NCREE NEWSLETTER

December 2014 VOL. 9 NO. 4



CONTENTS

- An S-wave Velocity Model of the Taipei Basin
- ShakeMap Estimation and Its Applications
- Installation of a Vertical Seismograph Array and Observation
- Study of Seismic Anomalies in the Crust from Observed Waveform Analysis in Yun-Chia-Nan Area, Taiwan
- Application of a Real-Time Database for Earthquake Precursory Research
- 5th Asia Conference on Earthquake Engineering
- Introducing and Demonstrating Earthquake Engineering Research in Schools (IDEERS) 2014
- The International Training Program for Seismic Design of Structures 2014

DIRECTOR

Kuo-Chun Chang

EDITORS

Shih-Chung Wen

Chun-Hsiang Kuo

National Center for Research on Earthquake Engineering

An S-wave Velocity Model of the Taipei Basin

Che-Min Lin, Chun-Hsiang Kuo, Kuo-Liang Wen, NCREE

The Taipei Basin is a triangular alluvium basin. Owing to the complex Tertiary basement and the weak Quaternary alluvium, the site effects of the basin, which amplify and extend seismic waves, are the major reason for seismic disasters in Taipei. The deepest part of the Tertiary basement is over 700 m along the western border of the basin. Since a detailed and correct velocity model is the key to ground motion estimation, this study applied a Receiver Function (RF) technique and microtremor H/V spectral ratio modeling to delineate the S-wave velocity model of the Taipei Basin.

In the RF analysis, sixty-four Taiwan Strong Motion Instrumentation Program (TSMIP) strong-motion stations located in the Taipei Basin were chosen. The period of the database was from 1992 to 2009. The RFs of all events recorded by stations were calculated and the RFs with high correlation coefficients were chosen to obtain the average RFs for each station. The difference in RFs among stations was obvious, but a similar converted phase could be observed at most stations with different arrival times. The stations located on the western side where the basin is deeper showed later arrival times, and the stations located on the eastern side where the basin is shallower showed earlier arrival times. A genetic algorithm (GA) approach was applied to search for the 1-D S-wave velocity profile with the best fitness between the observed and synthetic RFs. According to previous studies, we assumed a model with six layers covering a half-space for the GA search. The P- and S-velocities of the layers were fixed to avoid the trade-off between the velocity and thickness of layers. Fig. 1 shows the results of the GA search for station TAP010. All the average RFs of the stations were modeled to estimate the 1-D S-wave velocity profiles as the reference and initial models for this study.

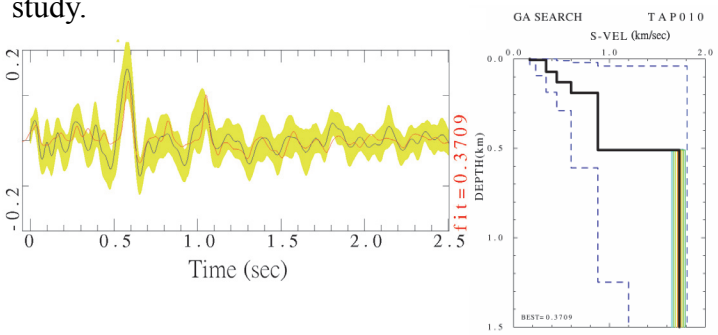


Fig. 1. The results of the RF analysis for station TAP010. The image on the left illustrates the comparison between the observed average RF (black line) and the synthetic RF (red line); the image on the right shows the estimated S-wave velocity profile

In Taipei, a dense single-station microtremor survey of almost 600 sites, which were well-distributed inside and around the Taipei Basin, was conducted. The microtremor H/V spectral ratios mostly showed obvious site amplifications at a frequency band of 0.5 to 2 Hz. Due to good agreement of the theoretical SH-wave transfer function of the estimated profiles by RFs with the observed microtremor H/V spectral ratio, especially for the main amplification frequency band, the theoretical transfer function was combined with the GA approach to estimate the S-wave velocity profile by fitting the observed H/V spectral ratios. The H/V spectral ratios with different dominant frequencies could be simulated by our method to estimate the S-wave velocity profile for the sites (Fig. 2).

