

Tohoku Pacific Ocean Earthquake and Tsunami

Quick observations from the PEER/EERI/GEER/Tsunami Field Investigation Team

SUMMARY OF OBSERVATIONS

The March 11, 2011 Tohoku Pacific Ocean Earthquake and Tsunami caused tremendous damage to a highly industrial nation in which buildings and infrastructure are well designed and constructed and where the citizenry is generally prepared for natural disasters. Nonetheless, the very large magnitude of the earthquake and the tremendous wave heights of the ensuing tsunami would be expected to cause damage and consequences well beyond the typical levels considered currently in design and planning. While it is of course important to study and learn from all natural disasters, and thereby advance fundamental knowledge and mitigate future disasters, the 2011 Tohoku Pacific Ocean Earthquake and Tsunami provide especially important opportunities for such studies. This finding is due to the:

- Scope and scale of the general damage to engineered facilities and lifeline systems, and the widespread consequences of this damage,
- Long-term effects on society of very low probability, high consequence phenomena, such as the tsunami and damage to the Fukushima Daiichi Nuclear Power Plants.
- Substantial amount of instrumentation installed throughout Japan to measure the movement of the ground, water and structures,
- Highly detailed documentation being compiled of the direct damage and of the economic, social, political, medical and other impacts, and
- Longstanding and strong collaborative ties between US and Japanese researchers.

The PEER/EERI/GEER/Tsunami field investigation team has identified the following key areas related to engineering as being of high priority and that would benefit from immediate study by US, Japanese and other investigators.

The tsunami and its effects. – The tsunami caused widespread damage throughout the Pacific coastal region of Japan as well as in other countries around the Pacific Ocean. Tsunami waves, with heights measuring up to 35 meters, were responsible for the majority of earthquake casualties and a large portion of the physical damage and loss. There is thus a need and opportunity to benchmark and improve abilities to predict tsunami waves, their interaction with coastal geometries and structures, and the regions of expected flooding. The effectiveness of early warning systems and evacuation procedures should be studied. Similarly, there is a need to understand better and improve the behavior of engineered structures to tsunami wave action, impact by debris and scouring. In particular, various aspects of the design of structures as vertical evacuation shelters should be investigated.

Liquefaction- or settlement-related damage to structures. -- Much of Japan is constructed on sites susceptible to liquefaction. Permanent vertical and horizontal displacements of the soils supporting a structure's foundation were responsible for much of the damage to structures away from the tsunami-affected zone. These damages were seen over a large geographic region, and occurred for a wide variety of soil types and ground motion characteristics. As such, there is an opportunity to improve greatly understanding of the triggering of liquefaction and/or lateral spreading, the deformations that occur, and the consequences of soil spreading and liquefaction on the behavior of supported structures.

The nuclear power plant and related issues. – There are a multitude of engineering issues raised by the response of the Fukushima Daiichi Nuclear Power Plant to the initial shaking and aftershocks as well as to the tsunami. In addition, more than 20 other fossil fuel and nuclear power plants were taken off line. These outages are continuing to have a critical effect on Japanese businesses and overall quality of life; this situation is expected to worsen during the summer. Special issues related the behavior of nuclear power plants (and critical

industrial facilities, in general) to earthquakes and tsunamis, the effect of the inoperability of critical lifeline facilities on a community, region and nation, and the special issues related to radioactive contamination, are high priority topics for investigation.

Disruption of Business and Social Systems. -- Wide spread economic and social disruption has resulted from the damage to housing, schools, hospitals, commercial structures, factories and infrastructure systems. In many cases, a facility's structural system may not have been substantially damaged, but damage to nonstructural elements and equipment as well as loss of lifelines (power, water, gas, transportation, communications, etc.) renders it inoperable. Transportation was impaired since several national and local highways remain closed due to ground shaking and landslides, and in the tsunami-affected region, many highway and railway bridges were completely destroyed. In some areas, manufacturing and other critical facilities in the tsunami-affected zone suffered little structural damage, but are inoperable due to water damage or the presence of debris. Thus, in addition to general economic, business and related studies, investigations on improving the seismic resistance of the nonstructural components and equipment and operationally critical lifelines is needed.

