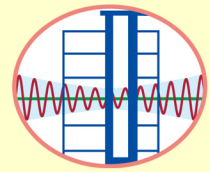
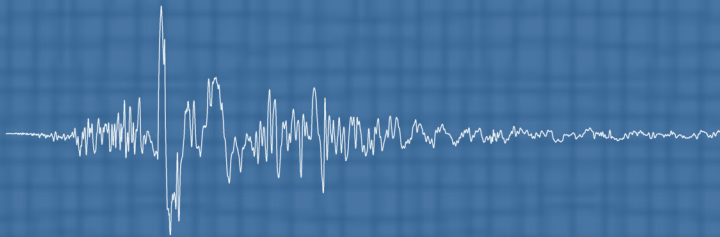


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Interim Seismic Retrofit for Existing Buildings

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Taiwan is in a seismically active zone in the Pacific Ring of Fire and is located on the tectonic convergent boundary between the Philippine Sea Plate and the Eurasian Plate, to the east and west of the island, respectively. Since the Chi-Chi Earthquake in 1999, the central government has actively implemented seismic retrofit subsidy policies and achieved significant results for public buildings. For example, over 95% of high school and junior high school buildings have been evaluated and retrofitted or demolished. Retrofitted buildings have withstood the 2010 Jiashian earthquake, the 2016 Meinong earthquake, and the 2018 Hualien earthquake.

However, the situation is more complex when dealing with private buildings because of potential issues such as multi-possession, construction fees, housing problems during the period of construction, and so on. As a result, the Executive Yuan in Taiwan has announced a new policy entitled “Project of Seismic Evaluation and Retrofitting for Existing Buildings”, which focuses on private buildings. The project includes “Interim Seismic Retrofit”, a short-term contingency protection strategy that can be easily executed before full retrofitting or rebuilding.

Interim Seismic Retrofit

Interim Seismic Retrofit aims to protect buildings from soft-and-weak story collapse with a minimum budget, and thereby provide safety for life and property. To achieve this, the project proposes two methods, which are illustrated in Fig. 1. Method A involves retrofitting buildings to eliminate soft-and-weak story problems, which often occur in the first or lower floors. Method B involves further retrofitting buildings to upgrade their seismic capacity to at least 80% of the seismic demand of earthquake-based design in accordance with Taiwanese seismic regulations. It is essential to note that owners of buildings that undergo Interim Seismic Retrofit are still encouraged to conduct rebuilding or full retrofitting in the future.

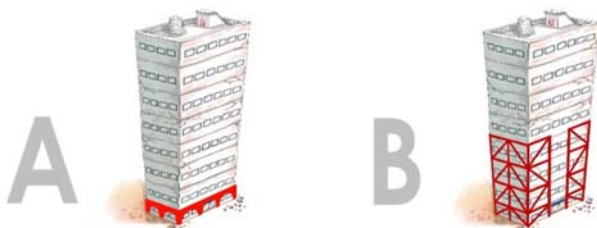


Fig.1 Two methods proposed for Interim Seismic Retrofit

Governmental Subsidy Policy for Interim Seismic Retrofit of Private Buildings

In accordance with the “Subsidy Guidelines and Implementation on Seismic Rapid Screening and Interim

Seismic Retrofit for Existing Buildings”, owners of all private buildings with more than one resident are encouraged to participate. The amount of the subsidy depends on the size of building area and the choice of method, with a limitation of 2.2 million NT dollars, as shown in Table 1. However, if in a case where the building has a high seismic risk and retrofitting is approved by local authorities, the amount of the subsidy can rise to 85% of the total construction fee.

Table 1. Subsidy of Interim Seismic Retrofit

Method	Construction Area	Amount of subsidy
A	Below <u>500 m²</u>	Limitation of 1.1 million NT dollars as well as below than 45% of total construction fee
	<u>Above 500 m²</u>	1.1 million NT dollars with an increase of 100 thousand NT dollars per extra 50 m ² and a limitation of 2.2 million NT dollars and 45% of total construction fee
B	-	Limitation of 2.2 million NT dollars and 45% of total construction fee

Project Office of Interim Seismic Retrofit

Since June 2019, the National Center for Research on Earthquake Engineering (NARLabs) has conducted project research under the auspices of the Interim Seismic Retrofit program and set up a project office authorized by the Construction and Planning Agency, Ministry of the Interior, to promote engineering techniques and subsidies of the project to householders, professional engineers, architects, administrators, etc. In addition, the office is responsible for establishing technical review mechanisms and providing training and support. To date, one residential building in Hualien has been through the Interim Seismic Retrofit program and serves as an example. The result is shown in Fig. 2. An observation and learning activity was held at this site in order to demonstrate the significance of the program to potential participants.



Before retrofitting After retrofitting
Fig.2 Residential building in Hualien involved in the Interim Seismic Retrofit project

To accelerate execution of the program, the project office provides free presentations to the residents. Related news and information can be found on the website: <http://privatebuilding.ncree.org.tw/>.

