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National Center for Research on Earthquake Engineering

Inspecting and Monitoring the Safety of Optical Fiber Bridge C907 on the Wugu-Yangmei Overpass of National Highway 1

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Introduction

This study was conducted to solve national bridge-building project issues and encourage future relevant studies. Sub-project C907 of the Wugu-Yangmei Overpass Widening Project involved the construction of the Luzhu section and the airport interchange in Taoyuan of National Highway 1, specifically, along the girders P19N-P20N, and P21S-P22S and P31S-P32S, which are located on the main route directing toward northern and southern Taiwan, respectively. However, during construction, because the concrete was not tamped after the cement was poured, honeycomb deficiencies occurred. Although concrete reinforcement was performed, because this highway is crucial in Taiwan, the safety of the national highway bridge must be attentively focused on. Therefore, our center developed fiber optic sensors that enabled long-term monitoring and synchronized vertical displacement and physical crack detecting and recording to ascertain bridge conditions and protect driver safety.

Our achievements in the study and development of the optical fiber bridge sensors and software can be applied to instantaneously monitor the structural safety of the bridge. When changes occur, warning signals are activated, thereby providing bridge-management authorities with accurate and reliable information, which can be used as a reference for determining the bridge maintenance cycle and evaluating bridge durability.

Bridge Health Monitoring

Because of Taiwan's unique geographical environment and because drivers have varying driving habits, immediate monitoring of highway changes and data analysis and interpretation are required to obtain immediate feedback regarding bridge conditions when sudden changes, such as earthquakes, overloaded vehicles, speeding, and heavy traffic occur. This information is transmitted promptly and accurately to the bridge-management authorities to ensure that the bridges are fully functional. The remote, real-time monitoring system can be used to evaluate and diagnose bridge conditions based on bridge usage, thereby providing a favorable monitoring and warning system.

Because bridge conditions change over time, bridge designs and construction quality inevitably deteriorate, despite receiving perfection and high safety factor scores. In addition, because of damage caused by sudden activities, such as heavy traffic, vehicle overloads, and earthquakes, bridge safety monitoring and inspections must be implemented to protect driver safety.

Visual Inspecting

We marked on an optimal spot under girders P19N and P20N, P21S and P22S, and P31S and P32S. Next, we fixed the target outside the fence and under the girders to distinctly indicate the target positions, which were subsequently recorded. We inspected the reinforced areas (where honeycomb deficiency occurred) and used the first images of the bridge as the baseline values (Fig. 1).



Fig. 1. Visual inspection of bridge

We performed an inspection under favorable weather conditions. In addition to capturing images of the girders, we visually examined and recorded the physical conditions of the entire bridge. We then compared these images with old images to determine whether new cracks had developed. Finally, we archived the images to determine the physical condition of girders in various road sections.

Bridge Loading Test

The girders examined in this study underwent manual load testing on February 7, 2013 and March 13, 2013, and manual leveling measurements to obtain deflection responses (Fig. 2). The deflection responses can be used as parameters for establishing safety indicators. We used fiber optic leveling to conduct regular measurements and inform owners of girder deflection changes.



Fig. 2. Bridge loading test and manual leveling on March 13, 2013

We placed a fiber optic leveling sensor in the box girders of the bridge sections. Next, we used a laser-leveling scanner to delineate a reference point before stabilizing the fiber optic leveling sensor. We then

fused optical fiber lead wires to the tubes and the P19N–P20N, P21S–P22S, and P31S–P32S sensors and connected the tubes using fiber optic connectors to the instrument box under the bridge pillars.

We collected the data at the site and determined the displacement by conducting data analysis. If the results show that changes in girder deflection had reached a critical value, this value can be used to set half of the maximum deflection value that was obtained through the load testing (Table 1) as the abnormal value.

Table 1. The maximum deflection values obtained through load testing

Girders P19N and P20N	Girders P21 and P22S	Girders P31 and P32S
16 dump trucks Each dump truck = 20 tf	28 dump trucks Each dump truck = 20 tf	12 dump trucks Each dump truck = 20 tf
2.6 cm	4.4 cm	1.0 cm

Fiber Optic Leveling Measurement

Fiber optics leveling measurement is an application involving the principles of leveling pipes (Fig. 3). When a pipe rises or sinks (i.e., vertical girder displacement), the water level changes, causing water to flow from top to bottom, creating optical fiber strain. This informs technicians that a bridge pier is sinking or the girder deflection is changing. Once the change in girder deflection falls below the safety value, an immediate warning is activated to notify the bridge-management authorities

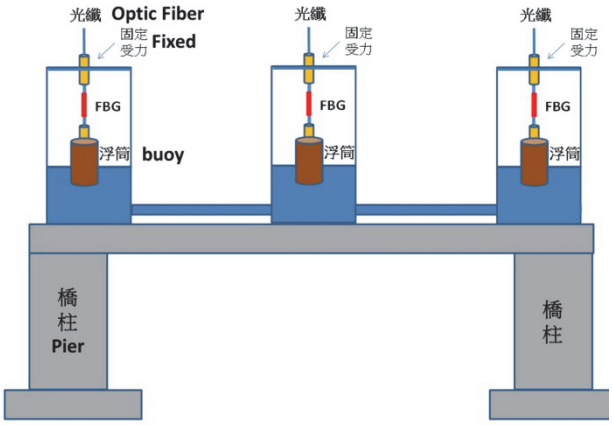


Fig. 3. Application of fiber optic leveling sensors

Sensor Layout on Bridge

Figure 4 presents the sensor layout on the bridge, the pillars and girders of P21S–P22S and P31S–P32.