The effect of the earthquake shaking on engineered facilities. Heavily populated regions of Japan were strongly shaken during the earthquake. Strong motion records are very intense (<2.9 g), and very long (3 minutes). The motions are quite complex, showing strong evidence of multiple segments rupturing along the fault. There are several thousands of records from this earthquake and its aftershocks, at free field sites, down hole arrays and in buildings, as well as from past earthquakes. While there were substantial numbers of damaged structures, these tended to be older residential and commercial structures with known deficiencies. Modern buildings and other structures are not designed to be damage free during rare earthquakes. However, the absence of substantial and widespread damage to modern structures suggests that study is needed to better understand the special features of the ground motions, structures and supporting soil that led to less than expected damage. A significant number of buildings in Japan designed to achieve high levels of performance. The ability of highly engineered structures to perform as desired is a topic of high interest.

Thus, high priority research is needed to assess current design, analysis, construction and retrofit techniques, evaluate adequacy of performance goals and acceptance criteria used for individual facilities and infrastructure systems, benchmark and improve strategies and procedures for emergency response and disaster management, and investigate the multiple interrelated factors that effect the post-disaster recovery of a family, community, region and nation.

The above list is not exhaustive, as many consequences of the earthquake may yet to be discovered. Moreover, there are multiple important areas of study related to the earth sciences, as well as to economic, social, medical and behavioral sciences, public policy and urban planning, and management that should be investigated. These are not identified as they are out side of the scope of expertise of the field investigation team.

Given the numerous and active investigations underway in Japan that are starting and likely to continue for several years, there are many opportunities for collaborative US-Japan research. This will leverage resources and accelerate the generation of new knowledge by sharing of existing knowledge and the exchange of data and personnel.

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BACKGROUND

On March 11, 2011 a major earthquake and tsunami struck northeastern Japan. The magnitude 9 earthquake is among the largest experienced in modern times. The causative fault ruptured over a length of more than 400 km, resulting in large amplitude and long duration shaking, and wide spread tsunami flooding in Japan and elsewhere. Since the main shock, hundreds of large ($M > 5$) aftershocks have occurred, with five having a magnitude greater than 7. As a result of the earthquake and tsunami, about 27,000 individuals were killed or remain missing. It is estimated that about 210,000 houses were damaged, resulting in more than 160,000 displaced persons. The direct losses associated with the earthquake are currently estimated to be in excess of \$300 billion.

Because of the wide spread devastation of buildings and infrastructure north of Tokyo, the Japanese government limited travel to the heavily affected regions by individuals not directly involved in emergency response. Travel restrictions were also imposed by the Japanese (and US) governments for the area surrounding the damaged Fukushima Daiichi nuclear power plants. During the last week of March 2011, the first teams of Japanese researchers were officially allowed to travel to the Sendai and surrounding regions. In early April, a small group of researchers representing the Pacific Earthquake Engineering Research Center (PEER), Earthquake Engineering Research Institute (EERI), Geotechnical Extreme-Events Reconnaissance (GEER), and the tsunami research community were invited to visit Japan by the Science Council of Japan (SCJ), Japan Association for Earthquake Engineering (JASEE) and the Center for Urban Earthquake Engineering (CUEE) at the Tokyo Institute of Technology. A team of nine investigators, with funding from the US National Science Foundation, and logistical support from CUEE, visited the Kanto and Tohoku regions of Japan from April 11 to 16, 2011.

The team uncovered a lot of useful information, and is currently preparing a brief report on their findings. This report will be made available shortly. In the interim, this quick report, focusing on major conclusions and sources of information is being made available. The results herein are preliminary, do not reflect the consensus of the full field investigation team, and are subject to change.

This earthquake and tsunami are currently referred to by several names, and no consensus has been reached within Japan as to the appropriate naming. The earthquake and tsunami are generally referred to as the 2011 off the Pacific Coast of Tohoku Earthquake (JMA). Reference is made to the 2011 Tohoku-Kanto Earthquake and Tsunami, reflecting the widespread damage in northeast Japan. More frequently the events are referred to as the Tohoku Pacific Ocean Earthquake and Tsunami. There is a current recommendation that it simply be referred to as the 2011 Tohoku earthquake and tsunami (ERI). Quite frequently, when referring to the effects of the earthquake and tsunami (and not to the events themselves) one sees the terminology, the 2011 Great Tohoku Earthquake and Tsunami.

