combinations with other materials are avoided.

Key to building code development process

It is well-known that most building code changes and code improvements over the last 50 years have been the result of observations of earthquake damage. Data collected after an earthquake are critical to the building code development process today. Resultant codes have provisions that are quite prescriptive, they prohibit the use of certain materials or structural systems, and they require that certain structural systems must be configured and constructed in very specific ways. Often, these prescriptive criteria are quite detailed in describing the required characteristics of construction; therefore the requirements relating to these provisions are referred to as "detailing." Such provisions come directly from field observations and the reconnaissance reports generated by EERI following all significant earthquakes.

The other major basis for modern building codes is our scientific understanding of the phenomena that produce earthquakes, the nature of earthquake-induced ground motion, the response of structures to this ground motion, and the ability of structures to withstand certain types of damage yet continue to remain erect and protect the lives of occupants. Most of this understanding is also built on reconnaissance observations. The first two earthquakes listed here, while not directly supported by the NSF LFE program, led to important, long-lasting changes, which were built upon in the subsequent NSF program.

1964 Alaska earthquake

A very large earthquake that caused significant liquefaction and liquefaction-induced landslides. Redundant shear wall buildings performed well even while designed for very low seismic force levels. In contrast, a poorly detailed non-redundant shear wall structure collapsed. This was the first earthquake where a study of performance of non-structural building components was conducted, leading to attention of proper seismic detailing of these building elements.

1967 Caracas, Venezuela earthquake

The first earthquake where building damage was observed to be concentrated in areas of deep alluvial soil leading to the eventual soil factor in our building codes. The effect of masonry infill panels on structural performance was clearly observed, including building collapse where infill panels were not present in the ground story (soft story). The numerous concrete column failures demonstrated the importance of overturning moments and led to the elimination of the J-factor in U.S. codes, which significantly discounted overturning moments and forces in design. Numerous diagonal cracks in concrete beam to column connections led to research and present code requirements for beam to column joints.

1971 San Fernando earthquake

While not supported directly by NSF, a major reconnaissance effort took place after the 1971 San Fernando earthquake that resulted in many changes in the modern building code and led to the LFE program. Observed weaknesses in connections resulted in requirements

for positive direct connection of concrete and masonry walls to diaphragms. An additional seismic zone was added in regions with large active faults, with a requirement for 40% larger design seismic forces in these regions. The effect of site conditions on ground shaking intensity was rediscovered and reintroduced into the code in the form of an S coefficient within the base shear formula. The continued observations of the very poor performance of concrete frame elements not designed for ductile response led to 1973 code requirements that all concrete frame members designed to resist earthquake forces must be detailed for ductile performance. This represented a very significant improvement in the seismic safety of concrete buildings. The concept of Occupancy Importance Factors for important facilities and requirements for Special Inspection and Testing of lateral force-resisting systems were also introduced.

1972 Managua, Nicaragua

This earthquake, with fault breaks through downtown Managua, demonstrated the good performance of reinforced concrete shear wall buildings.

1976 Friuli, Italy earthquakes

Two separate earthquakes in May and September demonstrated the cumulative effects of damage when unrepaired buildings are subjected to a subsequent earthquake, including collapse of heavily damaged structures.

1979 Imperial Valley, California

Following the 1979 Imperial Valley earthquake, limitations on certain types of structural irregularities were introduced into the code, based on observations of damage to the Imperial County Services Building.

1985 Mexico City

Studies of the collapse of the Piño Suarez towers resulted in requirements to consider structural overstrength in the design of columns. Other studies led to revision of the site class coefficients used in the base shear formula, and to requirements for building separation to avoid widely observed and highly damaging pounding.

1994 Northridge

The Northridge earthquake provided as many important lessons as the 1971 San Fernando earthquake. It revealed the vulnerability of moment-resisting steel frames and light wood frame residential construction, two systems previously thought to be highly earthquake-resistant. It demonstrated that code provisions for anchorage of concrete and masonry walls to wood diaphragms in tilt-up and similar commercial/industrial construction were inadequate, despite revisions to these requirements following the 1971 San Fernando and 1987 Whittier earthquakes. The Northridge earthquake also highlighted problems arising from the lack of redundancy in many types of modern building construction, as well as poor practices in the design of some types of diaphragms in buildings. Reconnaissance identified tuck-under parking, certain precast garages, and thin-wall tube-braced frames as unacceptably vulnerable to damage. Finally, data showed the unusual characteristics of ground motion in the near field of the fault rupture and permitted special requirements for the design of near-fault structures to be added to the code.

Understanding building configuration

The performance of many of the larger buildings in Mexico City offered a natural laboratory to improve basic engineering knowledge regarding the influence of building configuration on seismic performance. Much of this information was perishable because the damaged buildings were torn down, but the LFE program ensured that the information was not lost. In a number of recent events, the regular configuration of buildings played an important role in their superior performance compared to irregularly configured buildings.

Importance of shear walls

In Nicaragua, Chile, Armenia, India, in earthquake after earthquake, researchers have noted that buildings with substantial shear walls performed with minimal damage, even when the quality of construction workmanship was poor.

Understanding ductility

In Armenia, researchers noted the absence of ductile detailing, inadequate connections and eccentricities in column bars at splices, all contributing to building failure. Buildings in the same general area with highly redundant lateral force-resisting systems and better interconnections performed, on the whole, well.

In Kobe, investigators noted that single family buildings with heavy tile roofs and old wood construction lacked adequate lateral strength to resist the 10-15 seconds of shaking in the 1995 earthquake. Older commercial and multifamily residential buildings of nonductile concrete frame construction also performed poorly

Basic engineering knowledge regarding soft first stories

Earthquakes over the last 30 years have confirmed the poor performance of buildings with soft first stories. Both Northridge and Kobe underscored earlier observations of poor performance of soft first-story construction. In Japan, these buildings commonly were a combination of commercial and residential uses, and in Los Angeles they were apartments over garages.

Contributing to basic engineering knowledge about differential performance

Reconnaissance affords the opportunity to analyze why two similar buildings perform differently in an earthquake, or why similar earthquakes can cause widely varying damage. Reconnaissance information from the August 1999 Kocaeli, Turkey (magnitude 7.4) earthquake indicated that about 15% of the structures were damaged. However, over 50% of the structures were damaged in a November 99 (magnitude 7.1) earthquake. An evaluation of building response during the two events is contributing to fundamental knowledge regarding structural behavior.

In addition, reconnaissance can contribute to understanding performance of retrofit structures. Buildings damaged in a 1995 Dinar, Turkey earthquake were retrofit and when an earthquake struck the same region in 1998 (Adana-Ceyhan), researchers were able to evaluate performance of these retrofit structures. Reconnaissance reports for both earthquakes support these lessons.

Developing retrofit approaches

Field reconnaissance after the Loma Prieta and Northridge earthquakes led to the development of retrofit standards for unreinforced masonry and tilt-up buildings. Existing unreinforced masonry buildings in Los Angeles received much attention. Investigators examined the relative performance of retrofitted vs. unretrofitted buildings. Field observations confirmed the improved performance of strengthened buildings throughout the city.

Improvements in wood frame construction

The CUREE Caltech Woodframe Project grew out of initial observations made during field reconnaissance, both after the Loma Prieta and Northridge earthquakes. This project coordinated engineering investigations and implementation activities to significantly reduce earthquake losses to wood frame construction, including larger apartment and condominium buildings; non-residential (e.g., school and commercial); and residential buildings--both existing and new construction. The project was funded by the Federal Emergency Management Agency (FEMA) through a grant administered by the California Governor's Office of Emergency Services.

Significance of nonstructural damage

Beginning with the 1964 Alaskan earthquake, field investigators began formal observation and documentation of damage to nonstructural building components. In addition to the performance of ceilings, partitions, building facades and elevators, the lack of anchorage and bracing of plumbing, mechanical and electrical equipment and distribution systems has led to detailed studies and code requirements for these elements. As the profession advances into performance-based design, this knowledge is essential to achieve higher performance levels during earthquakes.