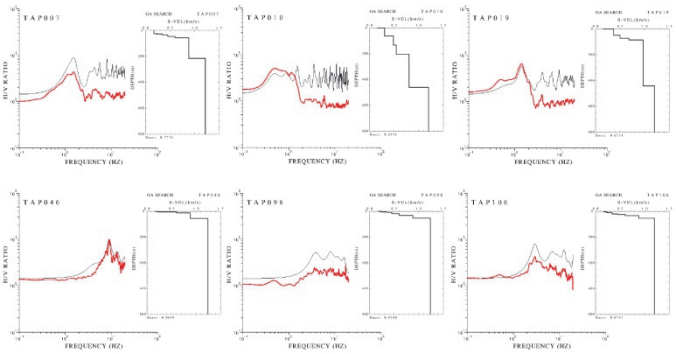


Fig. 2. Six results of the H/V spectra ratio modeling, including the observed H/V spectra ratio (red line), theoretical transfer functions (black line) and the estimated S-wave velocity profiles

All 1-D profiles of over 400 sites were combined to delineate the depth contour maps of four major S-wave velocity interfaces (Fig. 3), including the bottom of the Sungshan, Chingmein, and Wuku Formations, and the Tertiary basement in the Taipei Basin. The detailed S-wave velocity model of the Taipei Basin will be beneficial to strong motion predictions and simulations in the future.

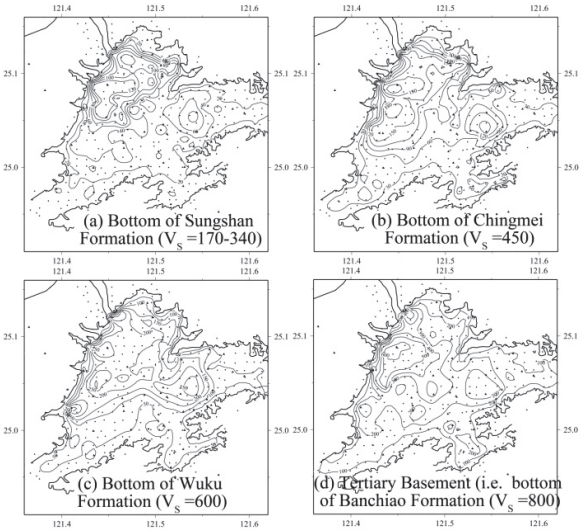


Fig. 3. Depth contour maps of four major S-wave velocity interfaces in the Taipei Basin delineated by modeling the microtremor H/V spectral ratios

ShakeMap Estimation and Its Applications

Yu-Wen Chang, Wan-Ting Chang, Wen-Yu Jean, NCREE

A reliable ShakeMap provides strong ground shaking information for emergency response directors in the event of a disastrous earthquake. The purpose of this paper is to establish an integrated ground motion prediction system using a graphical user interface (GUI) to obtain a rapid estimating ground motion ShakeMap, and allow inquiries to site-specific ground motions of the past.

The main factors that affect the results of ground motion prediction analysis are the existence of source, path, and site effects. It is believed that a theoretical 3-D model could be developed to precisely solve this problem of ground motion estimation. However, it takes time to develop the model and to determine the parameters for simulation. Consequently, an empirical attenuation relationship is developed to consider the influence of important items on ground shaking estimation.

In order to provide reliable ground motion prediction when an earthquake occurs, a hybrid procedure that combines a site-dependent ground motion prediction model and the limited observations of the Real-Time Digital stream output system (operated by the Central Weather Bureau, CWB) provides a near-real-time ShakeMap. The former is a site- and intensity- dependent ground motion prediction model (attenuation relationship) that considers the source effect/or earthquake location uncertainty for a particular earthquake. The observed data from the latter can be used to correct the systematic bias that exists between the reference ground motion prediction model and the event characteristics, and replace its estimated value in the ShakeMap in order to improve reliability.

Fig. 1 presents a flowchart that shows the procedure for estimating the ShakeMap. Fig. 2 represents a case study that illustrates the systematic bias due to the uncertainty of the location of an earthquake. It is intuitively clear, for instance, that the systematic bias have been corrected in the reference ground motion prediction model (the blue dotted line in Fig. 2a). In other words, it is clear that the event-dependent prediction model should provide an exact estimation for ground motion ShakeMap, such as shown in Fig. 3a. It shows that although it contains some error due to uncertainty in earthquake location, the hybrid procedure can use more data to provide an accurate and more detailed ShakeMap that is better than the one first published by CWB. For an application, the ShakeMap of a historic damaging earthquake, such as the 1906 Meishan Earthquake, can be re-evaluated. Fig. 3b shows the comparison of the pattern between the ShakeMaps from this system and the damage distribution during the earthquake. It shows an approximate result of the earthquake with a magnitude of 6.8 induced by the Meishan fault rupture. As a consequence, the system provides a function to inquire the historical site-specific ground motions.