SOURCES OF INFORMATION

In the immediate aftermath of the March 11, 2011 Tohoku Pacific Ocean earthquakes and tsunami, restrictions were placed on travel by academic and research institutes (and others) not officially associated with a government ministry responsible for direct operations of lifelines or with emergency response. Thus, local engineers, associated with local chapters of the Architectural Institute of Japan, the Japan Society for Civil Engineering, Japan Geological Society, and local engineering companies and universities (as well as the news media) were the primary means for identifying and assessing damages. Engineers in Tokyo inspected in Tokyo, those in Yokohama inspected there, and those in Sendai inspected in the Tohoku region. As a result, many of us in the US have about the same access to data about the earthquake and damages, as do many engineers in Tokyo or elsewhere in Japan.

During the middle of the last week of March, these travel restrictions were lifted, and several groups from Tokyo and elsewhere in Japan carried out preliminary reconnaissance missions. The availability of food, gas and other supplies were quite limited at that time. Since then, logistics have greatly improved so that more engineers and others specialists are venturing forth to do highly detailed reconnaissance investigations. Thus, during the first and second week of April a number of public briefings were offered by various organizations, summarizing the preliminary findings of these reconnaissance teams. Some of this information (AIJ, JSCE, CUEE, ERI, etc.) is public, but other studies, done for building owners or by engineering firms may take some time (if ever) to become available.

Data of all types is very limited in the vicinity of the Fukushima Daiichi Nuclear Power Plants. There are several Japanese websites identified below that contain important information about the earthquake and tsunami.

A GENERAL NOTE ON FINDING INFORMATION

There are numerous sites hosted in Japan that contain information about the Tohoku Pacific Ocean earthquakes and tsunami and their effects. It is not possible herein to provide a comprehensive list of all sources of information. The information provided below focuses on Japanese based sources of information identified during the field investigation team's visit to Japan. Excellent information is available also from the EERI Clearinghouse on the Tohoku earthquake and tsunami, and websites established by USGS, GEER, Google Earth, and others.

Official statistics on the number of casualties, and the number of damaged buildings and lifeline structures are compiled by the National Police Agency and can be seen at:

<http://www.npa.go.jp/english/index.htm>

There are several useful clearinghouse and other sites that have aggregated information about the earthquake and tsunami, and their effects. For instance, the clearinghouse website of the Center for Urban Earthquake Engineering (CUEE) of the Tokyo Institute of Technology is in English and welcomes reconnaissance and research teams from Japan, the US and elsewhere to contribute information and findings to their website. The presentation

slides from the presentations made to the US field investigation team are available on this web site. There is a mechanism for directly uploading and adding new links or PDF documents. See: <http://eqclearinghouse.cuee.titech.ac.jp/tohoku2011/Welcome.html>

Another important clearinghouse website written in English that focuses on tsunami effects is the website of the 2011 Tohoku Earthquake Tsunami Joint Survey Group. This is maintained by the Coastal Engineering Committee of the Japan Society of Civil Engineering. It may be found at: <http://www.coastal.jp/tsunami2011/>. Information on the Japanese version of the website is undoubtedly more abundant and frequently updated. This site links to many useful websites that provide a wide variety of information spanning from survey data to remote sensing data to the results of numerical simulations.

Many useful websites are understandably available only in Japanese. Note that where an English version of a website exists, additional or more recent information may be found on the Japanese version of the same site. While non-Japanese reading researchers may find these Japanese sites difficult to navigate at first, in many cases, an adequate translation of a word, a portion of a document (150 words at a time) or an entire website can be obtained using Google translate. See: <http://www.google.com/ig#max5>. One must be aware that in some situations unduly creative and possibly misleading translations can be provided. However, this mechanism allows non-Japanese speakers to explore quickly many sites and sources of information.