Further observations in recent urban earthquakes in California, Japan, Iran, the Philippines, and Costa Rica have drawn increasing attention to the impacts of nonstructural damages on the operations of businesses and industrial facilities. Extensive damage to expensive equipment, and loss of functionality due to water damage or lack of power, has contributed to large economic losses. Recent field observations have underscored the potential for significant deaths and injuries in classrooms, theaters, and other common assembly areas from the failure of nonstructural elements. Today, building owners are placing increasing demands on engineers to assure building functions will not be seriously disrupted following earthquakes. This presents a serious challenge to architects, interior designers, and engineers.

Problems with steel moment frame buildings

Early field investigations in Northridge brought to light startling instances of damage to welded connections in steel moment frame buildings. Initially observed in buildings under construction, these failures were later found to be widespread throughout the affected area. Similar failures occurred in Kobe, a dramatic example of the utility of field investigations to uncover problems that demand immediate attention from the research community. This discovery has resulted in considerable new research and laboratory testing designed to improve our scientific understanding of the performance of welded connections and the implications for codes, design, and construction practices.

Development of the entire FEMA model building category system

FEMA has adopted 15 standard construction (Model Building construction) types to label the structural system of most buildings. This system is based on observations and information gathered during earthquake reconnaissance.

ASCE 31: A standard for the evaluation of existing buildings

One of the great mysteries of earthquake damage is why some buildings are not damaged as much as would be expected. In numerous earthquakes this phenomenon has been encountered, and led to ATC 14, the first attempt to document the source of damage in existing buildings and to propose an evaluation methodology based on actual earthquake observations. The method proved useful and was transformed into FEMA 178, then evolved into FEMA 310, and finally was approved as the ASCE 31 standard several years ago. It is in use throughout the U.S., as well as other parts of the world, and focuses attention on the building types that actually need to be strengthened, rather than on all that do not meet the current code. But, while it is a great improvement, it is still too conservative and will benefit from refinements based on observations in future earthquakes. The LFE program supports continued improvements. The long-term benefits can be measured in billions of dollars since more buildings that do not meet the code can be evaluated.

Better understanding of effects of masonry infill walls in developing countries

Reconnaissance after three or four of the recent earthquakes in India has shown researchers and practitioners around the world the potentially beneficial effects of masonry infill walls in multistory buildings. The conventional wisdom in developed countries has been to discourage the use of masonry infill in seismic regions, but the Indian earthquake damage has shown that masonry infill walls provide additional support in structures with rather poorly designed and constructed reinforced concrete frames. The added support is enough to keep the buildings from collapse. This observation has potentially huge life-saving implications in many developing countries.

Earth Sciences and Geotechnical Engineering

Advancing the basic science of seismology

Field observations of aftershock activity provide critical data that is used in clarifying the physical characteristics of the main shock. These data also provide a regional characterization of aftershock activity and a body of fundamental scientific knowledge that is used for evaluating future earthquake hazards.

Integration of seismological and geological field data has greatly enhanced understanding of the basic physics of the fault rupture process.

Advancing the science of geology

Post-earthquake geologic field investigations increase understanding of fault behavior space-time history of faulting, relationship to tectonic setting, and relationships to seismological features of earthquakes. Geologic field investigations improve the database, add to the physical understanding of the rupture process, and aid in the dynamic modeling of the rupture process.

Similarly, post-earthquake investigations have yielded data on fault rupture length, total fault length, geometry of fault slip, and other near-field effects such as patterns and locations of landslides, ground cracks, subsidence and local uplift. This information has been critical to the development of methods for estimating future earthquake magnitudes and for identifying the local character of permanent ground deformation and transient ground motions.

Geologic data from post-earthquake field studies are being used to provide input for dynamic modeling of faults, particularly in California. In areas with a history of low earthquake activity, post-earthquake studies are particularly useful in delimiting approaches to characterizing earthquakes from poorly known geologic settings.

Understanding site conditions

Investigations of damage patterns after the 1985 Mexico, 1988 Armenia, 1989 Loma Prieta and 1990 Philippines earthquakes, and analysis of strong motion records from the Loma Prieta earthquake, emphasized the significant role played by site conditions on amplification of ground motions and localization of earthquake damage. These observations point out the importance of incorporating the influence of local ground conditions into design decisions.

Analysis of strong motion records following the 1994 Northridge earthquake reconfirmed the significant role played by site conditions in the amplification of ground motion. Because the area was unusually well-instrumented, the records showed the possible role of directivity and large vertical accelerations in the subsequent failure of modern concrete parking structures. These observations emphasize the need to incorporate information on ground motion, directivity, and fault mechanism into design decisions.

Understanding liquefaction and landsliding

Reconnaissance investigations following the 1989 Loma Prieta, 1991 Costa Rica, 1995 Kobe, and the recent Niigata ken Chuetsu, Japan, earthquakes have created an extensive data base on damages caused by liquefaction and landslides to engineered buildings, bridges and pipelines, in some cases at relatively great distances from the earthquake rupture zone. These observations have contributed to our basic scientific understanding of regional/geologic conditions as well as local geologic and soil conditions and their behavior under earthquake loading. Data collected from post-earthquake reconnaissance investigation has led to much improved understanding of the liquefaction process. Reconnaissance observations, along with follow-up subsurface investigations at liquefaction sites, are the basis for procedures to evaluate liquefaction resistance of soils and potential for post liquefaction ground deformation.

In Kobe, investigators noted that extensive liquefaction, lateral spread, and differential settlement caused significant damage to port facilities, engineered buildings and bridges, waste and water systems. Field observations also indicated that deep pile foundations performed well, when designed to current standards.

The 1999 Taiwan earthquake generated two enormous landslides, at Tsaolin and Nankang, in the area that was strongly shaken. These landslides were 3 x 5 kilometers in dimension, i.e., half the size of the mountains on which they occurred. The Tsaolin landslide alone killed 35 persons. The debris of this landslide formed a natural dam and impounded an artificial lake, creating the potential for rupture during the monsoon season. Such a catastrophic rupture of a landslide-induced lake occurred in Taiwan in 1941 and killed scores of people. Lessons from catastrophic landslides fill gaps in our existing data sets and lead to the development of life-saving hazard mitigation tools useful in the U.S. and other earthquake-prone regions of the world.

Increasing basic knowledge about ground motion

The 1999 earthquakes in Taiwan and Turkey were watershed events for earth scientists and geotechnical engineers. Initial reconnaissance observations have led to further research projects which have advanced the state of knowledge exponentially. For example, prior to these two earthquakes, there were only eight ground motion recordings worldwide for earthquakes greater than M7 and at a distance of less than 20 kilometers from the fault. The Turkey earthquake generated an additional five recordings, almost doubling the information previously available, and the Taiwan earthquake generated an additional staggering 65 recordings. The mainshock in Taiwan and associated aftershocks greater than M6 were recorded by over 500 instruments. Ongoing analysis of these records has the potential of changing attenuation relationships, hazard maps, building codes, legislation and the general practice of earthquake engineering.

Understanding surface faulting

The 1999 Turkey and Taiwan earthquakes also produced surface fault ruptures that cut through urban and industrial areas. Engineered structures were subjected to large strike-slip

fault displacements in Turkey (up to 5 meters) and reverse faulting in Taiwan (vertical displacements and shortening of ground surfaces of several meters). Reconnaissance reports from these earthquakes demonstrate that all types of structures are vulnerable to severe damage from fault rupture and that set-back requirements in modern seismic safety provisions are essential for protecting public welfare and safety. The Turkey, Taiwan, and three U.S. earthquakes (1983 Borah Peak, Idaho, 1992 Landers and 1999 Hector Mine, California) show that the surface deformations associated with large fault ruptures can be difficult to predict, especially in fault step-over localities, on the hanging wall of normal and thrust earthquakes, and adjacent to the primary fault trace(s).

1989 Loma Prieta earthquake

The 1989 Loma Prieta earthquake provided a wealth of geotechnical information including ground motion data for various site classes at varying distances from the zone of fault rupture, as well as information on the performance of pile foundations and liquefaction. These observations led to the introduction of near-fault ground motion criteria, new site class definitions and coefficients, extensive detailing criteria for foundations, and requirements for consideration of potential ground failure. This earthquake also highlighted economic losses associated with earthquakes, spurred the introduction of several high-performance structural systems including base isolation and energy dissipation, and raised interest in performance-based design procedures.