Bond Slip Behavior of Beam Main Bars within Reinforced Concrete of Interior Beam-Column Joints

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The use of high-strength reinforced steel bars in construction of high-rise buildings reduces the amount of steel bars required as well as mitigates against poor construction quality caused by congested reinforcement configurations. However, in the absence of structural test verifications using SD 550W or higher grade bars, most current seismic design provisions in concrete structure design codes stipulate that steel bars be limited to grade SD 420W. In a revision of the American Concrete Institute building code requirements (ACI 318-19), a yielding strength of 550 MPa is permitted for reinforcement bars in special moment resistant frame systems. Additionally, in prescribing dimensions of column members in beam-column joints, the revised code specifies that the development length of the beam reinforcement through the joint is proportional to the yielding strength. This means that the minimum depth of column members should not be less than 20 or 26 times the diameter of beam bars of grade SD 420W or SD 550W respectively. However, this provision does not consider the contribution of concrete strength, which is inconsistent with the design concept of the bond between the reinforcement bar and concrete. To address this problem, the current study planned and conducted a series of full-scale reinforced concrete (RC) internal beam-column joint seismic tests to clarify the bond performance of beam reinforcement through joints. Based on the beam-column joint seismic performance, the study also proposes an equation for the minimum dimensions of column members.

Experimental Plan and Process

In this study, six groups of beam-column joints were tested for seismic performance. The parameters of the joints were: #8 (D25) and #10 (D32) for the diameter of the beam bars, SD 420W and SD 550W for the grade of bars, and 42 and 70 MPa for the strength of the concrete. The design of the column depths is based on the ACI 318-19 code and the results of previous research on the cyclic bond performance of bars, values of $20d_b$, $26d_b$ and $34d_b$, were used here. Table 1 presents details of the design parameters for the joint specimens.

Conclusion

In Taiwan, there is an enormous number of old private buildings with high potential seismic risk. In order to prevent a future tragedy, both the government and citizens need to positively face this issue and work together to promote seismic evaluation and retrofit.

Table 1. Design parameters for the specimens

Spec.	f_y (MPa)	f_c (MPa)	Beam Bars		Column ($b \times h$) (mm)	Column Depth (d_b)	V_{jd}/V_{jn}	$\Sigma M_{nc}/\Sigma M_{nb}$
			Top	Bot.				
JI1	420	42	2-D32	2-D32	650×650	20	0.698	1.94
JI2			2-D25	2-D25				2.14
JI3	550		4-D25	4-D25		500×850	26	0.716
JI4	420		3-D32	3-D32	0.641			2.91
JI5	550		70	4-D25	4-D25		34	0.697
JI6						26	0.539	2.42

The symbols in the table are as follows: f_y is the yielding strength of the bars (in MPa), f_c is the compressive strength of concrete (MPa), b is the section width of specimens (mm), h is the section depth of specimens (mm), d_b is the diameter of bars, V_{jd} is the shear demand in the joint, V_{jn} is the shear capacity in the joint, and $\Sigma M_{nc}/\Sigma M_{nb}$ is the ratio of strong column to weak beam.

Figure 1 shows the configurations of the beam-column joint testing device. Both beam and column ends in this device can be regarded as hinge bearings. The axial force on the column that increases the shear strength of joints is set to $0.075A_g f_c$ (A_g is the cross section of column). A hydraulic jack is connected to the end of each beam to apply a gradually increasing and reversing cyclic vertical load to simulate a seismic force induced by an earthquake. The displacement of the beam ends is calculated by multiplying the drift ratio of the structure by the distance from the center of the column to the beam end and is shown in Figure 2. The drift ratio at each peak is applied three times.

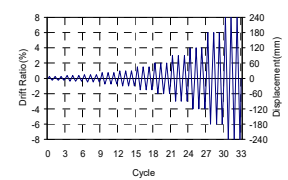


Fig. 1. Testing setup Fig. 2. Loading history of tests

Test Results and Analysis

Figure 3 plots the relationship between the bending moment and the drift ratio of the beam for each specimen. Comparing results for specimens JI1, JI2, and JI4 (which have SD 420W beam bars), it is evident that JI4 has better hysteresis behavior in strength and deformation than JI1 and JI2. The unloading stiffness

(which is defined in the second and fourth quadrant) of JI4 is also larger than that of JI1 and JI2 at the drift ratio of 4% radian. Comparison of results for specimens JI3, JI5, and JI6 (which have SD 550W beam bars, Table 1), indicates that JI5 and JI6 also have better hysteresis behavior in strength and deformation than JI3. The unloading stiffness for JI5 and JI6 are also better than that of JI3. In summary, it has been shown that an increase of column depth and concrete strength can effectively improve the seismic performance of the joint, and that this increase can also enhance the unloading stiffness in the second and fourth quadrant, and delay the occurrence of bond slips for beam bars in joint areas.