Please be aware that some early earthquake reconnaissance reports are not as accurate as later ones. Thus, data reported should be viewed with due consideration of the conditions in the field.

EMERGENCY RESPONSE AND MOBILIZATION

A good summary of the general damages to lifelines, residential and other buildings, and emergency response operations undertaken as well as planned recovery actions by the Ministry of Land, Infrastructure and Transportation is provided in several documents that can be found at: <http://www.mlit.go.jp/common/000138154.pdf>

Detailed information on local damage can be often found on the websites of local municipalities. For instance, general policies for recovery and so on can be found for Sendai at: http://www.city.sendai.jp/shicho/message_20110404.html. Specific information on various outages, emergency shelters, lifelines, etc. can be found at: http://www.city.sendai.jp/shicho/message_20110404.html. Similar information can be found for various prefectures and municipalities on their websites. Reportedly, fire departments often gather the relevant information. Interestingly, in Japan, damage is apparently initially self-reported, as building owners expect to receive some type of monetary assistance from the government. Some owners of businesses may not want damage known and may not report damages quickly or in detail. Inspection by AIJ and other groups of engineers is voluntary, and conducted to advance the understanding of earthquake effects by the professions involved. Owners may deny access to facilities. Several professional committees are approaching the government to get a formal

declaration encouraging owners to cooperate with such investigations. Some national tabulations of data have been done for specific issues, such as casualties, houses destroyed or partially damaged, as noted above for the National Police Agency.

Although information on the economic, social, medical and other impacts of the earthquake and tsunami do not seem to be gathered with the same regularity as for direct damage to engineered facilities, it appears that there are substantial impacts associated with the disruption of businesses due in large part to loss of electric power, damage to manufacturing and auxiliary equipment by shaking and tsunami, and evacuation of personnel from the region near the Fukushima Daiichi nuclear power plants and from damaged areas near the coastline. Concern has been expressed regarding the economic impact of the tsunami on ports, especially on shipping and fishing industry. See, for instance:

http://eqclearinghouse.cuee.titech.ac.jp/groups/tohoku2011/wiki/79be6/Economic_and_Social_Impact.html.

CHARACTERISTICS OF THE EARTHQUAKE AND GROUND MOTION SHAKING

An excellent source of information on the nature of the earthquake and tsunami can be found at a special website set up by the Earthquake Research Institute (ERI) of the University of Tokyo. It can be found at: http://outreach.eri.u-tokyo.ac.jp/eqvolc/201103_tohoku/eng.

Additional information on rupture mechanism, fault models and ground movements during the earthquake, can be found at: <http://www.hinet.bosai.go.jp/topics/off-tohoku110311/>, <http://www.geol.tsukuba.ac.jp/~yagi-y/EQ/Tohoku/> and <http://www.gsi.go.jp/chibankansi/chikakukansi40005.html>

The Japan Meteorological Agency maintains a large network and establishes the seismic intensity at a site based on the JMA scale. It also maintains weather and tsunami monitoring stations. For information see:

http://www.jma.go.jp/jma/en/2011_Earthquake.html#Observation

An interesting paper on why the earthquake occurred where it did, and where the next earthquake might strike and when by the President of the National Research Institute of Earth Science and Disaster Prevention (NIED), can be found at:

http://www.bosai.go.jp/e/international/Preliminary_report110328.pdf. NIED has also established in conjunction with others a Japanese language clearinghouse type website that provides links to a broad range of other websites covering the 2011 Tohoku earthquake. <http://all311.ecom-plat.jp/>

GROUND MOTION RECORDS

There are numerous strong motion networks in Japan, and more than a hundred records are currently available. An aggregated database of some of these records is available in English from the Center for Engineering Strong Motion Data (CESMD) at:

<http://www.strongmotioncenter.org/>

These records have been obtained from three networks in Japan:

K-NET of NIED: <http://www.k-net.bosai.go.jp/>

KIK-NET of NIED: <http://www.kik.bosai.go.jp/>

Building Research Institute (BRI), Strong Motion Observatory:

<http://smo.kenken.go.jp/smreport/201103111446>

It should be noted that the BRI network includes a significant number of records from instrumented buildings, including records from nearby free field sites and down hole arrays.