A future study requires to efficiently mitigating probable earthquake hazards. Further, the investigation of the corresponding proper ground motion estimation at different distances from a fault is necessary to be further studied in order to efficiently mitigate the probable earthquake hazard.

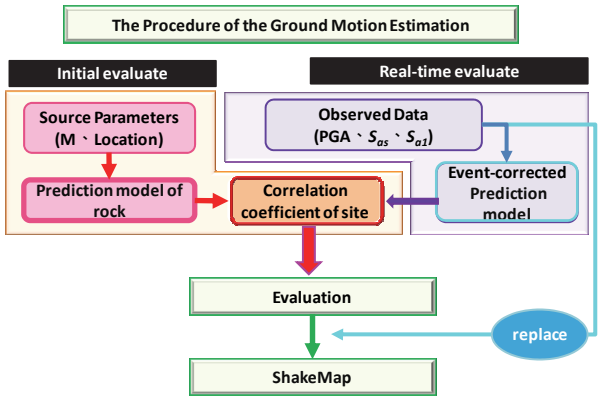


Fig. 1. The flowchart of the ground motion prediction system

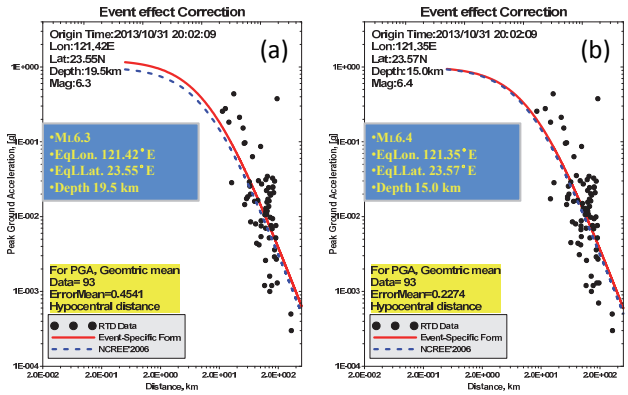


Fig. 2. Comparison between the ground motion prediction model and the observed data of the particular earthquake

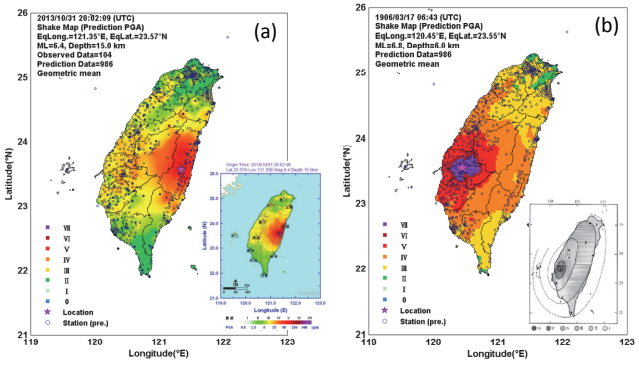


Fig. 3. The ShakeMaps of PGA at (a) the Oct. 31, 2013 Hualien Earthquake and (b) the 1906 Meishan Earthquake

Installation of a Vertical Seismograph Array and Observation

Chun-Hsiang Kuo, Hung-Hao Hsieh, Che-Min Lin, NCREE
Kuo-Liang Wen, National Central University

We commenced the installation of a vertical seismograph array at a vacancy behind NCREE at the end of 2013 in order to understand effects on seismic waves caused by near-surface strata. We also utilized microtremor measurement and analysis, borehole drilling and investigation, and velocity measurements prior to the installation of this vertical array. Since the site is at close proximity to the edge of the Taipei Basin, the deepest seismograph was placed inside the bedrock and the propagation of seismic waves from the basement to sediments and surface can thus be observed by this vertical array. Therefore, we can understand the characteristics of seismic waves in the near surface layers and the resultant site amplifications of the Taipei Basin.

Several downhole seismographs were installed in Taiwan. The Tai-Power Company and the U.S. Electric Power Research Institute conducted the Lotung Large Scale Seismic Test, Huslien Large Scale Seismic Test, and Strong Motion Array in Taiwan, phase II projects. The Harbor and Marine Technology Center installed vertical arrays at several important harbors. The Institution of Earth Science, Academia Sinica, and the Central Geological Survey installed strong motion and broadband downhole seismographs in the Taipei Basin. The Central Weather Bureau also spread downhole seismographs to increase monitoring capability.