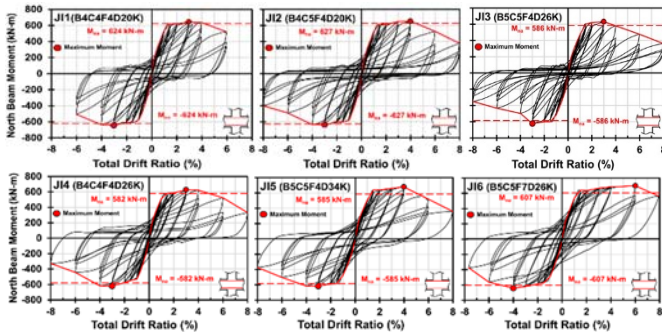


Fig. 3. Relationship between the bending moment and drift ratio of beams for joint specimens

The failure modes (defined as bond failures or plastic hinge failures) of the specimens are shown in Figure 4. This figure indicates that, for specimens with SD 420W beam bars, those with a joint depth of $20d_b$ (JI1 and JI2) have spalling and are crushed at the beam-column interface, but there are no significant plastic hinges in beam members. On the other hand, there is a significant plastic hinge area for specimen JI4 (with a joint depth of $26d_b$). The failure modes of specimens with SD 550W beam bars indicate that bond failure of specimen JI3 (with a joint depth of $26d_b$) is the same as for specimens JI1 and JI2, and that plastic hinge failures in beam members of specimens JI5 and JI6 ($f_c = 70$ MPa, joint depths of $34d_b$ and $26d_b$) are the same as in specimen JI4.

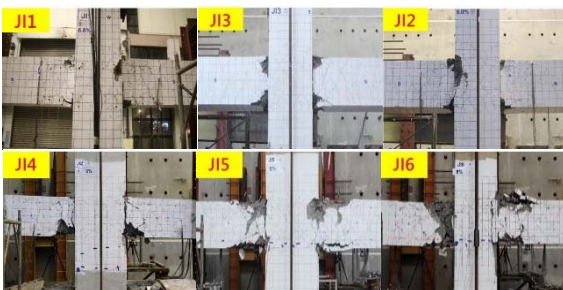


Fig. 4. Failure modes for joint specimens

Discussion of Bar Slips

This section refers to the ACI 374.1-05 standard for evaluating the seismic performance of joints. The bond stiffness (K_b) is defined as the secant stiffness between the positive and negative 0.35% of the third cycle at 4% drift ratio. Figure 5 shows that the average bond stiffness ratios (R_{kb}) between specimens JI3 and JI5 (left hand diagram) and JI3 and JI6 (right hand diagram), all of which have SD 550W beam bars, are only 0.16 and 0.12, respectively. This shows that the depth of the column and the strength of the concrete are the key factors affecting beam bar slip and the seismic performance of joints.

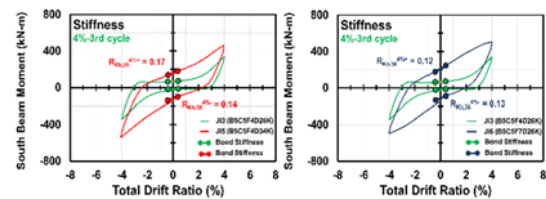


Fig. 5. Comparisons of bond stiffness of specimens with grade SD 550W bars

Proposed Equations of Minimum Dimensions for Columns

The recommended minimum column depth proposed in this study is given in Equation (1). It is based on the past researches about monotonic and cyclic bonding tests. The parameters in the formula include the bond capacity of the bars under cyclic loadings $u_{ultimate}$, the strength of the concrete f_c , the axial loads applied on the column N , the area of reinforcement in tension A_g , the depth of the column h_c , the axial load effect α_p , the over-strength of bars α_o , and the development coefficient of compressive bars β .

$$\alpha_p = 1 + 0.8 \frac{N}{A_g f_c}, \quad u_{ultimate} = 1.08 \alpha_p \sqrt{f_c} \tag{1}$$

$$h_c \geq \frac{(\alpha_o + \beta) A_s f_y}{u_{ultimate} \pi d_b}$$

Conclusions

The results of this study show that when the column depths of the beam-column joints is insufficient, bond slip tends to occur in beam bars under seismic forces. Increasing the column depth or the concrete strength of the joint can effectively delay or avoid bond slips of beam bars, and thus improve the seismic performance of beam-column joints.