Many additional networks are operated by universities (ERI, Tohoku University, Tokyo Institute of Technology, etc.), businesses, engineering firms, and other government agencies (JMA, AIST, etc.). These records may become available later or by contacting the network managers directly.

GEOTECHNICAL AND RELATED INFORMATION

Several websites contain information of interest to those interested in site conditions. For example, the Center for Urban Earthquake Engineering of the Tokyo Institute of Technology Clearinghouse Website in English contains links to a number of interesting sites related to geotechnical engineering:

<http://eqclearinghouse.cuee.titech.ac.jp/tohoku2011/Welcome.html>

These include links to:

- + Geological, topological and other maps;
- + Bore hole logs by the Ministry of Land, Infrastructure, Transportation and Tourism (MLIT), National Research Institute for Earth Science and Disaster Prevention (NIED), and several prefecture governments;
- + Quick overview report by Prof. Tokimatsu on the local geotechnical conditions in the Kanto area, and damages associated with permanent ground deformations (as of March 25, 2011);
- + Quick overview of damage to levees in the Kanto region (Prof. Takahashi);

TSUNAMI AND TSUNAMI-RELATED PERFORMANCE OF ENGINEERED STRUCTURES

The Ports and Airports Research institute (PARI) carried out a quick reconnaissance immediately following the earthquake. See:

<http://www.pari.go.jp/en/eq2011/20110325.html>

The Center for Urban Earthquake Engineering of the Tokyo Institute of Technology Clearinghouse Website in English contains links to a number of interesting sites related to tsunami: <http://eqclearinghouse.cuee.titech.ac.jp/tohoku2011/Welcome.html>

These include links to:

- + Quick reports by the Port and Airport Research Institute. PARI has large teams in the field now gathering more detailed information.

- + Maps prepared by the Japan Geospatial Authority of Japan of the Japanese coastline showing areas that have been flooded by the tsunami.
See: <http://www.gsi.go.jp/kikaku/kikaku60003.html>
- + Various sources of interpreted and raw high-resolution satellite and aerial photos of the Pacific Coast of Japan north of Tokyo.
- + Reports from the Disaster Control Research Institute of Tohoku University with detailed surveys of damage in some locations as well as pre-event predictions of tsunami hazard.

Some additional information on the effects of the tsunami on transportation systems can be found below under Lifelines.

BUILDING-RELATED PERFORMANCE

The Architectural Institute of Japan (AIJ) has established a detailed website, some of which is in English. It covers a far ranging set of topics related to the ground shaking, tsunami and structural performance. This provides links to surveys done by both the Kanto and Tohoku regions of Japan. See: [http://bousai.env.nagoya-u.ac.jp/wiki/saigai/index.php?The 2011 off the Pacific coast of Tohoku Earthquake](http://bousai.env.nagoya-u.ac.jp/wiki/saigai/index.php?The+2011+off+the+Pacific+coast+of+Tohoku+Earthquake). Information on individuals who might be appropriate to contact for additional information on specific topics related to buildings can be found at this site. A formal integrated report by AIJ is expected by mid- to late-summer 2011.

CUEE's clearinghouse website also has sections with detailed information on wooden, reinforced concrete, steel buildings as well as ones that have seismic isolators or other passive or semi-active devices installed.

See: <http://eqclearinghouse.cuee.titech.ac.jp/tohoku2011/Welcome.html>

The Japan Society for Civil Engineering (JSCE) has a web page where various presentations and documents are available that describe building and soil response.

See: http://www.jsce.or.jp/committee/eec2/eq_report/11tohoku.html

PERFORMANCE OF LIFELINES FOCUSING ON BRIDGES AND UTILITIES

A preliminary but detailed report on damages to roadways and bridges due to ground shaking, instability of slopes and fill, and tsunami by the Public Works Research Institute (PWRI) (March 24, 2011) can be found at:

http://www.thr.mlit.go.jp/road/jisinkannrenjouhou_110311/dourohisaijyoukyou.pdf

Additional information on the actions taken by PWRI to inspect and restore highways, investigate sediment transfer and scouring, and landslides as they effect highways can be found at: <http://www.pwri.go.jp/eng/news/2011/0316/>

The Japan Society of Civil Engineering (JSCE) has prepared a lengthy preliminary report. For a copy of the preliminary report, see: <http://committees.jsce.or.jp/report/node/40>

JSCE held a public briefing on the effects of earthquake shaking and tsunami on highway and railway systems, levees, and water distribution systems.