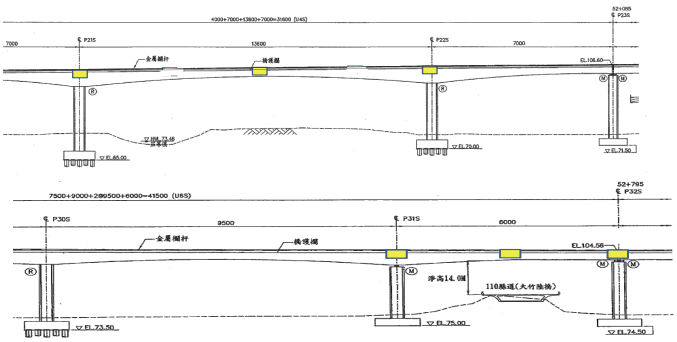


Fig. 4. Schematic diagram of the monitored spot location

Conclusion and Future Prospects

1. This study implemented the bridge-inspection and monitoring technology on the bridge C907 on the Wugu-Yangmei Overpass of National Highway 1 and gained insight regarding experiences in system maintenance. The system not only provides safety warnings, but also protects driver safety; thus, our research results contributed to industries and societies.
2. In addition to verifying immediate measurement data, the fiber optic sensor system could transmit quick and accurate warnings to bridge-management authorities, thereby allowing them to instantly activate emergency responses.
3. We combined the fiber optic sensor with monitoring software technology, both of which were developed by our research team, and anticipated that this innovative technology will provide industries with an easy, user-friendly, and economical measurement technique.
4. By using the on-site assessment records and fiber optic monitoring technology, we developed a bridge safety evaluation system and bridge safety warning standards, which facilitate the prevention of property loss and casualties caused by bridge accidents, thereby emphasizing the concept that an ounce of prevention is worth a pound of cure.
5. By using lengthy multi-span bridges and combining fiber grating sensors and communication technology with bridge construction projects, we verified the durability of the disaster-prevention monitoring system.

(Lee Zheng-Kuan, zklee@ncree.narl.org.tw)

Study on Carbon Fiber Reinforced Concrete for Structural Health Monitoring

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Introduction

Structural monitoring systems are important in civil engineering. However, traditional structural monitoring systems have disadvantages such as the shorter life span of sensors relative to that of the structure being monitored. The present study uses carbon fiber reinforced concrete (CFRC) as a structural monitoring sensor to extend the life of a sensor to match that of the structure.

Experimental Investigations

The design concrete strength was set at 500 kgf/cm^2. The cement was blended Portland cement. Specimens were prepared from a mix with the following composition: water-to-cement ratio (w/c), 0.4; sand-to-cement ratio (s/c), 0.75; silica fume, 15% by weight of cement; methylcellulose, 0.4% by weight of cement; and carbon fiber (diameter = 7 μm, length = 15 mm), 0.2% of total volume.

From the aforementioned concrete mixture, 5 CFRC bone-shaped specimens, 4 CFRC cylinders, and 7 different styles of CFRC beams at 28 days of age were fabricated for testing. Bone-shaped specimens with dimensions of 455 × 50 × 20 mm were prepared for uniaxial tension testing. Cylinders with dimensions of 100 × 200 mm were prepared for uniaxial compression testing. Beam specimens with dimensions of 550 × 150 × 150 mm were prepared for three-point bending testing. The test setup is shown in Figure 1.

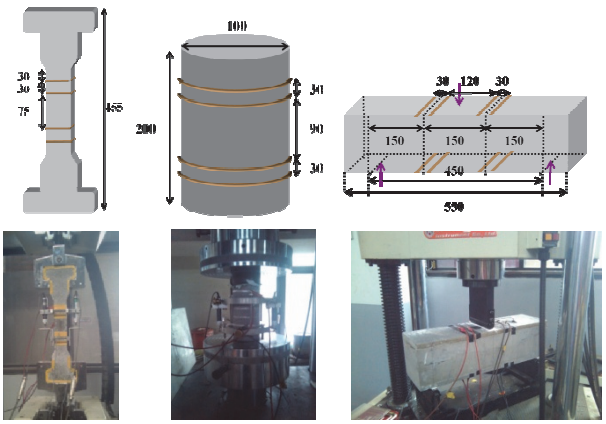


Fig. 1. Test setup for uniaxial tension test, uniaxial compression test, and three-point bending test

Results and Discussion

Figure 2 shows that the fractional change in electrical resistance has a linear relationship with tensile strain in region-I, and rapidly decreases in region-III because of the fast increase in electrical resistance due to damage accumulation. The slope of the curve of fractional change against tensile strain is a good indicator for damage detection under tensile loading.

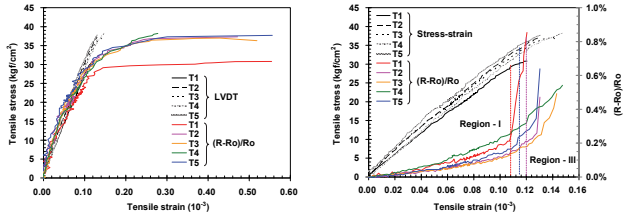


Fig. 2. Tension test, variation of tensile stress and fractional change in electrical resistance with strain

Figure 3 shows the fractional change in electrical resistance has a linear relationship with the compressive strain in region-I and region-II where GF1 and GF2 are used for compressive strain measurement. The fractional change in electrical resistance rapidly decreases in region-III because the electrical resistance increases quickly due to the damage accumulation. The slope of the curve is a good indicator for damage detection under compressive loading.

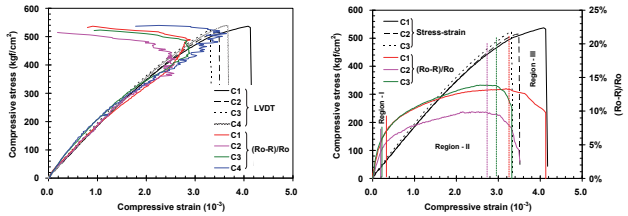


Fig. 3. Compression test, variation of compressive stress, and fractional change in electrical resistance with strain

Comparison between the pure CFRC beams and the CFRC-coated beams revealed that the gauge factor of the CFRC-coated beams was larger than that of the pure CFRC beams (Table 1). Generally, the CFRC-coated beams had a larger gauge factor.