Study of the Loading History of Steel Beam-to-Column Connection with Near Fault Effects

Ker-Chun Lin, Research Fellow, NCREE
Sheng-Jih Jhuang, Assistant Researcher, NCREE

Taiwan is situated in the Circum-Pacific seismic belt, and faults in the country are spread across the east and west plains. About one-third of Taiwan's population lives within 10 kilometers of a fault. Therefore, the near-fault effect is an issue that needs to be addressed urgently in domestic seismic engineering research. In the past, because of the lack of geological survey data in Taiwan, the location and distribution of faults were unclear, with the result that the design of buildings did not take into account the characteristics of near-fault effects. In 2005 and 2011, the Construction and Planning Agency, Ministry of the Interior (CPAMI) promulgated a code entitled "Building Seismic Design Specifications and Commentaries" (CPAMI, 2005, 2011). This code specially formulated provision for the consideration of near-fault effects for the first type of active fault identified by the Central Geological Survey in 2000 and 2010. This provision prescribed the acceleration method of the site affected by the fault to enhance the design of seismic force requirements of buildings.

The main purpose of the moment resisting frame (MRF) structural system is to provide the ductility capacity of the system through the inelastic deformation of the beam-end flexural plastic hinge. Therefore, it is necessary to ensure that the beam-to-column connection of the MRF can provide the necessary deformation. In the past, when the engineering industry in Taiwan used test methods to evaluate performance of the steel beam-to-column connection, the loading history recommended in the 2002 edition of the American Institute of Steel Construction design specification (AISC 341) was generally used to carry out the test (AISC, 2002). This continued until the 2016 edition was published (AISC, 2016), after which the loading history was of the far-field type, as shown in Figure 1. The loading history encompasses a gradually increasing story drift angle without residual displacement. However, the deformation requirement for the beam-to-column connection of the structure is likely to depend on the seismic hazard of the location of the structure. Because surface vibrations of near-fault earthquakes have high velocities and large relative displacements, the loading history near faults is likely to be different from the far-field type. The specific loading history of near faults should therefore be related to the seismic design response spectrum of the local site.

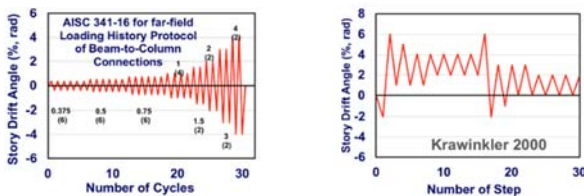


Figure 1. Steel beam-to-column connection loading history with far-field of AISC 341-16

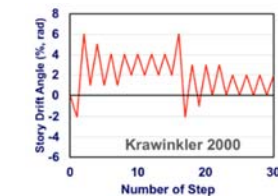


Figure 2. Steel beam-to-column connection loading history with near-fault effect of Krawinkler

Scope of this Study

In 2000, Krawinkler proposed a loading history with far-field effects for steel beam-to-column connection tests (see Figure 1). He also proposed a loading history that is suitable for near-fault effects (Krawinkler, 2000), as shown in Figure 2. However, this reference does not describe the design seismic force requirements.

This paper carried out an inelastic dynamic history analysis of structures in accordance with provisions ASCE 7-16. It then uses the results to adjust the acceleration record according to the basic vibration period of the structure and the target design

acceleration spectrum. The adjustment method could adopt the acceleration spectrum matching method and amplitude scaling method. This was done in accordance with provisions ASCE 7-16 of the American Society of Civil Engineers (ASCE), which stipulate that at least 11 sets of acceleration records are required for nonlinear dynamic analysis (ASCE, 2016).

The purpose of this study is therefore to establish a loading history for steel beam-to-column connection tests that meets the current seismic force design requirements in Taiwan and that considers near fault effects. The records are selected from the pulse records defined by the Pacific Earthquake Engineering Research Center (PEER) strong earthquake database.

Establishing the Loading History of Beam-to-Column Connection with Near Fault Effects

The structural model analyzed in this study is a 15-story steel structural moment resisting frame building. The height of the first floor is 5.1 m, and the remaining floors are 3.4 m high, so that the height of building is 52.7 m. The site is assumed to be located on the second-class site in Shigang District of Taichung City, 5-8 km from the Chelangpu Fault. According to the provisions of ASCE 7, when structural modelling involves nonlinear dynamic history analysis, it is necessary to first establish an acceleration target response spectrum that conforms to the structure site. The magnitudes of earthquakes considered in this study include a design earthquake with a 10% exceedance probability (return period, RP: 475yrs) and a maximum consideration earthquake with a 2% exceedance probability (RP: 2500yrs) during the 50-year useful life.

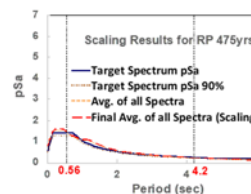


Figure 3. Target spectrum of the RP 475yrs and the adjusted response spectrum of each record

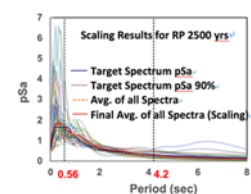


Figure 4. Target spectrum of the RP 2500yrs and the adjusted response spectrum of each record

Because the number of recorded earthquakes in Taiwan exceeding magnitude 6.5 is limited, it was decided to use the near-fault records of the PEER strong earthquake database and select the acceleration history orthogonal to the fault direction in order to obtain a more objective test loading history. Earthquake records were taken from 34 stations in this study and the scaling method was used directly to adjust the acceleration history record. The target spectrum and the adjusted response spectrum of each record for RP 475yrs and 2500yrs are plotted in Figures 3 and 4, respectively.