Knowledge about crustal earthquakes

Recent experience with crustal earthquakes is limited to Taiwan (M7.2) and Turkey (M7.6). A magnitude 7.5 earthquake has constituted the basis for design, but it has been estimated with extrapolations that the Turkey and Taiwan earthquakes have called into question. Rupture directivity effects were more subdued than suggested by current models. Furthermore, there are implications for current models intended to represent moderate high frequency near-fault ground motions. Broadband digital recordings have provided the first reliable data on long-period ground motions close to a large earthquake.

Understanding soil/structure interaction

Several urban areas in the Turkey and Taiwan earthquakes have provided data on unique, invaluable soil-structure interaction phenomena, contributing enormously to the improved scientific understanding of these phenomena. The Adapazari region of Turkey provided an unusually important field laboratory for the study of earthquake effects that are poorly understood and are of great importance to U.S., Turkish, and international earthquake engineering practice. These effects include foundation settlement and tilting as a consequence of liquefaction-induced loss of bearing strength, response of a wide alluvium-filled valley (basin effects), and local ground response of soft, liquefiable sediments. Because soils and earthquake shaking are much the same in Turkey as in the U.S. and other parts of the world, procedures based on data from the Adapazari field site have already led to improved engineering criteria and safer and more economical design and construction, both in the U.S. and internationally.

Understanding effects of surface fault rupture on engineered systems

The Turkey and Taiwan earthquakes were both associated with surface faulting that ruptured through urban and industrial areas and affected hundreds of structures. These events provided a unique opportunity to assess first-hand how engineered structures respond to deformations associated with large strike-slip fault displacements (displacements of up to 5 meters in Turkey) and reverse faulting (vertical displacements and warping of up to 5 meters in Taiwan). These earthquakes, along with the Landers and Hector Mine, California quakes, show that the surface deformations associated with large fault ruptures can be difficult to predict, especially in fault step-overs and on the hanging wall adjacent to the primary fault trace(s). Advances in basic scientific knowledge can result from detailed studies of these events.

Understanding geological precursors

In Turkey there appeared to be precursors to the earthquake. There was a sharp increase in water temperature at the Yalova thermal baths, along with an increase in silt and mud. Fishermen reported seeing dead fish and shrimp by the thousands wash upon the coastline at about the same time. In Degirmendere, many residents who were awake in the early hours of the morning reported a bright luminescence in the sky minutes before the ground began to shake. Documenting these precursors through reconnaissance investigations is important to advancing the science of earthquake prediction.

Understanding tsunamis

Recently, there have been an unusually large number of damaging tsunamis: most tragically in the Indian Ocean on December 26th, 2004, but also in Nicaragua, Japan, and the Philippines. On July 12, 1993, the Hokkaido-nansei-oki earthquake and tsunami caused nearly two hundred deaths on the island of Okushiri, in the epicentral area, when a nearsource tsunami engulfed the Okushiri coastline. Field observations determined that local geology and bathymetry accounted for the extreme run-up reported at 31 meters in one location. Although the Japan Meteorological Agency issued its first warnings five minutes after the earthquake, residents reported seeing the first waves arrive with the shaking. Interviews with residents determined that a tsunami experience in 1983 led residents to seek higher ground immediately. This event sparked great interest in the U.S. in developing a real-time emergency tsunami warning program for a near-source event off the coast of California, Oregon, Washington, Alaska, or Hawaii.

Many important lessons regarding tsunami behavior and warning systems are expected to result from the staggeringly enormous losses associated with the December 26th magnitude 9.0 earthquake and tsunami. EERI, through the LFE program, is playing a major role in coordinating these lessons from teams in several countries.

2004 Niigata ken Chuetsu earthquake

Reconnaissance data from the LFE team studying the 2004 Niigata quake is still being analyzed at the time of this writing, but clearly landslide dynamics is a major focus. Because

of prior moisture from a typhoon, the ground in the epicentral area was saturated and the earthquake caused landslides of all types; some dammed streams, creating new lakes likely to overtop their new embankments at any moment and cause flash floods and mudslides; other landslides and permanent ground deformations damaged roads, rail lines and other lifelines, resulting in major economic disruption. The extent of landsliding is very large, and the reconnaissance team members are not aware of other earthquakes of similar magnitude that have caused such extensive slope instability. This emphasizes that risk of antecedent rainfall conditions should be considered in any evaluation of seismically induced slope instability. Seismically induced landslides under saturated ground conditions in the densely populated San Francisco Bay or Los Angeles areas would cause greater damages and many more casualties.

2001 Southern Peru earthquake

Data collected during the reconnaissance of the M_w 8.4 2001 Southern Peru earthquake are unique due to its large magnitude. These data will enhance empirical relationships used to correlate earthquake magnitude to liquefaction potential, lateral spreading, volumetric compression, and extent of seismic-induced landsliding. The first documented liquefaction in a heap-leach pad in a copper mine will undoubtedly lead to a re-evaluation of design procedures for such structures in seismic zones. Damage observations in highway fills, coupled with numerical modeling, have indicated basin-type amplification of seismic waves at a much smaller scale than similar effects observed in large-scale basins. Results from this research will improve risk evaluation methodologies for geotechnical structures and will contribute to our understanding of frequency scaling in basin effects. Researched sparked by the reconnaissance effort has led to the geotechnical characterization of ground motion sites, providing a set of well-documented ground motions for a mega-thrust event.

2003 Tecomán, Mexico Earthquake

Owing to their reliability and economy, the use of new geotechnologies such as geosynthetics and ground modification/reinforcement has become commonplace in the United States and abroad. While the performance of these technologies under routine static conditions has been well-demonstrated, their behavior in earthquakes remains poorly understood. Data collected by reconnaissance teams immediately after the Tecomán earthquake enhanced our understanding of the performance of different ground modification techniques and reinforcement schemes. This has translated into improved or refined design and analysis recommendations, with the net effect of increasing the costeffectiveness and reliability of several geotechnologies under seismic conditions.

Lifelines

As the performance of lifeline systems has become a recognized concern in earthquake design, emergency planning and post-earthquake recovery, engineering practices have changed. Post-earthquake reconnaissance reports have provided most of the available information on the extent of damage, lost service and needed repair. Investigations into 30+ earthquakes have resulted in changes in design practices, including anchorage details, welding practices, and materials. To ensure continued improved performance, it is critical to

document effects of earthquakes on lifeline systems, including systems that perform well, both in moderate shaking (Molise, Italy) and under maximum loading (Denali, Alaska). A more complete record of lifeline performance will help identify the necessary elements for seismically resilient systems.

Bridges and highway structures, gas and water pipelines all suffered significant damage in recent earthquakes. In the Loma Prieta earthquake, viaducts failed because of unconfined shear keys, inadequate joint steel, and variations in lateral stiffness. In Costa Rica, bridge failure was attributed to liquefaction of poor soils, inadequate pile lengths, and lack of redundancy. In the Philippines, liquefaction significantly affected waste and water systems, ports, roads, and bridges, calling attention to the need in seismic hazard areas to catalog potential liquefaction sites and to densify the soil to increase its bearing capacity where critical lifeline performance must be sustained. In Northridge and Kobe, field investigators observed a combination of contributing factors, many of which had been seen in previous earthquakes, including poor or variable site conditions. The Northridge earthquake tested bridge columns retrofit with post- Loma Prieta steel jackets, and showed their improved performance compared to nearby unretrofit columns. The Kobe earthquake demonstrated a failure of the bearings in new steel bridges that will undoubtedly influence bridge design in the future.

Fundamental scientific understanding of long-period ground motion effects

The Taiwan earthquake provided a wealth of ground motion measurements that can enhance our understanding of ground motion damage relationships for lifeline systems, including bridges and highways. Reconnaissance investigations suggested that engineers should re-think design parameters. Peak ground acceleration (PGA) or peak ground velocity (PGV) may not be the best ways to characterize ground motion in estimating damage to lifeline components. Spatial and temporal variation need to be included in characterizing ground motion.

Importance of redundancy

Damage to the power supply system in Taiwan exemplified the effects of lack of redundancy and the need for system analysis. A few key failures in transmission structures during the earthquake blacked out much of the country for many days. By studying the Taiwan power network we can learn what could have been done to minimize the impact, and what alternatives are available for faster recovery.