Table 1 Results of the three-point bending tests

Specimen		Strain (10^{-3})		GF		R^2	
		c	t	c	t	c	t
CFRC	w/o Rebar	-0.08	0.040	175	220	0.97	0.81
	w Rebar	-0.17	0.075	52	87	0.96	0.90
		-0.15	0.075	78	89	0.92	0.89
Coat-ing	w/o Rebar	-0.11	0.075	252	160	0.97	0.91
		-0.15	0.060	49	78	0.88	0.95
	w Rebar	-0.15	0.060	1031	497	0.95	0.94
		-0.06	0.045	603	844	0.98	0.93

Conclusions

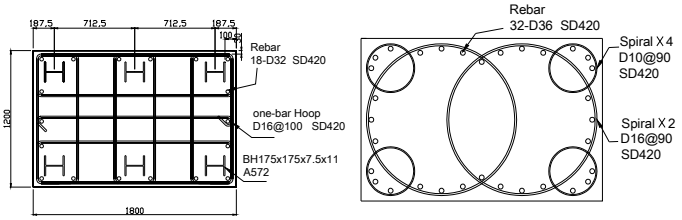
Experimental results of tests on uniaxial tension, uniaxial compression, and three-point bending show that CFRC at a fiber content of 0.2 vol.% can be used for strain measurement and damage detection. Self-sensing of the tensile strain, compressive strain, and damage detection in CFRC under monotonous loading was found to be effective in this paper.

(Fang-Yao Yeh, fyyeh@narlabs.org.tw)

New Bridge Pier Systems Constructed by Automated Methods

Hsiao-Hui, Hung, Associate Researcher, NCREE

Reinforced concrete is the most widely used construction material for bridge piers in Taiwan. As bridge piers is built high, due to the requirements for strength and ductility in seismic design of RC structures, a large amount of reinforcement, including longitudinal reinforcement, transverse reinforcement, and internal cross ties, is usually required. The construction process for a large amount of reinforcing binding is heavily reliant on skilled labor, which is time-consuming and costly. This tight arrangement of reinforcement not only complicates the construction work, but also deteriorates the quality of concrete casting. Thus, bridge pier systems based on conventional construction technology likely have long construction period and inferior seismic performance. To solve this problem and to improve the construction safety at reasonable construction cost, this study aimed to develop innovative bridge pier systems with good seismic performance that are built through automated construction methods. Two bridge pier systems that possess these features were proposed. One is a steel and reinforced comcrete composite bridge pier system and the other is a multi-spiral stirrup pier system. To verify the constructability of the proposed method and to investigate the seismic performance of the proposed systems, large-scale specimens for both systems (specimens C1 and C2) and a conventionally detailed system (specimen C3) were constructed at the National Center for Research on Earthquake Engineering in Taiwan. A cyclic loading test was subsequently performed on each specimen.



(a)Composite column (C1) (b) Multi-spiral stirrup column (C2)

Fig. 1 Design details of specimens

The design details of the two proposed test columns, C1 and C2, are schematically shown in Fig. 1. Fig. 2 illustrates the test setup. During the test, an axial load of $0.07A_g f_c'$ was applied to the test column through a tap beam using two vertical, high-tensile-strength rods. The vertical loading was kept constant throughout the test to simulate the tributary dead load of the deck. In addition, three horizontal actuators were used to apply a lateral force to the column's top to simulate the seismic loading. The displacement loading protocol for the cyclic loading test in which the excited drift ratios ranged from 0.25% to 9.0% is also described in Fig. 2. Fig. 2 also shows the hysteretic curves for the test columns. As can be seen, the lateral strength of the conventionally detailed column degraded significantly at the third cycle of displacement, corresponding to a drift ratio of 5%. On the other hand, the lateral strength of specimens C1 and C2 could maintain a stable value until drift ratios of 8% and 9%, respectively. These test results confirm that both proposed columns exhibited higher ductility than did the column with conventional design.

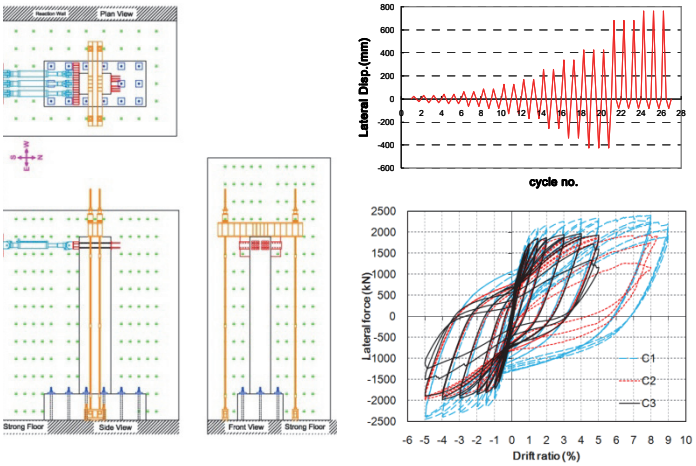


Fig. 2. Experimental program and test results



(a) (b) (c)

Fig. 3. Comparison of failure mode

(a) C1 at 9% (b) C2 at 8% (c) C3 at 5%

The superior confinement effect of the proposed columns could also be clearly observed in the close-up photos of the failure mode (Fig. 3). Even though the proposed columns were subjected to a higher value of drift ratio of 9% or 8% rather than the conventional value of 5%, most of the rectilinear hoop for the composite column was still in its original position. Similarly, the six spirals and the core concrete in the spiral-confined column were maintained in a satisfactory condition. On the other hand, most of the hooks of the cross ties opened up in the traditional column.

Because of the automated work of the pre-assembled hoop cage and the support provided by the steel section, the construction efficiency of the proposed systems is better than that of its conventional counterpart in construction practice. In addition, the cyclic loading test confirmed that the seismic performance of the proposed columns is superior to that of the conventional one. Thus, the proposed pier systems may offer an attractive and superior alternative to the traditional design of conventional RC columns.