In this study, the structural nonlinear behavior analysis software PISA3D developed by NCREE was used for nonlinear dynamic history analysis. The main result of interest in nonlinear history analysis is the floor drift angle. The floor in which the maximum drift angle occurred during the earthquake history was selected in the analysis, and that floor drift angle history was used as the basis for establishing the test loading history distribution of steel beam-to-column connections. The following steps were performed in order to establish the loading history:

1. The peak value of the inter-story drift angle history of the floor was captured by the rainflow method, and the horizontal time axis was converted into the step axis.

2. The maximum pulse drift angle ($\delta\theta_{max}$) of the inter-story drift angle distribution was selected after peak values for each group in the previous step were acquired, and then $\delta\theta_{max}$ was made positive.
3. All inter story drift angle distributions were aligned with $\delta\theta_{max}$, the data points that were less than 80% of $\delta\theta_{max}$ were deleted, and the cumulative inter-story drift angle ($\Sigma\delta\theta_i$) and its average value ($(\Sigma\delta\theta_i)_{avg}$) were calculated for each group of drift angle distribution.
4. The average ($\delta\theta_{avg}$) and standard deviation (σ) of all the distribution points of the inter-story drift angles were calculated.
5. The length of the inter-story drift angle distribution was calculated from $(\Sigma\delta\theta_i)_{avg}$.
6. Because the force of the beam-to-column connection is negative, the load was reversed using the X-axis as a mirror after the distribution result in the previous step was obtained.

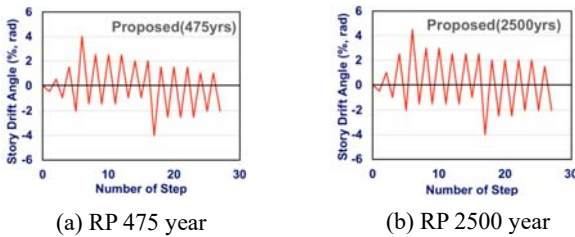


Figure 5. Static test loading history of beam-to-column connection proposed in this study

Analysis of Results

This study proposes procedures for estimating beam-to-column connection (or substructure) static test loading history that takes into account near-fault effects and that is based on the RP 475yrs and RP 2500yrs target acceleration response spectra. The procedures are in accordance with the Taiwan building seismic design code for steel buildings, and the results are shown in Figure 5. In this study, the cumulative inter-story drift angle $\Sigma\delta\theta_i$ and cumulative plastic inter-story drift angle $\Sigma\delta\theta_{pi}$

are used as evaluation indicators. These parameters can be compared with values suggested by Krawinkler (2000) for near-fault static test displacement history reached 4% and the AISC 341-16 (2016) static test displacement history for far-field earthquakes reached 4%. The comparison of the cumulative inter-story drift angles and cumulative plastic inter-story drift angles for the four types of history is shown in Figure 6.

Conclusions

The test load history recommended in this article is based on considerations of near-fault effects, and is estimated for return period values of RP 475yrs and RP 2500yrs. Evaluation of $\Sigma\delta\theta_i$ and $\Sigma\delta\theta_{pi}$ indicates that both cases are stricter than that of Krawinkler (2000). The maximum difference of the inter-story drift angle due to a pulse is 6% and 6.5% radians, respectively, which are smaller than the 8% radians in Krawinkler but larger than the 4% radians obtained from the AISC 341-16 (2016) model. The results of this study show that the four types of static test loading history of the beam-to-column connection discussed can be evaluated by three indices: $\Sigma\delta\theta_i$, $\Sigma\delta\theta_{pi}$, and the maximum difference in inter-story drift angle caused by a pulse. Because the results of the evaluated indices are different for the different models, it is recommended that full-size beam-to-column connection tests be conducted to confirm the applicability of these three indices to beam-to-column connection specimens.