Social Sciences

Fundamental changes in social science research approaches

Since the inception of the NEHRP program in 1977, social science research and reconnaissance have increased in terms of knowledge, focus, clarity, sophistication and applications. Social science participation on LFE reconnaissance teams has played a major role in advancing knowledge in these fields of research. Mitigation, preparedness, and response are studied during reconnaissance investigations. Pre-disaster programs of public

education and awareness, land use management, building codes and practices, insurance, and forecast and warnings are reviewed. Emergency response and immediate relief are assessed. Subsequently, recovery and reconstruction can be studied with LLOT grants. The disciplines of reconnaissance team members have included psychology; geography; economics; policy analysis; sociology; history; economics; anthropology; social psychology; political science, architecture and planning, among others.

Reconnaissance provides framework for scenarios, disaster planning

Many of the observations from field reconnaissance are used to improve future disaster planning efforts. Documented experiences with initial response and recovery from around the world have been used in the design of disaster plans and programs in the U.S. in areas that have not recently experienced an earthquake. Reconnaissance observations are also used in scenario development.

Understanding cross-cultural impacts

The LFE program has made major contributions to understanding cross-cultural impacts of earthquakes, unique for a U.S.-based research program. However, social scientists understand the need for cross-societal comparisons in order to understand whether certain social phenomena are specific to a particular society or common to many. The LFE program has furthered knowledge of social dynamics related to earthquake disasters and, by extension, to other quick-onset disasters.

For example, we now clearly understand that societies across the world share many emergency response patterns, search and rescue for example. As a result of LFE studies, we know that the most effective search and rescue activity is neighborhood-based, involving informal groups of individuals who are on the scene because they live, work, or happen to be there. The Kobe earthquake highlighted the fact that locals serve as the primary and most effective rescue personnel in the immediate aftermath of an earthquake. It also reaffirmed the long standing adage that people must be able to function on their own for the first 72 hours after a major urban earthquake. This insight has led many U.S. communities to train neighborhood groups in basic search and rescue techniques, and has been incorporated into emergency preparedness plans throughout the world.

We have also learned that some self-protective behaviors in well-designed and built structures do not work in poorly built housing or housing that uses a completely different structural system—built with random rubble or stone, heavy roofs, poor lateral reinforcement. Directions for self-protective behaviors must reflect the specific nature of the risk.

The LFE program has also contributed to important basic knowledge about different social impacts of earthquakes. For example, it has furthered the understanding of the differential impacts of earthquake disasters in societies at varying levels of development. We now understand that industrialized societies such as the U.S. and Japan are far more earthquake-resilient than emerging countries such as Turkey, India or Iran. This important basic knowledge extends our appreciation of the relationship between disasters and development, and highlights the importance of sustainability.

Emergency response

In general, greater training and education of the public and relevant professions is critical. Attention in the past to preparing plans for immediate shelter, temporary housing, and longterm community reconstruction has been seriously inadequate. Recent large urban earthquakes have demonstrated the need for an integrated approach to building design, land use, and emergency planning in seismic hazard areas.

Following devastating losses in Armenia and other areas where soil conditions dramatically affected ground motion, liquefaction, architects and urban planners have come to acknowledge the need to work more closely with geoscientists and engineers to identify appropriate zones for redevelopment of entire cities.

Dramatic life loss in fires, housing collapse and soft-story failures in Kobe and Northridge emphasized the need to know more about how and why people die in earthquakes, the relative role of fire and other secondary hazards, and measures to improve the effectiveness of search and rescue techniques.

The Kobe earthquake underscored the importance of pre-event planning for response, mutual aid, large-scale shelter needs, temporary housing, and post-earthquake reconstruction. Reconstruction efforts in the months following the Northridge earthquake, while admittedly a much smaller event than Kobe's, benefited greatly from having a reconstruction planning process in place at the time of the earthquake.

Standardized emergency response procedures

The Loma Prieta and Northridge earthquakes, as well as other disasters such as the Oakland Hills fire, highlighted the importance of standardizing emergency response procedures, including the importance of standardized protocols for communications and the need for redundancy. The State of California Office of Emergency Services used reconnaissance team observations as a basis for the Standardized Emergency Management System (SEMS) used in California, which creates standard protocols for the various functions necessary in managing any kind of disaster.

Development of appropriate warnings

Reconnaissance investigations after the Loma Prieta earthquake documented the importance of an appropriate and easily understandable warning system for aftershocks. The State of California used observations from the reconnaissance to design message content for both aftershock warnings and forecasts of increased likelihoods for earthquake activity. The recent tsunami tragedy in southeast Asia will undoubtedly generate further lessons regarding warning systems and the appropriate distribution of such warnings.

Land use lessons from fault rupture

The Taiwan and Turkey earthquakes offered opportunities to study the effects of two types of fault rupture in urban areas. Many U.S. policies and regulations are based on

understandings of fault rupture which may change as new knowledge comes from these earthquakes. What are the implications for zoning, permit processes, local decisions regarding land use? How should we anticipate "shadowing" and near-field effects? Should the fault zone legislation in California be changed?

Recent emphasis on understanding recovery processes

LFE funding has enabled several reconnaissance teams to return to earthquake-affected areas several months to years after an event to document important lessons in recovery. Most recently, teams visited Bam, Iran and Gujarat, India. As noted by one researcher, "the Gujarat experience must be one of the largest-scale reconstruction processes attempted after a natural disaster, particularly unique because of the large area it encompasses, requiring institutional innovation. The intent to have a decentralized process and emphasize the building of local capacity was a good decision, and it appears to have been largely successful. This makes it an important model for all to learn from, in all parts of the world." The LFE program offers a unique ability to interest the social science community in this research direction by providing data that can be used for building more theoretical models of recovery.

Advances in provision of temporary shelter

Reconnaissance after recent devastating earthquakes, especially Kobe, Japan, highlighted the need for U.S. cities to identify strategies for providing large-scale temporary shelter. The Loma Prieta and Northridge quakes did not cause damage extensive enough to force large numbers of people into officially-established shelters; many sheltered with friends and family. However, Kobe illustrated what might happen in a more catastrophic event, prompting American Red Cross and local emergency officials to revise their plans.

Loma Prieta and Northridge did illuminate problems in the provision of temporary shelter and emergency food to various ethnic groups. Recent immigrants showed an unwillingness to go into buildings, or to eat food at shelters, that was understandable in light of where they had come from. Researchers were able to be in the field immediately, documenting these perishable phenomena. Many jurisdictions have made major changes in their plans for the provision of such services as a result of this reconnaissance.

Advances in provision of relief supplies

After both U.S and foreign earthquakes, LFE reconnaissance team members have noted the vast quantities of inappropriate donations that pour into an area, necessitating attention from emergency responders that would be better spending their time on other things. Protocols have been developed by organizations as diverse as the Pan American Health Organization and the City of Watsonville to handle donations more effectively.

Rapid information from a seismic network

In the Taiwan earthquake, receipt of rapid information from a sophisticated seismic network played an important role in early situation assessment at the national government level. An intensity map was produced within just over a minute of the earthquake, but no formal distribution of this information was made to emergency responders, who would have been able to identify and direct resources to highest priority areas. A similar seismic network has been developed in California, along with a capability to produce ShakeMaps shortly after a shock, and recent small or less damaging earthquakes have provided opportunities to test and improve rapid information dissemination procedures to the emergency community.

Information Technology

Reconnaissance in recent earthquakes has highlighted the increasing value of new information technology tools in observing and documenting damage and subsequent lessons. Through the LFE program, EERI is taking a leadership role in developing these tools further.

The use of satellite imagery

Recent earthquakes in Algeria, Iran, Japan and now the Asian tsunami and earthquake, have allowed investigators to begin to integrate high-resolution, quickly-available, satellite imagery with field reconnaissance. Many promising developments are emerging in this field, including the ability to quickly gain an overview understanding of the extent of damage. There are also promising future applications of such technology to creating building inventories, which would greatly improve our ability to collect more systematic data after an earthquake.