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Experimental Study on the Seismic Performance of a Single Span Bridge Model with Scoured Pile Foundation

Kuang-Yen Liu, Chia-Han, Chen, NCREE
Kuo-Chun Chang, Neng-Hong, Chen, National Taiwan University

This work aims to investigate the seismic performance of simply-supported bridge models with exposed pile foundations. A series of shaking table tests were conducted to study the seismic behavior of a piled bridge model based on combinations of exposed pile length. Specimen 1 was fixed on the ground, and specimen 2 was designed to expose piles within two biaxial laminar shear boxes. It is expected to compare the bridge performance of the simple case of fixed-end condition of the column and the complex case that includes soil–pile-structure interaction.



Fig. 1. Test speciment

Five cases for specimen 2 were tested. The designations 0D, 3D, and 6D represent exposed lengths (0, 3, and 6) multiplied by the outside diameter of the pile. For specimen 1, each case was first vibrated by white noise with peak ground acceleration (PGA) of 30 gal to identify the system period and damping. Subsequently, recording with El-Centro, TCU076, and Artificial-TCU076 at PGAs of 0.1g, 0.15g, and 0.2g was performed. The test sequence for specimen 1 was used on specimen 2 and one case for 0.35g with El-Centro.

Table 1 shows that the structural period of specimen 2 increased from 0.73 to 1.28 sec at extended scouring depth, relative to the period of 0.36 sec for specimen 1 at fixed-base condition. The period was identified by the half-power method from the transfer function of measured accelerations in the white-noise case of 0.03g, which took acceleration at the bottom of the shear box as the input signal and the acceleration at the middle span of the girder as the output signal. The identified system damping gave an average damping of 15.2%.

The acceleration and displacement response of the superstructure of specimen 2 in the case of Artificial-TCU076 is shown in Table 2. The maximum acceleration decreased as the scouring depth increased, but the displacement also increased because of the considerable extension of the structural period. For the pier and pile, the structural performance was expressed as a relationship between moment demand and moment capacity, defined as the D/C ratio. As shown in Fig. 2, there was only a slight change in the pier even when the scouring depth was 6D. However, the D/C ratio for the pile slightly increased. If the scouring issue is taken into account, then this increase is evidence of the mechanism of failure transfer from pier to pile.

Table 1. Identified structural period and damping

Case	Period (second)	Damping (%)
H0D-R0D	0.73~0.79	13.34
H0D-R3D	0.85~0.93	16.25
H3D-R3D	1.02~1.14	18.64
H3D-R6D	1.14~1.14	10.87
H6D-R6D	1.24~1.28	16.84

Table 2. Acceleration and displacement response of the superstructure in Artificial-TCU076 case

PGA / Case	Acc.(gal)			Disp. (cm)		
	100	150	200	100	150	200
H0D-R0D	100	139	179	30	50	73
H0D-R3D	100	132	157	33	52	71
H3D-R3D	77	108	158	38	68	107
H3D-R6D	76	113	161	40	70	112
H6D-R6D	86	118	161	55	81	126

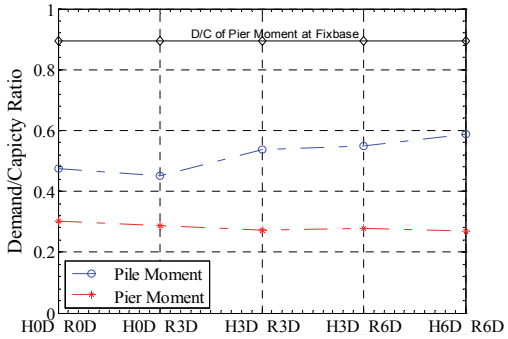


Fig. 2. Moment D/C ratio of the pier and pile in Artificial-TCU076 case (PGA=200 gal)

The seismic performance of the scoured piled bridge was investigated by using a shaking table test to simulate the damage of a scoured bridge under earthquake conditions. The experimental results demonstrate that the D/C ratio, moment demand, and capacity ratio for the pier exhibited a minor change, but those for the pile increased markedly when the scouring depth was increased to up to six times the diameter of the pile. Meanwhile, the comparative case under fixed-base conditions, a conservative approach for preliminary design, resulted in maximum force and displacement demand compared with other cases with exposed piles. In addition, the experimental results are represented by an analytical approach that considers the stiffness and force contribution from soil springs. The trend of the prediction was satisfied by using the test observations, but detailed modeling of the nonlinear behavior of sand under strong earthquake agitation should be explored in the future. (Kuang-Yen Liu, kyliu@narlabs.org.tw)

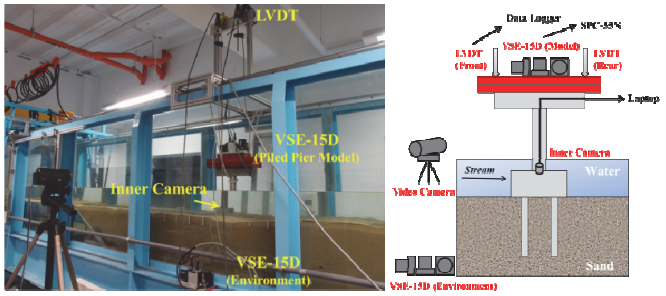
Feasibility Study on Developing Scour Fragility Curve by Flume Experiments

Chun-Chung Chen and Kuo-Chun Chang, NCREE

The escalating scale of natural disasters associated with global climate change and the growing world population increasingly threatens civil infrastructure. In particular, flooding is a major disaster that can result in damage to or failure of cross-water bridge structures. This study proposed a procedure for constructing a scour fragility curve from flume experimental data for a piled bridge pier. Several flume experiments with model pier scouring under controlled conditions were conducted and the variation of the scour process variation was observed. Scour depths observed from the flume experiments were used to develop a scour fragility curve, which could be applied to evaluate the scour vulnerabilities of piled bridge piers in preliminary studies.