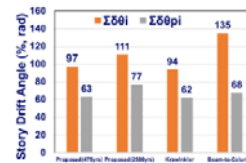


Figure 6. Comparison of results suggested in this study, with those of Krawinkler (2000), and those obtained from AISC-341-16 (2016) reached 4% radian

Simulation and Analysis of the Three-Story Building Tested on the Opening Date of the NCREE Tainan Laboratory

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 Yuan-Tao Weng and Shu-Hsien Chao, Associate Researcher, NCREE
 Wen-Cheng Shen, Pu-Wen Weng and Yi-An Li, Assistant Researcher, NCREE
 Wen-Hui Chen, Research Assistant, NCREE

A shaking table test of a three-story reinforced concrete (RC) model building was conducted on the opening date of the NCREE Tainan laboratory (Figure 1). The tested building is vertically irregular because of the elevated height of the first story and the added RC walls of the third story. In addition to far-field ground motions, near-fault ground motions were exerted on this building. A numerical model of the three-story building was constructed. Comparison of numerical results with the test results indicated that the numerical model is satisfactory for simulating the seismic response of the three-story building. The validated numerical model was then applied to investigate two issues: the effective section rigidities of RC members and the effects of near-fault ground motions. The study results revealed the magnitude of the possible discrepancy between the actual seismic response and the seismic response that is estimated when the effective section rigidities of the RC members are treated in the conventional way. For instance, conventional estimates of peak inter-story drift may be in error by more than two-fold when compared with the validated numerical model. An incremental dynamic analysis (IDA) of the three-story RC building was conducted by studying the effects of one far-field and one near-fault ground motion, denoted as CHY047 and TCU052, respectively. In light of the estimated incipient intensities of ground motions causing the building collapse, the near-fault ground motion (TCU052) was shown to pose a much more severe threat to the three-story building than the far-field ground motion (CHY047). In addition, the effect of the near-fault ground motion (i.e., TCU052) on the collapse of the building was clearly identified.

the simulation results (shown in blue). Likewise, Figures 3c and 3d are equivalent diagrams for the building when shaken by TCU052. The closely matched phases imply that the fundamental vibration period computed from the numerical model, 0.395 s, is relatively accurate.

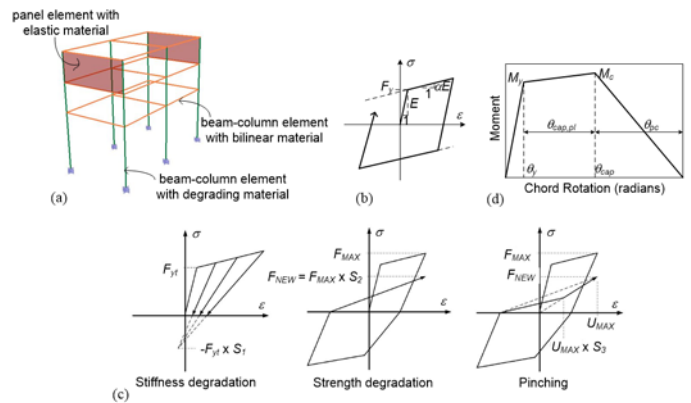


Fig.2. (a) The numerical model, (b) the bilinear material model, (c) the degrading material, and (d) a sketch of the backbone curve.

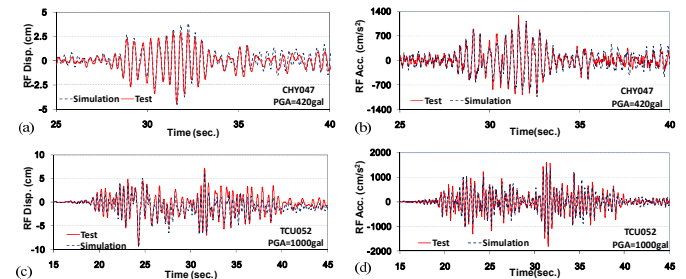


Fig.3. (a) Roof displacement and (b) roof acceleration of the building shaken by CHY047. (c) Roof displacement and (d) roof acceleration of the building shaken by TCU052.

Both Figures 4a and 4b indicate that the inter-story drift of the first story (solid blue curves) increases much more rapidly with increase in the intensity measure, i.e., $S_a(T_1, 5\%)$, in comparison with the second and third stories (dashed curves). This means that the deformation concentrates on the soft-and-weak first story, and the collapse mechanism of this numerical model eventually forms at the first story.

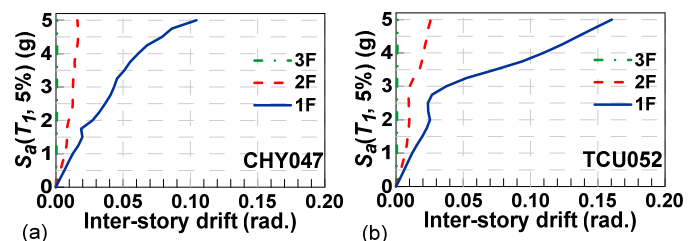


Fig. 4. The IDA curves for (a) CHY047 and (b) TCU052.



Fig.1. (a) NCREE Tainan laboratory. (b) The 8 m × 8 m shaking table and the three-story RC building (the white part).