This briefing was held at the main auditorium of the Institute of Industrial Science, University of Tokyo, in Tokyo, Japan on Monday, April 11, 2011 from 13:30 - 18:00. The program (the list of lectures is translated using Google Translate) is provided immediately below.

1. Outline of Field Survey (Kawashima)
2. The characteristics of earthquakes and ground motion: Goto (Kyoto University)
3. Earthquake damage in and around Tokyo Bay and the rock sites in inland Iwate Prefecture: Konagai (Tokyo)
4. Levees from damage: Higashihata (Tokyo)
5. Tsunami Earthquake Stories: Yoshida (Tohoku Gakuin)
6. Damage to inland Fukushima: Nakamura (Nihon Univ.)
7. Damage to coastal areas by tsunami: Miyajima (Kanazawa Hiroshi)
8. Damage caused by the tsunami to Bridges: Left Division (KIT)
9. Damage to bridges damaged by the tsunami: Watanabe (Yamaguchi Univ.)
10. Damage to Tohoku Shinkansen viaduct: Takahashi (Kyoto Univ.)
11. Damage to railroad viaducts: Akiyama (Waseda Univ.)
12. Seismic performance of bridges supported by rubber bearings: Kawashima (TIT)
13. The earthquake resistance of bridges and earthquake-proof bridges damaged by 1978 earthquake off Miyagi Prefecture: Matsuzaki (Tokyo Tech)
14. Damage to water supply facilities: (Kobe Univ.)
15. Tokyo Bay Area Liquefaction: Susumu Yasuda (TDU)
16. Damage to land reclamation: Wakamatsu
17. On the organizing and lessons of the tsunami survey: Imamura (Tohoku Univ.)

PPT files of the above presentations are available at:

<http://committees.jsce.or.jp/report/node/42>

A summary presentation of the main findings from the above presentations prepared in English by Prof. Kazuhiko Kawashima, of the Tokyo Institute of Technology, is available at: <http://peer.berkeley.edu/news/wp-content/uploads/2011/04/East-Japan-Earthquake-21.pdf>

The Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) is in the process of compiling detailed damage reports on national and prefecture highway systems. A complete compilation is expected around June 2011. It appears that relatively little information has been compiled yet regarding smaller municipal and private bridges at this time. JR East is compiling extensive data on the performance of their rail and Shinkansen viaducts, bridges and stations.

The CUEE Clearinghouse has two sections on lifelines, including links to information on:

- + Water and gas distribution systems and sewage treatment facilities (Kobe University),
- + Nuclear power plants and electricity distribution systems. See:

(<http://eqclearinghouse.cuee.titech.ac.jp/tohoku2011/Welcome.html>)

US-JAPAN FIELD INVESTIGATION TEAM PARTICIPANTS

US Team Members representing PEER/EERI/GEER/Tsunami community:

Structural Focus: Stephen Mahin (Berkeley) – Team Leader
Gregory Deierlein (Stanford),
Gilberto Mosqueda (Buffalo)

Lifeline/Fire Focus: Charles Scawthorn (Wasada University, PEER, etc.)