Prior to the drilling of boreholes, we conducted a microtremor measurement and analysis. The results showed that the site belongs to class D, the estimated Vs30 is 265 m/s, and the sedimentary depth is 50.1 m. Meanwhile, the drilling results showed that the depth of bedrock is 57.7 m. We converted the SPT-N values to S-wave velocities and the Vs30 were calculated as being 213.9 m/s. After the measurement of the P- and S-wave velocities using a suspension PS-logging system, the P- and S-wave velocity profiles were plotted as shown in Fig. 1. The S-wave velocity increased with depth from 150 m/s and remained at 300 m/s after a depth of 30 m, and then increased dramatically to higher than 1,000 m/s as the basement at a depth of 58 m was reached. The measured Vs30 is 236.7 m/s in the site. This vertical seismograph array includes five strong motion sensors at depths of 0, 20, 30, 58 (the depth of the interface between sediments and the bedrock), and 78 m (Fig. 2). We would like to observe the property changes of the seismic waves propagating from the bedrock to the surface.

This vertical array commenced monitoring in March 2014. When acceleration of the deepest downhole seismograph is larger than 0.003% of the full-ranges, the recorders will be triggered to record the event. The sampling rate was set as 100 Hz in the earlier stage and was then changed to 200 Hz. The epicenters of the events recorded by this vertical array until October 2014 are shown in Fig. 3. Most of the observed earthquakes were located onshore and offshore of eastern Taiwan (Ilan and Hualien). The monitoring range of the vertical array for M_L 3, 4, and 5 earthquakes can reach Hualien City, Juisui, and Taitun City, respectively. Further, the monitoring radii are around 130 km, 180 km, and 250 km, respectively.

The largest PGA of recorded data (13 gal) thus far was caused by the earthquake (M_L 5.9) that occurred on the 21st of May. More and larger strong motion data are necessary for the analysis of site effects and application in the seismic code.

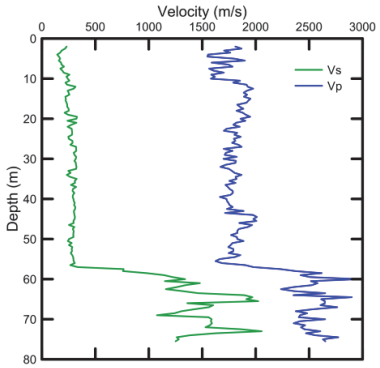


Fig. 1. P-wave and S-wave velocity profiles under the vertical array station



Fig. 2. In-situ photograph of the vertical array

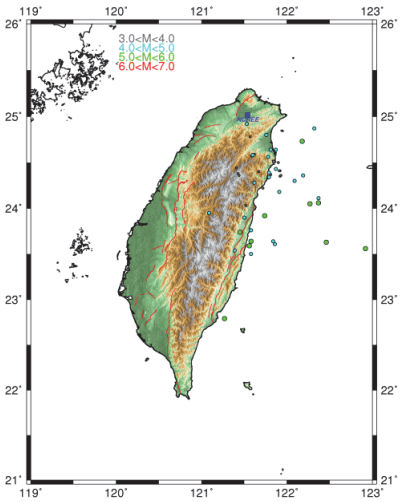


Fig. 3. The epicenter distribution of the events recorded by the vertical array until October 2014

Study of Seismic Anomalies in Crust from Observed Waveform Analysis in Yun-Chia-Nan Area, Taiwan

Yi-Zen Chang, Assistant Researcher and Shih-Chung Wen, Associate Researcher, NCREE

Foreword

The applications of ultrasound are widespread, including use in military, medical, and industrial applications. For the case of ultrasonic flaw detection, when a wave encounters cracks in a medium, a part of the reflected sound waves generated would be received by detectors to identify the cracks through a waveform analysis. This can assist in identifying the location and size of the internal cracks in the material or the thickness of materials. Similarly, we apply the same situations in seismic wave propagation to analyze daily natural seismic waves, which derive information from a material through the analysis of seismic wave propagation.