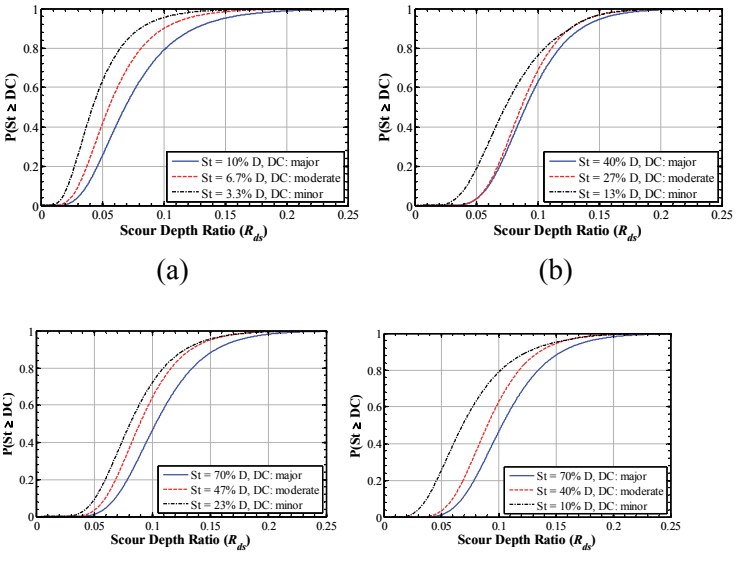
The most important part of this study is the defined damage index and the damage severity. For this reason, several preliminary tests were conducted to determine the soil and flow properties to obtain an acceptable failure mode. After the experiment setup was decided, the experiment was repeated to obtain sufficient data to construct the scour fragility curves. Since the laboratory conditions only allowed the flow conditions to be set as a range, the bridge structure configuration must be primarily based on the flow conditions. This study designed a reduced-scale bridge pier model to conduct the experiment (Figure1). The piled bridge pier model was set up in the flume for scour tests conducted under certain flow conditions with specific initial embedded conditions. Variations in scour depth, which could indicate the pile embedded depth and pier settlement changes over time during the scour process, were observed and recorded. Thereafter, the pier settlement was used as the damage parameter to define the damage states, including major, moderate, and minor failures of the bridge pier model. Flume experimental data were used to build the scour fragility curve, a function of the scour depth ratio, which is a ratio of the scour depth at the pile to the pile length. It was assumed that the scour fragility curve could be drawn in the form of a two-parameter lognormal distribution function. This hypothesis had been verified through the Kolmogorov–Smirnov test. Statistics such as mean and log standard deviation were calculated according to the maximum likelihood method.

The main purpose of this study is to show how flume experimental data could be used to build a scour fragility curve. The measured trend of the curve is consistent with the general scour process and the realistic behavior of the damage sequences of the piled bridge pier. This study demonstrated a feasible methodology for constructing the scour fragility curve from flume experiments (Figure 2). Through this methodology and a sufficiently large database, scour fragility curves for different types of structure and foundation and various factors effecting scour depth such as the properties of the soil and flow could be built. Once the scour depth is measured by the monitoring system or predicted by the scour depth formula as in HEC-18, the failure probability of the bridge pier could be estimated and could serve as a warning index. Thus, further studies focusing on diverse soil and flow conditions and different failure modes are necessary to establish a more precise and more generalized approach to form practical fragility curves that can be applied in diverse situations.



(a) Photos of the instruments (b) Diagram of the instruments

Fig. 1. Layout of measuring instruments for the flume experiment observations



(a) (b)

Fig. 2. Scour fragility curves with failure criteria of (a) 1 mm, (b) 4 mm, and (c) 7 mm. (d) Scour fragility curves with major settlement criteria of 1, 4, and 7 mm.

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The October 31, 2013 M_L-6.3 Hualien Earthquake in Taiwan

NCREE Emergency Response Team for Earthquakes

On October 31, 2013 at 20:02:9.0 CST (12:02:9.0 UTC), an earthquake with magnitude M_L of 6.3 occurred in the longitudinal valley of Hualien in eastern Taiwan. According to the report of the Central Weather Bureau (CWB), the epicenter of the main shock was located at 121.42°E and 23.55°N, about 52.9 km from the Hualien County Government. The focal depth was estimated at 19.5 km. The USGS also estimated the moment magnitude at 6.3, the location at 121.443°E and 23.591°N, and the focal depth at 12.0 km. The earthquake was felt all over Taiwan Island (Fig. 1).

The focal mechanisms calculated from institutes in Taiwan and in the U.S. are very similar. The present study used the centroid moment tensor solution from the CWB. The lower left figure of Fig. 1 resembles a thrust slip fault. According to the distribution of aftershocks and the tectonic setting near the hypocenter, the strike of the real fault plane solution may be 209°, with a dip angle of 59° to the west and slip of 51° along the rake. Many aftershocks with magnitudes larger than 3 and several with magnitudes even larger than 4 were observed after the main shock, the largest one (M_L 4.8) of which occurred on the same day of the main shock.

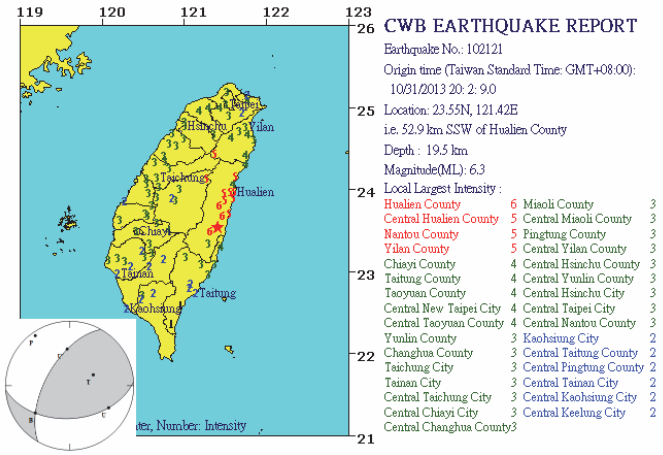


Fig. 1. The CWB report on the 1031 Earthquake

According to the earthquake report from CWB, the real-time, strong ground motion station EGF recorded the largest peak ground acceleration (PGA) of 306.32 gal in the EW direction. The ground shaking level at this station had an intensity of 6 (PGA from 250 to 400 gal). Shaking intensities of other regions in Taiwan are shown in Fig. 1. However, after recordings of the free-field strong motion stations became available, HWA035 station, which was at an epicentral distance of 20.62 km, recorded the strongest PGA (460.62 gal; intensity 7, which is larger than 400 gal) in the NS direction. Five other stations also recorded a shaking intensity of 7 during this earthquake. The recorded intensities at stations north of the epicenter were larger than those in the south. This might be because of directional effects of the source rupture.