Geotech Focus: Youssef Hashash (UIUC)
Steven Kramer (Washington)
Kyle Rollins (BYU)

Tsunami Focus: Philip Liu (Cornell)
Harry Yeh (OSU)

Japan Team Members

Organizer: Prof. Kazuhiko Kasai, CUEE (Tokyo Institute of Technology)
Team Leader: Prof. Kimiro Meguro (The University of Tokyo)
Team Sub-Leader: Prof. Saburoh Midorikawa CUEE (Tokyo Institute of Technology)
Members: Professor Aydan (Tokai University)
Assoc. Prof. Anil C. Wijeyewickrema (CUEE, Tokyo Tech)
Ast. Prof. Shoichi Kishiki (CUEE, Tokyo Tech)
Ast. Prof. Troy Morgan (CUEE, Tokyo Tech)
Prof. Masato Motosaka (Tohoku University)
Prof. Akenori Shibata (emeritus, Tohoku University)

TRIP LOGISTICS

- Sunday, April 10 - US team kickoff meeting in Tokyo (goals, safety, specific assignments, Q&A, etc.)
- Monday, April 11 - Morning: Symposium at Center for Urban Earthquake Engineering (CUEE) – briefing presentations by ten Japanese researchers on preliminary findings, discussions of research opportunities, etc.
- Monday, April 11 - Afternoon: Public Briefing by Japan Society of Civil Engineers (JSCE) on damages to bridges, rail systems, levees, etc.
- Monday, April 11 - Evening: Travel by Van to Sendai
- Tuesday, April 12 - Seminar at Tohoku University by local researchers on their findings from field and analytical studies; Inspection of building damage at Tohoku University and of their instrumented field site of full-scale three story isolated and fixed-based buildings, plus inspection of buildings in Sendai damaged by ground shaking; Site visits to tsunami damaged regions between the Port of Sendai and the Sendai Airport.
- Tuesday, April 12 – Evening: Travel north to Ichinoseki, Iwate
- Wednesday, April 13 – Early Morning: Visit to sites of free field instrumentation exhibiting high ground accelerations
- Wednesday, April 13 - Visits to the port cities of Rikuzen-takata, Kesenuma and Onagawa. Minami-Sanriku was missed due to road construction work (highway closed)
- Thursday, April 14 - Visit to headquarters of the Architectural Institute of Japan (AIJ) to discuss reconnaissance findings by AIJ Kanto earthquake damage inspection teams.
Tsunami team visit to Port and Airport Research Institute (PARI).
Some geotech team members go to field near Tokyo.
Meetings by individual team members in afternoon with other specialists (Economics Professor at Tokyo Tech, fire expert, etc.).
Wrap up meeting with CUEE/JAEE/SCJ members.
Some team members return home to US in evening.
- Friday, April 15 - Individual Team Members visit with local engineers from JSCE, AIJ, universities related to structures, tsunami, and geotechnical issues.
More members return to US.
- Saturday, April 16 - Remaining geotech-focus team members carry out field investigations in Tokyo (geotech)
Remaining structures-focus team members visit with US based insurance loss modelers carrying out detailed damage surveys in Japan
More members return to US.
- Sunday, April 17 - More geotech field investigations by remaining team member.

ACKNOWLEDGEMENTS

The US team members are greatly appreciative of the invitation by Profs. Masanori Hamada, Akira Wada and Kazuhiko Kasai on behalf of the Science Council of Japan, the Japan Association for Earthquake Engineering, and the Center of Urban Earthquake Engineering to send a small team to visit the earthquake and tsunami impacted areas of Japan, and to discuss with Japanese researchers the implications for practice and research. The trip would not have been possible without the able assistance of CUÉE, especially Profs. Kazuhiko Kasai, Kohji Takematsu and Saburoh Midorikawa and its staff, in making the arrangements for the various meetings as well as for planning the site visits and making the necessary logistic arrangements.

The success of this trip was only possible due to the generosity of many Japanese organizations and engineers in sharing their time and knowledge with the US team members. Japanese participants at the various meetings held at CUÉE, AIJ, JSCE, PARI, and elsewhere provided high value information and insights related to the earthquake and tsunami and the ensuing damages and impacts. These efforts were critical to the success of the mission.

The team members are appreciative of the encouragement and support by PEER, EERI and GEER in organizing the team and disseminating information gathered.

This trip was funded by a RAPID grant from the US National Science Foundation. This funding is gratefully acknowledged. It should be recognized however that the findings, observations and conclusions offered in this quick report are those of the authors and do not necessarily represent the views of the National Science Foundation, PEER, EERI, GEER or other organizations directly or indirectly affiliated with this field investigation.