After the Bam, Iran, earthquake, EERI members from ImageCat, Inc. loaded before and after satellite imagery on the computers that were going into the field. While team members encountered logistical challenges in using the VIEWS (*Visualizing Impacts of Earthquakes with Satellites*) system (deploying a laptop in the field was problematic and difficulties were experienced keeping it charged), the experience proved valuable in understanding how the imagery could indicate areas of severe damage and how it could be used to track reconnaissance activities in the field.

Staff members from ImageCat, Inc. traveled to Niigata, Japan with the EERI reconnaissance team. VIEWS was deployed by car and on-foot, enabling large swaths of land to be videotaped rapidly before impacts were lost to clean-up. VIEWS also allowed the geo-referenced video to cross-reference GIS data such as soil or ground motion with those structures that had been tagged green, yellow, or red in the evaluation of building safety. The Niigata area experienced heavy rainfall just prior to the earthquake, resulting in hundreds of landslides during the earthquake in this water-saturated area. Satellite imagery provided an excellent view of the extensive landslides in areas often inaccessible by land. Operated in conjunction with a digital camera and digital video recorder, VIEWS can be used from either a moving vehicle or on-foot during a walking tour. ImageCat estimates that this technology-driven approach has increased efficiency 25-fold. Traditional survey techniques typically enabled 20 to 100 buildings to be surveyed in one day. Using VIEWS and satellite imagery, our field experts were able to capture damage data for an average of 2,500 buildings per day. Capturing this data digitally also produced a permanent visual record of damage sustained by individual structures.

LiDAR

Another tool, employed for the first time by an EERI reconnaissance team after the recent Niigata earthquake, is LiDAR (Light Detection and Ranging), a scanning-laser that can create high-resolution, three-dimensional, digital terrain models of earthquake-related ground, structural, and lifeline deformations. Used in Niigata, LiDAR allowed field researchers to collect data from a large geographic area that was inaccessible by foot or in unstable or otherwise dangerous areas. It also provided the ability to measure deformation accurately in a matter of minutes an area that would have taken hours or days to measure using traditional, hand-held devices.

Virtual Clearinghouse

Recent experiences in San Simeon, Parkfield and Niigata have reinforced the value of the web as a place to quickly store and disseminate data, essentially functioning as a "virtual clearinghouse". These recent earthquakes have highlighted the importance of gathering a representative sample of data, using digital photographs, each of which including the date, a geocoded location, a brief caption and information on who took the image. This information could be quickly uploaded to the "virtual clearinghouse" on the EERI website and made available to other researchers and the larger community.

In addition to photos, such a "virtual clearinghouse" could be populated with other geocoded data on a GIS platform, allowing investigators to upload a wide range of data (reports, notes and images) and store them on (if desired) a password-protected website. It would also allow investigators to communicate with each other, to post questions, comments, travel plans, etc.

As part of the development of the "virtual clearinghouse concept, EERI is currently looking into the use of Manifold®. Manifold® is an **integrated** system that simultaneously works with vector drawings, satellite and aerial photos, other raster images, raster data, multichannel remote sensing images, 2D and 3D surfaces and terrain simulations, multilayered maps, user supplied or automatically generated labels and a vast range of database table formats. It also has a built in Internet map server. This program would allow us to combine field information with a wide range of information from other databases, such as soil types, ground motion recordings, population density, building inventory, lifelines, etc.

Electronic data collection

EERI has also been working with Accela® (www.accela.com) to develop an electronic data collection and mapping system (ERS). The system provides electronic guide sheets or reconnaissance forms that can be installed on a laptop, desktop or handheld PDA, such as a Tablet PC or iPAQ (the system is Windows CE-based). The reconnaissance forms currently available at the EERI LFE website are being modified as guide sheets. Field investigators enter data onto a geo-referenced guide sheet. When Internet access is available, the completed forms are uploaded to a central server and the basic information can be displayed in GIS format to all users in near real-time. If there is no Internet access, the system is

functional on a stand-alone server, where data are held until they can be uploaded to the web-based server. One major advantage of this system is the ability to upload different sets of guide sheets and to modify guide sheets "on the fly". If questions are not relevant to the particular earthquake, the form can be modified by one of the field administrators and updated in everyone's system. An additional strength of the system is its ability to handle cataloguing and managing of data from multiple sources, and to export collected data to other platforms for further analysis.

EERI had an opportunity to test this system in the December 2003 San Simeon EERI earthquake in California and in the more recent earthquake in Niigata, Japan. Field investigators found the current version of the Accela®, system cumbersome and slow. They suggest that Accela®, would be most productive if used by teams of researchers, where one focuses on observations, while the other fills out detailed guide sheets. The Accela® system seems better suited for secondary data collection, in which there are a larger numbers of field investigators devoted to the systematic collection of data. Further work is being carried out to refine the Accela®, procedure and to improve data input for the "virtual clearinghouse".

Through the LFE program, EERI is taking a leadership role in the earthquake engineering community in developing, identifying and testing tools that will improve reconnaissance and enhance our understanding of the scientific and engineering processes at work in earthquakes.

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Date	Location	Magnitude	Response	Report	Comments
12/23/1972	Managua, Nicaragua	6.2	RT	RR 5/73	
8/28/1973	Veracruz, Mexico	7	RT		
10/3/1974	Lima, Peru	7.6	RT	RR 5/75	
3/27/1975	Pocatello, Idaho	6.3	EIC	NL 5/75, 7/75	
6/7/1975	Fortuna, Ferndale CA	5.2	EIC	NL 7/75	
8/1/1975	Oroville, CA	6	RT, CH	NL special report 9/75, NL 11/75	
9/6/1975	Lice, Turkey	6.8	EIC	NL special report 11/75	
11/29/1975	tsunami & eq, Hawaii	7.2	EIC	NL special report 2/76, 3/76	
2/4/1976	Guatemala	7.5	RT,DT	NL special report 2/76, NL 5/76	
5/6/1976	Friuli, Italy	6.5	RT (1976, 1978)	NL 7/76, RR 8/79	
7/27/1976	Tangshan PRC	7.8	EIC	early 1977 NLs, NL 5/80 (recovery), RR 3/80	
8/17/1976	Mindanao, Philippines	6.4	RT	NL 1/77, RR 8/77	
3/4/1977	Romania	7.2	RT	NL special report 5/77, RR 3/80	
11/23/1977	San Juan, Argentina	7.4	RT	NL 1/78, 3/78, 5/78	4 people funded by EERI incl. G.E. Brogan, Woodward and Clyde; D. B. Slemmons, Univ of Nevada; plus Chris Rojahn USGS; Chris Poland Degenkolb
12/19/1977	Iran (Bal-Tengal)	8	EIC	NL 1/82	
6/12/1978	Miyagi, Japan	7.5	RT	NL 7/78, RR 12/78	EQ occurred between grants, so John Blume sent Peter Yanev from his office with his own funding; Gerald Brady went from USGS and also represented EERI. Greatest ground motions recorded to date at a nuclear power plant (Fukushima). 3 teams eventually traveledrepresenting EERI, FHA, and URS/J Blume, in addition to UJNR, USGS and NBS. A.G. Brady; J. Cooper (FHA); B. Ellingwood (UJNR, NBS); P. Yanev (URS); E Harp (USGS), D. Keefer (USGS), C. Wentworth (USGS). EERI member in Greece, Dr. Panayotis Caraydis led the group; including Paul Makrynassios. UBS/Blume engineer on leave in
6/20/1978	Salonica, Greece	6.4	RT	NL 7/78, RR 3/80	Athens; Ioannis Psycharis, a Calh Tech student sent back to Greece; Nove Naomoski on way back to Skope. USGS sent teamBob Yuerkes, Charles Bufe, Dick Maley. They coordinated with EERI team. (acc to John Blume, most important records since San
					Fernando. Reports submitted by John Meehan, Oris Degenkolb,
8/13/1978	Goleta (Santa Barbara), CA	5.1-5.9	RT	NL 9/78, 11/78, RR 12/78 (with UCSB)	Leon Stein
8/22/1978	Costa Rica	6.8	EIC	NL 9/78	
9/3/1978	Germany	5.7	EIC	NL 9/78	
9/16/1978	Tabas, Iran	7.7	EIC	NL 11/78	
10/4/1978	Bishop, CA (Helms)	5.7	EIC	NL 1/79	
44/00/4070	Onvers Mavies	7.0	DT		Nick Forell, TL. Ted Algermissen, Clarence Allen, Lloyd Cluff,
11/29/19/8		7.9	RI	NL special report 1/79, 5/79, RR 10/80	Halesil Shah, bob Olsen.
2/15/19/9	Arequipa, Peru	0.0	EIG	INL ARTICLE 3/79	
2/28/1979	St. Elias, Alaska	7.7	EIC	NL special report (USGS rpt)6/79	J. Lahr, G. Plafker, C.Stephens, K. Fogelman, M. Blackford
3/14/1979	Guerrero, Mexico	7.7	RT	NL special report 6/79	Joe Nicoletti, TL. Nick Forell, Andy Dawson.
4/15/1979	Yugoslavia	7.2	RT	NL 5/79. RR 11/80	··, · · · , · , · · , · · ·
				· · · · ·	