After receiving the earthquake report from CWB at 20:11, Server T2 at the National Center for Research on Earthquake Engineering (NCREE), began operating immediately for early seismic loss estimation (ESLE), and informed its clients of the earthquake summary and casualty estimate at almost the same time. NCREE released cell phone messages, indicating that no casualty was projected, which was confirmed later. (Fig. 2)

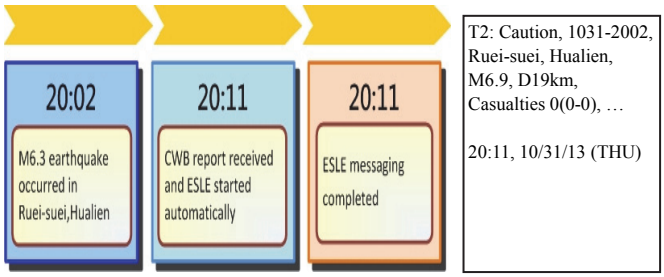


Fig. 2. ESLE operation and messaging of report on the earthquake

A reconnaissance team from NCREE was organized and was sent to the affected area to carry out a detailed investigation of the damage to school buildings. The major damage experienced in this earthquake was focused on nonstructural damage, particularly to suspended ceilings.

After detailed evaluation, five school buildings in which seismic construction was accomplished before the 1031 Earthquake were considered to be under high seismic risk, except one school building whose detailed evaluation was carried out in October this year. A comparison of maximum PGA values in the 1031 Earthquake before and after retrofitting is shown in Fig. 3. The PGA of the 1031 Earthquake was twice as high as the seismic capacity of the school buildings before retrofitting, but no structural damage actually occurred in this earthquake, as seismic construction had already been implemented.

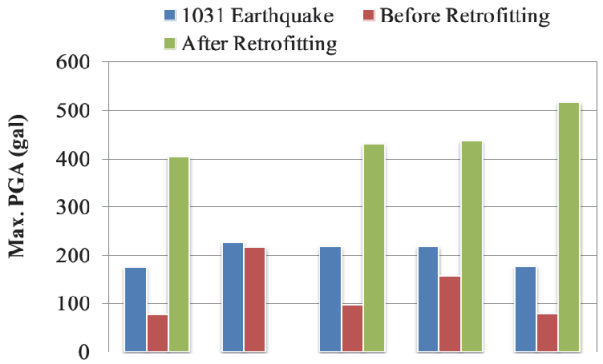


Fig. 3. Comparison of maximum PGA of the 1031 Earthquake before and after retrofitting

Introduction and Demonstrating Earthquake Engineering Research in Schools (IDEERS) 2013

Mu-Hsiung Li, Assistant Researcher, NCREE

The thirteenth annual Introducing and Demonstrating Earthquake Engineering to Students (IDEERS) competition was held thanks to the efforts of the National Applied Research Laboratories (NARL), the National Center for Research on Earthquake Engineering (NCREE), the National Center for Disaster Reduction (NCDR), and the British Council (BC), on September 14–15, 2013. There were a total of 17 graduate teams, 42 undergraduate teams, and 42 high school teams participating in the IDEERS modeling and testing event this year. The foreign teams came from China, India, Hong Kong, Korea, Indonesia, Malaysia, Vietnam, and Singapore.

On September 14, 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 glues, rubber bands, and string. The theme of this year's competition for high school team is "asymmetric-plan base". Each high school team constructed a model that must have asymmetric-plan base designed to resist torsional vibration. The theme of this year's competition for undergraduate team is "a high first floor with an open space". The model that was made by undergraduate team must have the high first floor to resist strong ground motions. Every model of high school team and undergraduate team had to resist strong ground motions from 250 cm/sec^2 to 800 cm/sec^2 while carrying loads of up to 26kg. Otherwise, the competition of the postgraduate teams is focused on how to apply the advanced technology to build a seismic structure with the energy dissipation and/or seismic isolation. The materials or devices that were prepared by postgraduate teams can be used to build a seismic structure in the competition if they pass through the registration. All models are ranked by using the efficiency ratio (ER). The value of ER is 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 would be the team whose model obtains the largest value of ER.

Participating students brought their creativity into full diverse types of structural designs appeared this On September 15, after the opening ceremony, models were tested on a shaking table earthquakes of different intensities. In the end, Henderson Secondary School team won first prize in the high school division, Minghsin University of Science and Technology team won first the undergraduate division, and the Hong Kong University of Science and Technology team won first prize in the division. More information about IDEERS available at http://www.ncree.org/ideers/2013/.