The Analysis of Seismic Waveform

Dispersion, which indicates the variation of wave velocity with frequency, can be used to obtain the quality factor, Q, which is referred to the attenuation of a seismic wave. The lateral variation of a velocity structure in geological structures cannot exceed 10%, but for the attenuation model, the variations can be up to 50~100% (Romanowicz, 1990). According to this argument, the seismic attenuation is more sensitive than the velocity structure. Since the data used in this method involves the collection of the first cycle of direct P-waves, it carries information when the wave propagates through the crust and without other wave phases being disturbed. Indeed, the waveform would exhibit some unusual characteristics and the P-wave attenuation dispersion is more sensitive to these variations. Prior to the occurrence of an earthquake, the major changes in the crust may be related to porosity, fluid invasion, and regional stress change.

The Analysis of Real-time Data

We choose seismic events with epicentral distances less than 30 km and $M_L \leq 3$. In Fig. 2, we illustrate the distribution of seismic events and the selected station, and the red stars indicate the earthquakes with magnitudes greater than 3.5. As the Q value would increase with increase in propagation distance, we eliminate the distance effect from the calculation of Q, and then obtain the residual value, dQ. In Fig. 3, we show the distribution of dQ for station CHN5.

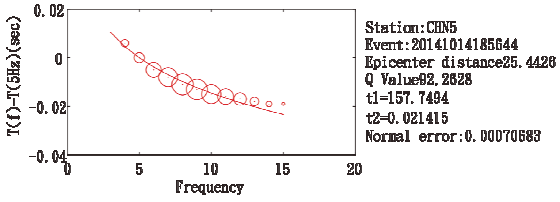


Fig. 1. The dispersion curve for station CHN5

The study of dQ yielded a very important feature. This was that the trend exhibited a great gradient variation before and after earthquakes, which indicates that dQ exhibits a relative increase and then decrease. We further used station CHN5 as a center-point to divide the study area into east and west sides, as shown in Fig. 4. In this figure, the symbols A, B, C, D, E, and F indicate the events and the dQ values were relatively higher before these events. The epicenters are also plotted as red stars in Fig. 2, and the earthquake cluster can also be identified (as shown in Figs. 2 and 4 by the dashed circle). In addition, the different pattern between the two sides reveals that dQ is more sensitive to the regional geological structure.

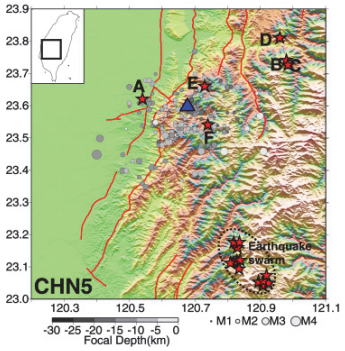


Fig. 2. The topography map and the distribution of seismic events in the study area

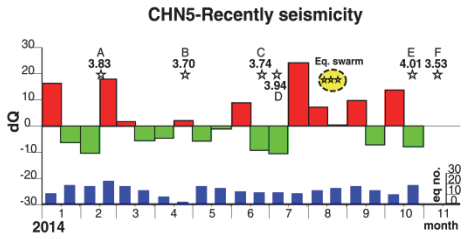


Fig. 3. The distribution of dQ for 11 months in 2014 for station CHN5

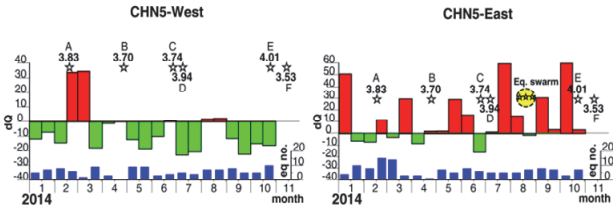


Fig. 4. The eastern and western parts of CHN5 to illustrate the distribution of dQ

Conclusion

Real-time data is currently available to analyze seismic anomalies through the above method for $M_L \geq 3.5$ and the anomalies may have occurred about one month prior for the current results. If we adopt the above method to monitor the high seismic potential area or important facilities, the results can be of great significance in earthquake prevention and mitigation.