8/6/1979	Coyote Lake CA	5.9	EIC	NL 9/79, 11/79	Robert Reitherman
10/15/1979	Imperial County, CA	6.9	RT	NL special report 11/79, NL 1/80, RR 2/80	(Gregg Brandow, TL. 42 contributors to RR.
					(James Stratta, TL. Bruce Bolt; Gordon Dean; Henry Degenkolb;
			510		Frank McClure; Robert Olsen; Chris Poland; Loring Wyllie; Peter
1/24/1980	Greenville CA	5.5	EIC	NL special report 3/80	Yanev.)
					John Blume (EIC): Arthus Sylvester, LICSB: Pierre St Amand
					Naval Weapons Ctr, China Lake; Ajit Virdee,
					Rumberger/Haines/Virdee; Andrew Cunningham, URS/JABlume;
					K.K. Honad and M.I. Towbin, URS/Jblume; Richard Wary, J.H.
5/25,26/1980	Mammoth Lakes, CA	6.1+	EIC, Clearinghouse opened May 26	NL 6/80, NL 3/80, NL 7/80	Kleinfelder; Leval Lund, LADept. Power and water;.
5/28/1980	Offshore Pt. Salinas, CA	4.6	EIC	NL 7/80, 9/80	
6/9/1980	Mexicali, Baja Mexico	6.2	EIC	NL 7/80, 9/80	
					Robert Hanson TL Raymond Anderson Gilbert Bollinger
					Ricardo Dobry, Jin-Long Huang, Delbert Ward, Alex Grinnell,
7/27/1980	Northern Kentucky	5.1	RT	NL 9/80, NL 11/80, NL 1/81, RR 9/80	Clark Hudec, Gus Giese-Koch, Donald Reinhold.
8/18/1980	Ecuador (Guayaquil)	5.6	EIC	NL 1/81	
					Haresh Shah, Vitelmo Bertero, TLs. Lloyd Cluff, Nick Forell,
					Peter Gergely, Max Irvine, Christian Mongat, Tom Saarinen, Bert Swap, Henry Taylor, Marcy Wang, Tom Wosser, Farouk
10/10/1980	El-Asnam, Algeria	7.2	BT	NL special report 1/81, RR 1/83	Tebbal, Amar Chakar, Ahmed Sendjani, Braham Rebzani
10/24/1980	Mexico (Huajuapan de Leon)	6.5	EIC	NL 1/81	
					John Meehan, Donna Leeds, Roy Imbsen, R. McJunkin, C.D.
11/8/1980	Trinidad, CA-Offshore	7	RT	NL special report 1/81	Turpen, S. Panos
11/23/1980	Campania-Basilicata Italy	68-70	RT	NII special report 12/80	James Stratta, TL, Luis Escalante, Ellis Krinitzsky, Lloo Morelli
11/28/1980	Sierra CA	5	FIC	NI 1/81	
12/19/1980	Iran (Give-Qum)	5.8	FIC	NL 1/82	
2/24 25/1981	Alcionides Isles Greece	6663	FIC	NL special report 9/1981	Gerhard Berz, Ekkehard Hettler
4/26/1981	Westmorland CA	5.6	FIC	NL special report 7/81	
6/23/1981	Carupano Venezuela	4.6	FIC	NL special report 1/82	
1/9/1982	Miramichi, New Brunswick series	5.7	EIC	NL special report 3/82. NL 9/82. RR 3/83	
3/21/1982	Urakawa-Oki, Japan	7.3	EIC	NL special report 9/82	
5/9/1982	Paria Peninsula, Venezuela	4.5	EIC	NL 9/82	
6/19/1982	San Salvador, El Salvador	7	EIC	NL special report 1/83	
1/1/1983	Mammoth Lakes, CA	5.4	EIC	NL special report 3/83	
3/31/1983	Papayan, Colombia	5.5	EIC	NL special report 7/83	
5/2/1983	Coalinga, CA	6.7	RT, CH	NL special report 7/83, RR 1/84	
5/26/1983	Nihan-Kai-Chubu, Japan	7.7	RT	Earthquake Spectra 2/85	
					report from USGS: Robert Page, Christopher Stephens, Kent
7/12 & 9/7/1983	Columbia Bay, Alaska	6	EIC	NL special report	Fogelman
10/7/1983	Blue Mountain Lake, NY	5.1	EIC	NL 11/84	
10/28/1983	Borah Peak, Idaho	7	RT	NL 11/83, RR 11/85, EQ Spectra 11/85	
10/30/1983	Northeastern Turkey	7.1	EIC	EQ Spectra 11/84	
11/16/1983	Kaoiki, Hawaii	6.6	EIC	EQ Spectra 11/84	
4/24/1094	Morgan Hill, California	6.0	DT	NI apopial roport 6.94 EQ Spactra E/9E	Bruce Bolt, Bob Bruce, Charles Scawthorn, Gilles Bureau, R.
4/24/1984	worgan Hill, California	0.2	KI	NL Special report 6.84, EQ Spectra 5/85	Guruun Deall, A. Geralu Diauy