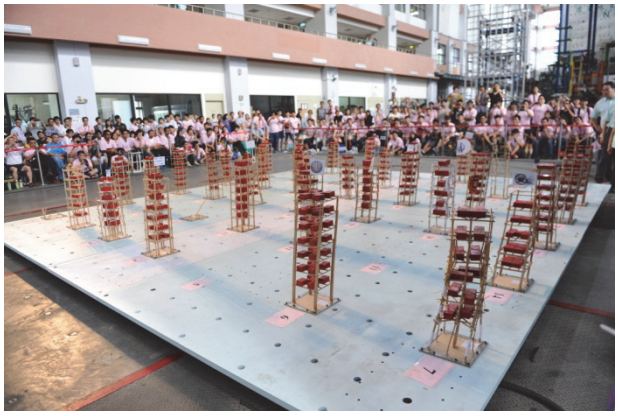


Fig. 1. Models were tested on a shaking table

Table 1. The winners in IDEERS 2013

Team	First Prize	Second Prize	Third Prize
Graduate Team	The Hong Kong University of Science and Technology	Keimyung University	National Cheng Kung University
Undergraduate Team	Minghsin University of Science and Technology	National Taiwan University of Science and Technology	DuyTan University
High School Team	Henderson Secondary School 1	Henderson Secondary School 2	Taipei Municipal Da-An Vocational High School



The First Prize of High School Team | The First Prize of Undergraduate Team | The First Prize of Graduate Team

Fig. 2. The first prize models

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Development of Monitoring System for Disaster Prevention for the Bridge over Jhuoshuei River

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Bridge safety is an important issue in public transportation, especially in terms of minimizing natural hazards. Serious hydrological conditions due to extreme weather and global climate change have been of great concern to the related safety problems with bridge structures. Heavy rainfall causes high-speed floods and transports sediment and debris in rivers, which damage bridge piers and foundations. Scouring around bridge piers remains a major cause of bridge failure by hydraulic phenomena. Hazardous conditions caused by rapid river flow cause significant scour and deposition around a bridge pier during a flood, making it difficult to detect deterioration of the structural foundation. Scour failure of structures tends to occur suddenly without any warning or signs of distress. It is thus important to monitor the change in scour-depth in real time in order to prevent catastrophic failure of the bridge and possible casualties. This is especially essential for bridges carrying high traffic loads. Therefore, real-time, reliable, and robust in situ monitoring system may improve the safety of a bridge and may be cost-effective, as it guards against the premature or unnecessary maintenance of a bridge. The objective of this paper is to provide a comprehensive summary of recent developments in bridge safety monitoring and management during flooding. These advances include the development and application of scour-depth instruments, real-time monitoring systems, the stability of bridge pier structure, the mechanism of scour evolution, the integration of hydrological forecasting for scour-depth prediction, and bridge safety management for bridge closure.

Considering that old bridges have insufficient resistance to flooding and insufficient seismic resistance, the DGH surveyed approximately 2,000 bridges nationwide during 2000 to 2007. Following the survey, the agency identified 40 bridges in Taiwan as critical and placed them on a top-priority list for repair work. Ten of the 40 bridges were considered extremely scour-critical and needed immediate reconstruction. In 2008, the DGH stated that repairs on these 10 bridges needed to be completed by 2013. Notwithstanding, most of these extremely scour-critical bridges, which are at a high risk of collapse during floods, are still open to traffic. To ensure safety, however, the DGH has introduced plans to temporarily close these bridges on the basis of predetermined flood-warning levels during extreme weather conditions.

During Typhoon Sinlaku in September 2008, which resulted in strong winds and heavy rain in Taiwan, 6 bridges collapsed and a landslide buried 8 cars, killing 7 and injuring 17. In August 2009, Typhoon Morakot, which successively accompanied the southwest cyclone that brought heavy precipitation of more than 2500 mm in southern Taiwan, hovered around Taiwan for three days. Approximately 200 bridges, mostly located in the mountain area around southern Taiwan, were damaged during this typhoon. Flood-induced bridge scour failures tend to occur suddenly and without warning. Hydraulic scouring is one of the major factors for bridge failure. Bridges that are subject to periodic flooding should be monitored during high-flow seasons for public safety.

The wireless sensor network has emerged in recent years as a promising technology in civil engineering and industrial applications. It will greatly influence the way in which we monitor and measure things. Wirelessly networked sensors can process vast amounts of data by monitoring and measuring structural damage, air quality, traffic conditions, weather conditions or tidal flow, and so forth. In the present study, a micro-electromechanical system (MEMS) vibration-based sensor was integrated with a wireless network on a sensor board for real-time monitoring of bridge scour. A wireless, MEMS vibration-based scour monitoring system was developed and utilized in the laboratory to obtain real-time measurements during the scour/deposition processes at the bridge pier. The scour model was employed to calculate the scour-depth evolution, which was compared against measurements. By applying the proposed MEMS vibration-based sensor/wireless network system, laboratory data on scour depth and deposition height were collected and analyzed (as Fig. 1).

The accelerometer used is an electromechanical device that measures acceleration forces. These forces may be static, such as the constant force of gravity pulling at our feet, or may be dynamic, that is, they are caused by movement or vibration of the accelerometer. Many types of accelerometers have been developed and reported. The first MEMS accelerometer was designed in 1979 at Stanford University, but it took over 15 years before the device became mainstream products for many applications. In the 1990s, MEMS accelerometers revolutionized the industry of automotive-airbag systems. Since then, they have enabled unique features and applications ranging from hard-disk protection on laptops to game controllers. A typical MEMS accelerometer is composed of a movable proof mass with plates that are attached through a mechanical suspension system to a reference frame. Micromachined accelerometers are a highly powerful technology with a tremendous commercial potential. They provide low-power, compact, and robust sensing. Important parameters for accelerometers that affect the system are sensitivity, bandwidth, and noise characteristic. Bandwidth is the frequency used to measure changes in acceleration. The frequency of the oscillator has to

be much higher than the bandwidth frequency because an electronic circuit must read changes in capacitance more quickly than it reads acceleration changes, and the demodulator needs a certain number of cycles before it calculates output. The noise characteristics influence the performance of the accelerometers, especially those operated at lower g conditions, since there is smaller output signal. Thus, there are three primary noise sources in a typical MEMS accelerometer measurement, namely, mechanical vibrations of the springs, signal-conditioning circuitry, and the measurement system itself.