Application of Real-Time Database for Earthquake Precursory Research

Vivek Walia, Arvind Kumar, Shih-Jung Lin, NCREE, Tsanyao Frank Yang, National Taiwan University

In the last few years, we focused on the temporal variations of soil-gas composition at established geochemical observatories along the Hsincheng fault (HC) in Hsinchu area, Hsinhua fault (HH) in Tainan and at Jaosi (JS) in Ilan areas of Taiwan, respectively. The study is aimed to determine the influence of enhanced concentrations of soil gases to monitor the tectonic activity in the region and to test the previously proposed tectonic setting based model from data generated at earthquake monitoring stations. The stress-induced variations due to impending earthquakes in radon are contaminated by meteorological changes (i.e.Atmospheric temperature, pressure, precipitation, etc.). Hence, assessment and quantification of these influences are a major prerequisite in the isolation of precursory signals. As per the present practice, the data from various stations are examined synoptically to evaluate earthquake precursory signals against the backdrop of environmental factors. To increase the efficiency of real-time base and to improve data processing system for earthquake precursory studies efforts were made to change the real-time database from manually to the automatically operative system. For the earthquake prediction the efficiency of an operation system depends not only upon its logical correctness, but also upon the response time. So, it's very important to work on reducing the "response time" effectively, which it can be achieved by using with some information technology techniques. The rolling average and normalization were used to quantify the probability distribution of variation in the data and final processed result computed from the R script. Comparing the results computed from business package software "Visual Signal" it has been found the result from both the techniques almost similar. We upgraded our working procedure to "programmed data operation and visualization", which not only helps to have the ability to achieve real-time, but also help in batch processing to reduce the response time. It also helps to move a step forward to integrate our data with the popular and famous open source web application solution stack "AMP" (Apache, MySQL, and PHP). The Apache HTTP Server, commonly referred to as Apache, is a web server application notable for playing a key role in the initial growth of the World Wide Web. MySQL "My S-Q-L"officially, but also called "My Sequel" is the world's second most widely used open-source relational database management system. Whereas, PHP is a server-side scripting language designed for web development, but is also used as a general-purpose programming language. Above said methodology was adopted to process the data from the monitoring stations (run by NCREE and NTU in collaboration) and automatically uploaded to the web service which provides the data management/exhibition with less response time database. In addition to monitoring station data, seismic parameters and meteorological parameter data are also uploaded from Central Weather Bureau of Taiwan (www.cwb.gov.tw) simultaneously (Fig.1). It would be helpful in increasing efficiency of earthquake prediction studies.