9/14/1984	Nagano-ken Seibu, Japan	6.9	EIC	NL special report 12/84	Yasushi Sasaki, PWRI
					Bruce Bolt, Norm Abrahamson, Mehmet Celebi, Loring Wyllie, Jim Gates, Gonzalo Coastro, Paul Smith, David McCormick.
3/3/1985	Vina del Mar, Chile	7.8	RT	NL special report 5/85, RR 12/85, EQ Spectra 2/86	Rene Luft, Luis Escalante, Rick Olson Mete Sozen, TL, Edwin Johnson, Ellis Krinitzsky, Samuel Swan
9/19/1985	Mexico City, Mexico	8.1	RT	NL special report 11/85, 12/85, EQ Spectra	Paul Flores, Luis Escalante.
1/31/1986	Ohio	5	EIC	NL special report 4/86	
					Coordinated by Robert Reitherman. Contributors: B. Bolt, R.
3/31/1986	Mt. Lewis, CA	5.8	EIC	NL special report 6/86	Uhrhammer; C. Thiel, C. Arnold, A. Schiff
5/5/1000			510	NII (700	David Glick, David McCormick, Nancy Horstmann, Neil Bass,
5/7/1986	Adak, Alaska	6.5	EIC	NL special report 7/86	Gary Ong
7/8/1986	North Palm Springs CA	5.9	EIC	NL special report 9/86	Luis Escalante, Coleman Jenkins, Le Val Lund, Richard Maley, John Mehhan, Ronald Procella, Charles Scawthorn, Anshel Shiff, Anthony Shakal, Mihailo Trifunac, Gerald Brady, Roger Scholl plus many non-EERI members
					William Bryant, Ted Canon, Earl Hart, Nancy Horstman, James Kable, Jay Love, David McCormick, Tony Shakal, Robert
7/12/1986	Chalfant Valley, CA	6.4	EIC	NL special report 11/86	Uhrhammer
8/10/1986	South East Romania		EIC	NL special report 1/87	
9/13/1986	Kalamata, Greece	6.2	EIC	NL special report 10/86, EQ Spectra 3:2	Dr. Panayotis Carydis, Natl. Technical University in Athens
10/10/1986	San Salvador, El Salvador		RT	NL special report 11/86, Spectra 3:3	
2/0/1097	Papua New Cuince	7.2	FIC	NIL anapial rapart 6/97	D. Tamsett, A.K. Aggarwal, PNG Univ of Technology, Papua
2/9/1907	Papua, New Guinea	7.5	EIC	NE Special report 6/67	T.N. Mitchell, NZ Ministry of Works and Development; Bruce Shenard (MWD), M.J. Pender, Univ. of Canterbury: R. P.
3/2/1987	Edgcumbe, New Zealand	6.3	EIC	NL special report 10/87, EQ Spectra 3:4	Kassawara, EPRI; D. Hopkins, NZNSEE.
3/5/1987	Antofagasta, Chile	7.3	EIC	NL special report 8/87	G. Rodolfo Sargoni, Univ. of Chile
3/5/1987	Ecuador (series)	6.1,6.9	EIC	NL special report 7/87	T.D. O'Rourke; E. Crespo, K.J. Nyman, Cornell Univ.
					K.B. Taylor and R. B. Herrmann, St. Louis Univ; W.J. Hall, S.
6/10/1987	Iliinois	5	EIC	NL special report 9/87	Schiff, S. Lu, Univ of Illinois Urban-Champaign.
7/31/1987	Humboldt, CA	5.5	EIC	NL 9/87	
8/8/1987	Arica, Chile	6.6	EIC	NL 9/87	
10/1/1987	Whittier, California	6.1	RT	NL 11/87, Spectra 4:1, 4:2	
11/23/1987	Superstition Hills, CA	6.6	EIC	NL special report 2/88	
12/17/1987	Tokyo, Japan	6.6	EIC	NL 2/88	
1/9/1988	Tirana, Albania	5.7	EIC	NL special report 6/88	
1/22/1988	Tanami Desert of	6.5,7	EIC	NL 4/88	
1/23/1988	Northern Australia	7, 7.2			
6/10/1988	Gorman, CA	5.2	EIC	NL 8/88	
6/12/1988	Tejon Rock, CA	5.3	EIC	NL 8/88	
11/6/1099	Yupon China	76 70	DT		Prelim report by Hu Qingchang and Chung Yicun. Lloyd Cluff,
11/6/1988	Pasadana CA	7.0, 7.2	RI	NL 4/89, RR	IL.
12/3/1988	Pasadena, CA	5	EIC	NL 5/89	
11/25/1988	Saguenay, Canada	Ö	EIC	NL 5/89, Spectra 8/1989	Preliminary newsletter report by Soviet investigation toom
12/7/1988	Armenia, USSR	6.8	RT	NL special report 5/89	Loring Wyllie. TL.
1/29/1989	Salinas, Utah	5.4	EIC	NL 5/89	Arturo Tena-Colunga, student member Univ of Illinois
		0	2.0		

4/25/1989	Mexico, Guerrero Gap	6.9	EIC	NL special report 8/89	Report provided by Enrique del Valle, UNAM
6/25/1989	Kalapana, Hawaii	6.1	RT	NL 10/89	Report by W. Lum and N. Nielsen
10/17/1989	Loma Prieta, CA	7.1	RT	NL , 11/89, NL 4/90, RR, EQ Spectra	
2/28/1990	Upland, CA	5.5	EIC	NL special report 4/90	
3/25/1990	Costa Rica	5.5, 6.9	EIC	NL special report 5/90	Report provided by F. Sauter and J.F. Cartin, Costa Rica
12/28/1990	Newcastle, Australia	5.5	EIC	NL 5/90	Report provided by Cynthia Perry, Dames & Moore; excerpts from EQE report
2/8/1990	Philippines	6	EIC	NL special report 6/90	Information provided by J.B. Tirol, Univ. of Bohol, Philippines
2/28/1990	Pomona Valley, CA	5.5	EIC	NL special report 5/90	Report provided by D. K. Jephcott
4/2/1990	Bishop's Castle, UK	5.0, 5.4	EIC	NL special report 7/90	Report provided by Roy Kunar and J. Donald
6/21/1990	Maniil Iran	73	RT	NI special report 12/90	Contributed by A. Astaneh, UC Berkeley and M. Ghafory- Ashtiany Iran
7/16/1000	Luzon Philippines	7.5	PT	NL special report 12/30	, tondary, name
7/10/1990	Luzon, Philippines	1.1	RI.	NE special report 10/90	Report provided by V.G. Ghabraman, student member
11/6 & 12/17 /1990	Darab and Bushehr, Iran	6.6, 6.5	EIC	NL 5/91	Northeastern Univ.
					Information provided by G. Santana and W. Vargas, Univ. of
12/22/1990	Costa Rica	5.7	EIC	NL 2/91	Costa Rica
4/22/1991	Costa Rica	7.6	RT	NL special report 5/91	EERI and NAS sent team. Eugene Cole, TL. Many collaborators.
6/28/1991	Sierra Madre, CA	5.8	EIC	NL special report 8/91	Many EERI members contributed.
10/20/1991	Garhwal, India	7.1	EIC	NL 2/92	Report provided by recon team members from IIT Kanpur
3/13/1992	Erzincan, Turkey	6.8	RT	NL special report, 4/93 (recovery)	James Malley, TL. Other colleagues from US and Turkey.
4/22/1992	Joshua Tree, CA	6.1	EIC	NL special report 6/92	
4/25 & 26/1992	Cape Mendocino, CA	7	EIC	NL special report 6/92, 7/92	
6/28/1992	Landers-Big Bear, CA	7.4, 6.5	EIC	NL 9/92, special report 8/92	many colleagues collaborated.
	-				report provided by F. Yudakhin, K. Dzhanuzakov, B. Ilyasov, A.
8/19/1992	Kyrgystan		EIC	NL 11/92	Muraliyev
9/2/1992	St George Utab	59	FIC	NL special report 10/92	report provided by Walter Arabasz, James Pechmann, Susan Nava, Terry Wallace, Gary Christenson
9/2/1992	Tsunami off coast Nicaragua	7	RT	NI 11/92	Mehmet Celebi TI 9 team members
0/2/1002	Tourianii on oodot, Modragua	,			Nabih Youssef, TL, Samy Adham, Mehmet Celebi, Josephine
10/12/1992	Cairo, Egypt	5.9	RT	NL special report 12/92	Malilay
					report contributed by colleagues at Earthquake Unit, Univ. of
1/13/1993	Woodford, Jamaica	5.4	EIC	NL special report 4/93	West Indies
1/15/1993	Kushiro-oki, Japan	7.8	EIC	NL 6/93	Report from Shimizu Corporation
3/25/1993	Scotts Mill, Oregon	5.6	EIC	NL special report 5/93	report from colleagues in Oregon and Washington
7/12/1993	Hokkaido-nansei-oki, Japan (tsunami & eq)	7.8	RT	NL special report 8/93, EQ Spectra 11: Supp. A	Combined EERI-UNJR team. Les Youd, EERI TL. Paul Somerville, Jane Preuss, Charles Scawthorn, team from NIST.
					Craig Comartin, TL. A. Gerald Brady, James Hengesh, Dennis
8/8/1993	Guam	8.1	RT	NL special report 10/93, EQ Spectra 11: Supp B	Ostrom, M. Saiid Saiidi.
9/29/1993	Maharashtra, India	6.2	RT	NL special report 12/93	
1/17/1994	Northridge, CA		RT, CH	RR, EQ Spectra 11: Supp C	Large multidisciplinary team, William Holmes, TL.
1/17/1995	Kobe, Japan	6.9	RT	RR, NL special report 1/96 (recovery)	Recovery report by Charles Eadie.
7/30/1995	Antofagasta, Chile	7.8	EIC	NL special report 9/95	report prepared by colleagues in Chile and JICA.
9/14/1995	Ometepec, Mexico	7.2	EIC	NL special report 12/95	report prepared by colleagues with Grupo Interuniversitario de Ingenieria Sismica (GIIS)