Numerical Simulation and Analysis

Figure 2a shows the numerical model. Figure 2b shows the bilinear material model used for the beams. The degrading material model for columns uses three additional parameters, denoted as S1, S2, and S3 (Figure 2c), to define the hysteretic rules for stiffness degradation, strength degradation, and pinching, respectively. The backbone curve (Figure 2d) was employed to determine the values of E , F_y , and U_{MAX} used in both the bilinear and degrading material models. Figures 3a and 3b show the displacement and acceleration of the roof (in red), respectively, when the building was shaken by CHY047; these are compared with

Study of the Seismic Evaluation Method by Considering the Characteristics of Existing Mid-to-High Rise Buildings in Taiwan

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Lap-Loi Chung, Deputy Director and Section Head, NCREE

The M_w 6.6 Meinong earthquake occurred on 6 February 2016 in the southern region of Taiwan. The earthquake caused significant damage in and around Tainan City, including a number of collapsed and severely damaged buildings, and 117 deaths. Building reconnaissance embraced commercial, residential and school buildings. The observed structural damage was characteristic of non-ductile and poorly configured buildings. The collapsed buildings all contained irregularities and soft-stories. The majority of older mixed-use buildings performed adequately, but severe column failures were observed in several taller apartment buildings constructed in the 1990s. In order to reduce the risk posed by critical structural weaknesses and to improve the safety and resilience of these buildings, efficient seismic performance evaluation and monitoring methods for mid-to-high rise buildings need to be developed. The objective of this study is to survey the effects of a soft/weak first story, non-ductile reinforcement, structural irregularity, and structural redundancy on the seismic performance of mid-to-high rise buildings in Taiwan. In order to upgrade the applicability of the preliminary seismic evaluation procedure of building structures, a revised draft based on actual case studies is proposed. Finally, some revised recommendations are referenced for future modification.

Modified Preliminary Seismic Evaluation E-value Method

The preliminary earthquake resistance assessment procedure of the buildings studied in this research is based on the preliminary assessment method of earthquake resistance of primary and middle school buildings in Taiwan [3], the preliminary assessment of seismic resistance of buildings by PSERCB [4], and the preliminary assessment of the E-value method proposed by Zhang Zhuyuan et al. [1]. The method must be in accordance with standard seismic capacity design specifications and explanations [5]. This is required to establish the relevant parameters needed to calculate structural seismic requirements and structural seismic resistance using a regression strength formula. This then permits use of the structural capacity:demand ratio to express the quality of the building for seismic performance. An objective of this research was to use empirical formulae for the ultimate base shear force and the floor weight to investigate the characteristics of the seismic resistance of existing medium and high-rise buildings in Taiwan. To do this properly, it is necessary to make corrections by statistical regression analysis using the E-value method for earthquake resistance preliminary evaluation. To achieve this objective, this research collected case studies of real damage to five selected middle and high-rise buildings affected by the Meinong earthquake [6]. A further three buildings previously used by Zhang Zhuyuan et al. [1] bring the

total number of buildings to eight. The three buildings studied by Zhang Zhuyuan et al. were used to obtain an approximate empirical formula for ultimate basal shear force and total floor weight (Equations 1 and 2). The ultimate base shear force is very different for each building and very different from the results of detailed evaluations. It is presumed that this results from use of the basic period calculation method. Here, the suggestion of Lin Zhilong and others is adopted, and a more appropriate minimum value for the ultimate base shear force is between values derived from the dynamic analysis period and 1.4 times values obtained from the empirical formula [7]. The revised process for calculation of seismic demand is summarized below.

First, the site amplification design and near-fault effect factors are determined from the building seismic design specifications and explanations [5], the building illustrations, site information, the short period of the site, and the one-second design horizontal spectral acceleration coefficient. Then, the empirical formula for the basic vibration period of the structure system to which the building belongs is used to determine the basic vibration period of the structure and the boundaries between the short, medium and long periods of the response spectrum [1]. The average ductility capacity obtained from the case analysis of the eight buildings considered is 3.10. Using this value, it is possible to estimate effects of all earthquakes, including the design earthquake, according to the specifications.

Linear analysis of the lateral strength per unit area of all the floors and the inner and outer columns of the structure in case is performed. These values are then multiplied by relevant unit areas and summed to obtain the ultimate base shear force as shown in Equation 1.

$$V_{bs} = \sum_{j=1}^{N_{CE}} \tau_{CE} A_{CE} + \sum_{j=1}^{N_{CI}} \tau_{CI} A_{CI} + \sum_{j=1}^{N_{BW3}} \tau_{BW3} A_{BW3} + \sum_{j=1}^{N_{BW4}} \tau_{BW4} A_{BW4} \quad (1)$$

where N_f represents the number of floors, τ_{CE} is the lateral strength per unit area of the outer column (equal to $-0.4953N_f + 77.16$ tf/m²), A_{CE} is the cross-sectional area of the outer column (in m²), τ_{CI} is the lateral strength per unit area of the inner column (equal to $-1.0154N_f + 112.87$ tf/m²), A_{CI} is the inner column unit area (in m²), τ_{BW3} is the lateral strength per unit area of the brick wall surrounding three sides of the building (33.6 tf/m²), A_{BW3} is the unit area of this wall (in m²), τ_{BW4} is the lateral strength per unit area of brick wall surrounding all four sides of the building (40 tf/m²), and A_{BW4} is the unit area of this surrounding brick wall (in m²). Equation 1 applies to the seventh to fourteenth floors.