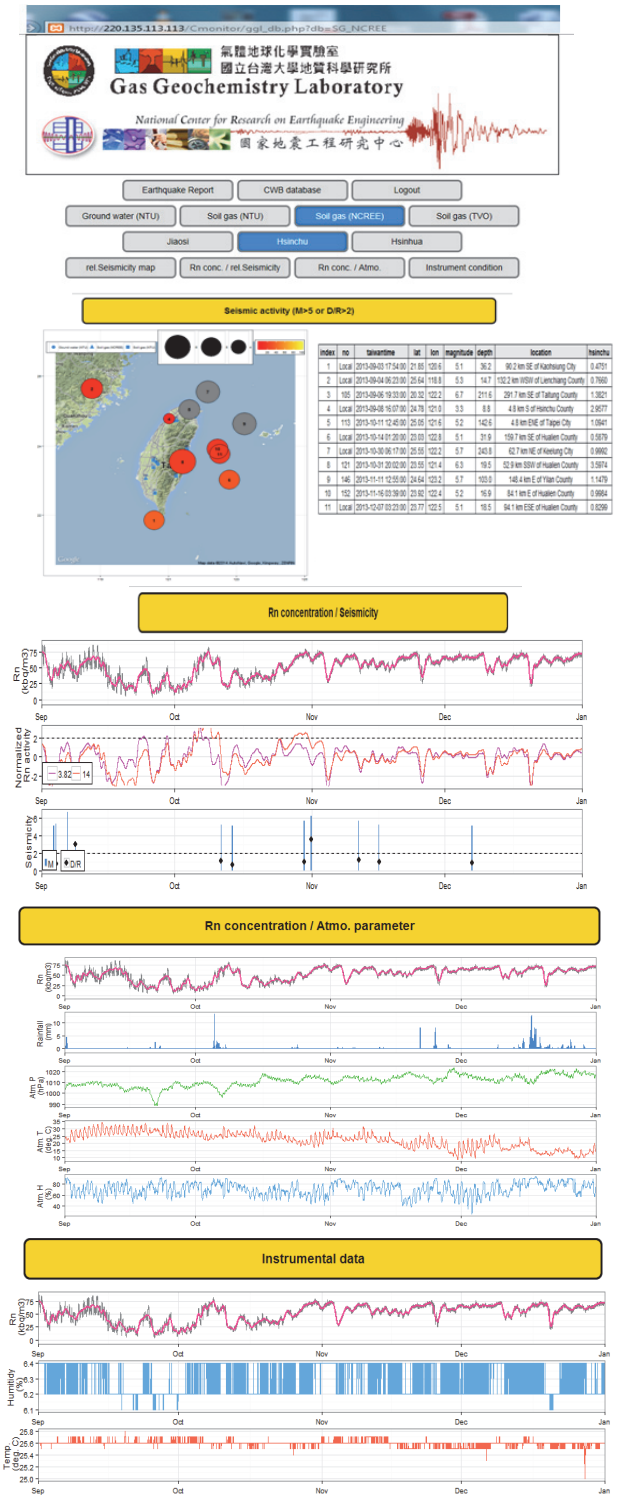


Fig. 1. Real-time database for all the monitoring station data (e.g. HC monitoring station) with seismic parameters and meteorological parameters

5th Asia Conference on Earthquake Engineering

Kung-Chun Lu, Assistant Researcher, NCREE

The Asia Conference on Earthquake Engineering (ACEE) was initiated by the Association of Structural Engineers of Philippines (ASEP) in 2004 to provide a forum for academics, researchers, and professionals involved in various aspects of earthquake engineering. The first two conferences were held in the Philippines, and were attended by hundreds of participants, mostly from the home country.

The third ACEE was held in Bangkok, Thailand on Dec. 1-3, 2010, and was co-organized by four organizations, namely the Asian Institute of Technology (AIT), the Center for Urban Earthquake Engineering (CUEE) at the Tokyo Institute of Technology (TIT), The Engineering Institute of Thailand (EIT), and the Earthquake Engineering Society of Korea (EESK). During the third ACEE, nearly 100 papers were received from more than 20 countries and nearly 100 participants out of the nearly 200 conferees were practicing engineers and involved in various aspects of earthquake engineering.

The previous ACEE, the fourth ACEE, was jointly held with the Ninth International Conference on Urban Earthquake Engineering (9CUEE), called the 9CUEE & 4ACEE Joint Conference, and was organized by the Center for Urban Earthquake Engineering (CUEE) at the Tokyo Institute of Technology (TIT). Thanks to the successful combination of 9CUEE and 4ACEE, there were about 300 papers presented at the 9CUEE & 4ACEE Joint Conference.



Fig. 1. The opening remarks and keynote session.

The Fifth Asia Conference on Earthquake Engineering (5ACEE) was held at the Howard International House in Taipei, Taiwan from October 16 (Thursday) to 18 (Saturday), 2014 with the theme "Earthquake Engineering for Resilient Communities". This conference was jointly organized by the National Center for Research on Earthquake Engineering (NCREE) and the National Taiwan University (NTU).



Fig. 2. Photos of the conference banquet

5ACEE provided an excellent forum to unite researchers, professionals, engineers, scientists, and academics to promote and exchange new ideas and experiences in the field of earthquake engineering.

Owing to the great contributions of all participants, 5ACEE was an unprecedented success. The program of 5ACEE included 10 keynote speeches, a near–fault forum, and 7 parallel sessions. There were over 190 papers presented at the parallel sessions, involving about 320 participants from 16 countries. These were (ordered by the number of participants) Taiwan (146), Japan (87), Philippines (31), China (14), United States (11), India (7), Korea (6), Thailand (4), Canada (2), New Zealand (2), Switzerland (1), Hong Kong (1), Myanmar (1), Peru (1), Singapore (1), and Russia (1). During 5ACEE, an exhibition zone with 17 booths was arranged in the conference venue; such a social activity provided a good opportunity for participants from both academia and industry to exchange their ideas.

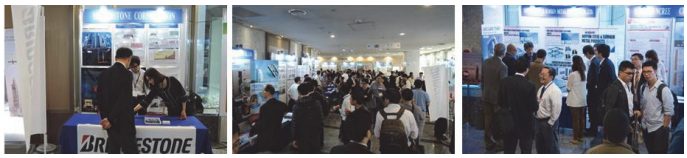


Fig. 3. The exhibition zone of 5ACEE

Considering the serious near-fault seismic disaster observed during the 1999 Chi-Chi Earthquake, NCREE is on the way to establishing a new long-stroke high-velocity shaking table system in a new laboratory of the Tainan branch to develop near-fault seismic resistance technology. The construction of the new laboratory in Tainan will commence in 2015 and is expected to be completed in 2017. On the first day of the conference, NCREE hosted a special forum to commemorate the 15th anniversary of the Mw-7.6 Chi-Chi Earthquake. More than 250 researchers joined the discussion in the forum and the conclusions drawn will become the basis for planning future research topics.