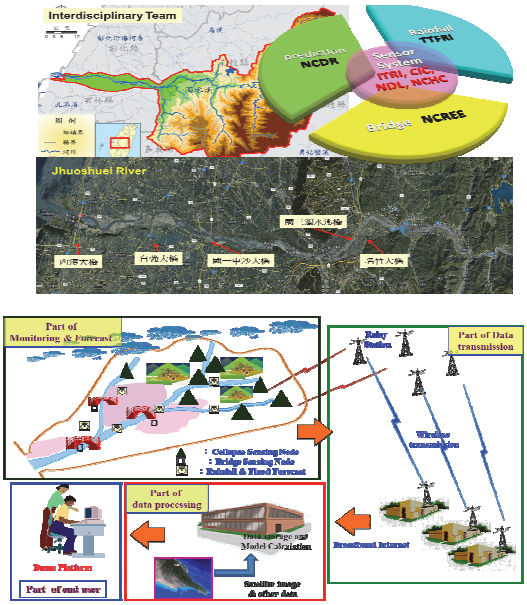


Fig. 1. Jhuoshuei River and NARLabls research team

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The 5th Asia Conference on Earthquake Engineering

The 5th Asia Conference on Earthquake Engineering (ACEE 2014) will be held at the Howard International House in Taipei, Taiwan, from October 17 (Friday) to 18 (Saturday), 2014 with the theme "Earthquake Engineering for Resilient Communities." This conference will be jointly organized by the National Center for Research on Earthquake Engineering (NCREE) and the National Taiwan University. ACEE 2014 will provide an excellent forum to bring together researchers, professionals, engineers, scientists, and academics to promote and exchange new ideas and to share experiences in the field of earthquake engineering.

In order to develop near-fault seismic resistance technology, NCREE will set up a new, long-stroke, high-velocity shaking table system inside the new laboratory in the Tainan office. The construction of the new laboratory in Tainan will start in 2015 and will be completed in 2017. NCREE will host an international workshop on the effects of near-fault ground motions immediately before the 5th Asia Conference on Earthquake Engineering. Interested researchers are welcome to join the discussion in the workshop. Conclusions in the workshop will become the basis for planning future research topics.

Topics:

1.Engineering seismology

2.Tsunamis

3.Geotechnical earthquake engineering

4.Innovative Design of new structures

5.Seismic evaluation and retrofit of existing structures

6.Infrastructures and lifeline systems

7.Urban risk assessment and emergency management

8.Others

Important date

Website opens for abstract submission: Nov. 11th, 2013

Deadline for submission abstract: Mar. 20th, 2014

Online Registration Open: Mar. 20th, 2014

Author Notification: Jun. 31th, 2014

Full length paper due: Aug. 15th, 2014

Pre-Workshop (Near-fault): Oct. 16th, 2014

Conference: Oct. 17th~18th, 2014

Contact Information

Email: kclu@narlabs.org.tw

Dr. Kung-Chun Lu / Conference Secretary

Conference official website:

http://ACEE2014.ncree.org.tw

The International Training Program for Seismic Design of Structures 2013

Chun-Chung Chen, Associate 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 for mitigating seismic hazards in high-seismicity regions such as Southeast Asia and Latin America, the National Science Council of Taiwan has continuously sponsored the International Training Program (ITP) for Seismic Design of Structures by the National Center for Research on Earthquake Engineering (NCREE). This training program allows participants from the aforementioned regions to learn about earthquake engineering research and practice in Taiwan, to exchange ideas, and to share experiences.

The ITP has been held annually since 2002. From 2002 to 2012, 361 participants from 22 different countries have attended the training programs. ITP2013 was held from October 21 to 25, 2012, at the NCREE. Nineteen technical lectures were scheduled in this program, including those 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 latest research programs conducted at the NCREE. Twenty-six participants from Guatemala, India, Indonesia, Jordan, Malaysia, Turkey, Vietnam, El Salvador, Haiti, Honduras, Dominican Republic, and Nicaragua have completed all of the courses.

In fulfillment of the goals of ITP2013, 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 in sharing experiences on earthquake hazard mitigation.

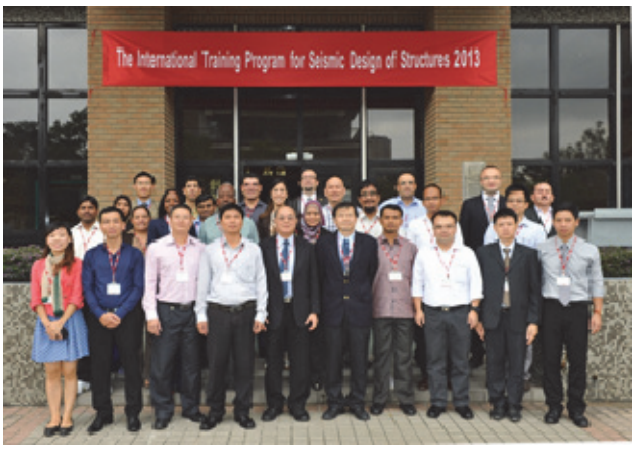


Fig. 1. Group photo of ITP 2013 participate

5th International Conference on Advances in Experimental Structural Engineering

Kung-Juin Wang, Technologist, NCREE

The "5th International Conference on Advances in Experimental Structural Engineering" was held in the National Center for Research on Earthquake Engineering (NCREE) on November 8 to 9, 2013. More than 70 international experts from 15 countries in the field of experimental structural engineering convened during this event to share and present their latest findings in research areas, including:

1. Novel testing, measuring, and monitoring techniques in structural/geotechnical engineering
2. Real time structural testing techniques
3. Hybrid simulations
4. Modeling and numerical simulation in predicting and interpreting experimental results
5. Standardization of testing procedures
6. Application of experimental results to structural design and analysis
7. Data management and information systems for structural experimentation
8. Design, construction, and utilization of novel testing facilities
9. Software and hardware development for structural experiments

In this event, eight keynote speeches from renowned experts were delivered and 55 technical papers were presented orally. All of the 67 accepted papers were included in the proceedings. During the conference the attendees also visited the NCREE laboratories and the isolation layer of the building of the Department of Civil Engineering, National Taiwan University.

6AESE will be held in 2015 at the University of Illinois at Urbana-Champaign, U. S. A.

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