10/1/1995	Dinar, Turkey	6.1	EIC	NL special report 11/95	report from three separate teams from Greece and Turkey
10/9/1995	Manzanillo Mexico	7.6	FIC	NL special report 12/95 1/96	1st report by Julio Ramirez, Purdue U, Raymond Pugliesi, Degenkolb Engineers; 2nd report excerpted from report from Grupo Interuniversitario de Ingenieria Sismica (GIIS)
			2.0		report provided by Prof. Ashraf Osman. Egypt and Prof. Ahmed
11/22/1995	Aqaba, Egypt	6.2	EIC	NL special report 5/96	Ghobarah, Canada
2/3/1996	Lijiang, China	7	RT	NL special report 5/96, RR	Lloyd Cluff, TL; Dan Abrams, Patricia Bolton, Leon Wang
2/17/1996	Irian Jaya earthquake & tsunami	8.2	RT	NL special report 5/96	report by International Tsunami Survey Team (ITST)
2/21/1996	Chimbote tsunamis, Peru	7.5	EIC	NL special report 5/96	report by Catherine Petroff, Jody Bourgeois, Harry Yeh
3/28/1996	Cotopaxi, Ecuador	5.7	EIC	NL 5/96	
11/12/1996	Nazca, Peru	7.3	EIC	NL special report 1/97	report by Juan Barioal and Julio Kuroiwa
					report by Wang Yayong and Xue Yantao, China Academy of
1/21/1997	Jiashi, China	6.2, 6.5	EIC	NL 7/97	Building Research
2/4/1997	Bojnoord, Iran	6.1	EIC	NL 6/97	report provided by colleagues at IIEES, Tehran
3/2/1997	Ardebil, Iran	5.5	EIC	NL 7/97	report provided by colleagues at IIEES, Tehran
4/24 & 5/9/1997	Guam	6.2	EIC	NL 6/97	report provided by Tom Camacho and T. Eric Gillham
5/10/1997	Ardekul, Iran	7.1	EIC	NL special report 9/97	report from colleagues at IIEES, Tehran and CEST, Tehran
5/22/1997	Jabalpur, India	5.8	EIC	NL special report	
7/9/1997	Cariaco, Venezuela	6.9	EIC	NL special report 10/97	
9/26, 10/3 & 7/1997	Umbria-Marche, Italy	5.8	RT	NL special report 12/97	Stephen Tobriner, TL. Mary Comerio, Mel Green
5/22,23/1998	Bolivian Earthquake series	4.2+	RT	NL special report 12/98	Report by Robert Olson, Juan pablo Sarmiento, Richard Olson
					1st report by Mehmet Celebi; 2nd report from Polat Gulkan and
6/27/1998	Adana-Ceyhan, Turkey	6.2	EIC	NL special report 9/98	colleagues at METU on performance of retrofitted buildings
7/17/1998	tsunami, Papua New Guinea	7.1	RT	NL special report 1/99	Lori Dengler, TL and Jane Preuss
8/4/1998	Bahia de Caraquez, Eucador	7.1	EIC	NL special report 11/98	report by Jeannette Fernandez and Hugo Yepes
4/25/4000	Quindia Calembia	5.0	DT	Nu anacial report 2/00 DD	Eduardo Fierro, TL. Interdisciplinary team of 7, including Maria
1/25/1999	Quindio, Colombia Chamali, India	5.9	RI	NL special report 3/99, RR	report propared by colleagues at UT Kappur
5/29/1999		0.3	EIC	NE special report 7/99	lulio Pamirez, TL, Santiago Puiol, James Miller, many other
					colleagues from CENAPRED and UNAM. CIESAS and other
6/15/1999	Tehuacan, Mexico	6.5	RT	NL special report 9/99	organizations.
8/17/1999	Kocaeli, Turkey	7.6	RT	NL special report 10/99, EQ Spectra 16:S1	Les Youd, TL. Many contributors, both in US and Turkey.
					Joe Uzarski, TL. Many contributors. Collaboration with other
9/21/1999	Chi Chi, Taiwan	7.6	RT	NL special report 12/99, EQ Spectra 17:A	organizations, scientists, engineers.
0/7/4000		5 4	510	Nu se sistere et 44/00	Report provided by many colleagues in Greece at NTUA and
9/7/1999	Athens, Greece	5.4	EIC	NL special report 11/99	other organizations.
9/3/2000	Napa, CA	5.2	EIC	NL special report 11/2000	Report jointly prepared by TCLEE and Degenkolb Engineers
					report provided by many colleagues from several teams; edited
1/13 & 2/13/2001	El Salvador series	7.3	EIC	NL special report 7/2001	by Conrad Paulson and Julian Bommer
1/26/2001	Bhuj, India	7.7	RT	NL special report 4/02, EQ Spectra 18: Supp A	Large reconnaissance team, jointiy led by william Lettis of U.S. & Sudhir Jain of India.
2/28/2001	Nisqually, Washington	6.8	EIC	RR	Large, local reconnaissance team
2/3/2003	Sultandagi, Turkey	6.2	EIC	NL special report	Contributed by Mustafa Erdik and colleagues
6/22/2002	Western Iran	6.5	EIC	web report	visual report provided by colleagues at IIEES
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10/31 & 11/1/2002	Molise, Italy	5.9	RT	NL special report 1/03, EQ Spectra 20: SI 1	Paolo Bazzurro, EERI TL. Joe Maffei, Barbara Foster, Sandro Kodama, Joshua Marrow and many Italian colleagues report provided by colleagues at Technical University, Malaysia,
11/2/2002	Sumatra, Indonesia	7.4	EIC	web report	led by Prof. Azlan Adnan
11/3/2002	Denali, Alaska	7.9	EIC	NL special report 2/03; EQ Spectra 20	many collaborators, particularly at USGS Rich Klingner from U.S. and Sergio Alcocer from Mexico jointly
1/21/2003	Colima, Mexico	7.8	RT	NL special report 3/03; EQ Spectra in progress	led international team.
5/1/2003	Bingol, Turkey	6.4	RT	NL special report 7/03	Colleagues from METU and KOERI in Turkey led recon. effort Fouad Bendimerad, TL. Many colleagues in Algeria and US
5/21/2003	Boumerdes, Algeria	6.8	RT	RR	contributed.
5/29/2003	Southern Xinjiang, China	6.4	EIC	web report	information provided by Prof. Fu Lin Zhou, China
8/14/2003	Lefkada Island, Greece	6.4	EIC	NL special report 11/03	Report provided by three institutions in Greece
9/22/2003	Dominican Republic	6.5	EIC	web report	preliminary report provided by Sergio Mora-Castro
					Scott Ashford, Yohsuke Kawamata, Rob Kayen, other
9/23/2003	Tokachi-Oki, Japan	8	RT	NL special report 12/03	colleagues and organizations
9/27/2003	Siberia, Russia Federation	7.3	EIC	web report	submitted by Mark Klaychko
12/22/2003	San Simeon, CA	6.5	EIC	NL special report 3/04, RR	many contributors from CA; Abe Lynn EERI TL.
					Farzad Naeim of U.S. and Mohsen Ashtiany of Iran, TLs. Many
12/26/2003	Bam, Iran	6.6	RT	NL special report 4/04; EQ Spectra in progress	colleagues from U.S. and Iran.
2/11/2004	Dead Sea region, Palestinian Territories	5.1	EIC	NL 5/04	contributed by An-Najah National University
2/24/2004	North coast of Morrocco	6.4	EIC	NL special report 5/04	Les Youd wrote NL report.
0/7/0004	Orations del Estars Devices Arrestina		510	NII 40/04	Information provided by Virginia Rodriguez, Universidad
9/7/2004	Santiago del Estero Province, Argentina	6.4	EIC	NL 10/04	Nacional de San Juan
9/28/2004	Parkfield, CA	6	EIC	web report, NL 11/04	web report contributed by Rakesh Goel and Charles Chadwell
10/23/2004	Niigata ken Chuetsu, Japan	6.6	RT	NL 12/04; EQ Spectra in progress	Charles Scawthorn, TL. Colleagues from U.S. and Japan. several teams in different countries; Bill Iwan coordinating
12/26/2004	SE Asia eq and tsunami	9	RT	in progress	publication
2/22/2005	Central Iran	6.4	EIC	web report	linked to IIEES images and reports
3/28/2005	Northern Sumatra, Indonesia	8.7	EIC	NL special report 8/05	report prepared by Teddy Boen, Indonesia
6/13/2005	Tarapaca, Chile	7.9	EIC	web report, NL article, NL special report 11/05	contributed by E. Oviedo and M. Moroni and colleagues