Fig. 4. The keynote speakers and award presentation

Introduction and Demonstrating Earthquake Engineering Research in Schools (IDEERS) 2014

Mu-Hsuan Li, Assistant Researcher, NCREE

The 14th annual Introducing and Demonstrating Earthquake Engineering to Students (IDEERS) competition was held owing to the efforts of the National Applied Research Laboratories (NARL), the National Center for Research on Earthquake Engineering (NCREE), and the British Council (BC), on September 19–21, 2014. There were a total of 15 graduate teams, 42 undergraduate teams, and 40 high school teams participating in the IDEERS modeling and testing event this year. The foreign teams were from China, Japan, Hong Kong, Korea, Philippines, Indonesia, Malaysia, Vietnam, and Singapore.

On September 20, the participants had 6.5 hours to complete their models using simple materials and tools, including long strips of wood, rectangular wooden base boards, PVC hot melt glue, rubber bands, and string. The theme of this year's competition for the high school teams was "asymmetric-plan base". Each high school team constructed a model that required having an asymmetric-plan base design to resist torsional vibration. The theme of this year's competition for undergraduate teams was "a high first floor with an open space". The model that was made by the undergraduate teams required having a high first floor to resist strong ground motions. Every model from the high school and undergraduate teams had to resist strong ground motions from 250 cm/sec^2 to 800 cm/sec^2 while carrying loads of up to 26 kg. Meanwhile, the competition for the postgraduate teams was focused on how to apply advanced technology to build a seismic structure with energy dissipation and/or seismic isolation. All models were ranked by using the efficiency ratio (ER). The value of ER was computed based on the mass of the model itself, the number of mass blocks supported by the model, and the PGA eventually resisted by the model. The winner was the team whose model obtained the largest value of ER.

Participating students conveyed their creativity into diverse types of structural designs. On September 21 after the opening ceremony, models were tested on a shaking table with earthquakes of different intensities. In the end, the National Huwei Agricultural and Industrial Vocational Senior High School team won first prize in the high school division, the Duy Tan University team won first prize in the undergraduate division, and the University of the Philippines Diliman team won first prize in the postgraduate division.

More information about IDEERS is available at http://www.ncree.org/ideers/2014/.

The International Training Program for Seismic Design of Structures 2014

Wang-Chuen Lin, Assistant Researcher, NCREE

Recent major earthquakes around the Pacific Rim have resulted in serious loss of life and damage to property. In order to promote seismic design technology to mitigate seismic hazards in high-seismicity regions, such as in South-East Asia and Latin America, the Ministry of Science and Technology (MOST) of Taiwan has continuously sponsored the National Center for Research on Earthquake Engineering (NCREE) to hold the International Training Program for Seismic Design of Structures (ITP). This training program allows participants from the aforementioned areas to learn about earthquake engineering research and practice in Taiwan, exchange ideas, and share experiences.

The ITP has been held annually since 2002. A total of 387 participants from 23 different countries have attended the training programs from 2002 to 2013. ITP2014 was held from October 13 to 18, 2014, at the NCREE. A total of 20 technical lectures were scheduled in this program, including topics on seismic observations and hazard analysis; seismic design force; seismic design of structures, bridges, and foundations; seismic evaluation and retrofitting; energy dissipation and isolation systems; seismic loss estimation; and the latest research programs conducted at the NCREE. Twenty-six participants from the Dominican Republic, Guatemala, India, Indonesia, Jordan, Malaysia, Turkey, Mongolia, El Salvador, Haiti, Honduras, Philippines, and Nicaragua have successfully completed all of the courses.

In fulfillment of the goals of ITP2014, the seismic design technology and earthquake-resisting capabilities of the participating countries will be steadily improved. We believe that this training program has been successful in strengthening international relationships as well as sharing experiences on earthquake hazard mitigation.

Published by

National Center for Research on Earthquake Engineering

200, Sec. 3, XinHai Rd., Taipei 106, Taiwan, R.O.C.

Phone: 886-2-6630-0888

Fax: 886-2-6630-0858

Website: http://newsletter.ncree.org

The National Center for Research on Earthquake Engineering (NCREE) is a laboratory of National Applied Research Laboratories (NARL)

Website: http://www.narl.org.tw