Because the static load of higher floors and the penthouse (or roof) floor of most buildings differs from that of the second and third floors, the total static load of

the structure is the sum of three parts, as shown in Equation 2.

$$W = \sum_{LF=2}^3 W_{LF}A_{LF} + \sum_{iF=4}^{N_f} W_{iF}A_{iF} + W_{RF}A_{RF} \quad (2)$$

where W_{LF} is 1.32 tf/m^2 , the weight per unit area of the lower floors (represented by LF , *i.e.* is the second and third floors), A_{LF} is the unit area of the second and third floors (in m^2), W_{iF} is 1.25 tf/m^2 , the weight per unit area of floors represented by $i=4,5,6\dots$ to N_f , A_{iF} is the unit area of floors $i=4$ to N_f (in m^2), W_{RF} is the weight per unit area of the top floor (RF referring to roof floor) and is 1.54 tf/m^2 if the roof floor is covered and 1.25 tf/m^2 if it is not, and A_{RF} is the unit area of the top floor (in m^2).

Using the results of the three case analyses cited by Zhang Zhuyuan [1] and the five buildings of this study, it is possible to derive a total of eight values for the ductility capacity of the buildings. The average value of ductility capacity (R) is 3.09.

According to the seismic design code [5], the total transverse force of the minimum design level can be estimated from Equation 3.

$$V = \frac{I}{1.4\alpha_y} \left(\frac{S_{aD}}{F_u} \right)_m W \quad (3)$$

where S_{aD} is the site design horizontal spectral acceleration coefficient, I is the occupancy factor, α_y is the initial yielding seismic force amplification factor, F_u is the structural system seismic force reduction factor, and W is the structure static load.

Equation 3 is suitable for elastic analysis, but the ultimate base shear force is the maximum lateral force that can be withstood. This lateral force enters the non-linear level. After taking this into consideration, the transverse force can be obtained from:

$$1.4\alpha_y V = \left(\frac{S_{aD}}{F_u} \right)_m IW \quad (4)$$

In Equation 4, the ultimate seismic force is the design seismic force times $1.4\alpha_y$. Substituting for the ultimate base shear force yields the seismic capacity requirement ratio R_{CD} , which is

$$R_{CD} = \frac{1.4\alpha_y V}{I \left(\frac{S_{aD}}{F_u} \right) W} = \frac{V_{bs}}{I \left(\frac{S_{aD}}{F_u} \right) W} \quad (5)$$

For simple quantitative presentation, the concept of scores is used here, and a magnification of 100 times is used to determine the basic seismic performance of

high-rise buildings:

$$E = 100 \times R_{CD} \quad (6)$$

If the basic seismic performance E-value is greater than 100 points, the seismic resistance of the building is undoubtedly considered to be satisfactory. If the E-value is less than 100, this means that the seismic resistance of the building may be insufficient, and a detailed evaluation is required.

In order to obtain the corresponding performance surface acceleration, RCD is multiplied by the required ratio and seismic capacity:

$$A_p = R_{CD} \times 0.4S_{DS} \quad (7)$$

If A_p is greater than $0.4S_{DS}$, this means that the building is undoubtedly considered to be earthquake resistant. On the other hand, if A_p is smaller than $0.4S_{DS}$ detailed evaluation is needed.

Conclusions

Calculations using the empirical period formula recommended by the current building seismic code [5] yields results that are significantly different from the period obtained from modal analysis of the five buildings investigated in this study. This leads to overestimation of the seismic requirements of the buildings, which will affect the preliminary evaluation results and generate a required ratio of seismic capacity that is too conservative. Therefore, it is recommended that the values obtained from dynamic analysis and 1.4 times the empirical period be used to limit the basic period of the E-value method for the initial evaluation of earthquake resistance. In conjunction with the newly revised empirical formula for ultimate shear stress of the base of the building, this preliminary evaluation tends to be closer to the simple detailed evaluation results and the TEASPA detailed evaluation results.

Analysis of results for the five cases discussed in this paper shows that, if the detailed evaluation and analysis result is shear failure of other floors, this will cause the simple detailed evaluation to depart further from the detailed evaluation result.

If no shear failure on other floors is identified by the detailed evaluation results, the initial evaluation and simple detailed evaluation are considered to be more conservative than the detailed evaluation results. If the result of the detailed evaluation is shear failure in other floors, the simple detailed evaluation will be underestimated.

Proposals for Revision of Importance Factor of Mixed-Use Buildings in Taiwan

Ker-Chun Lin and Wei-Chun Lin, Research Fellow, NCREE

Introduction

In accordance with Taiwan’s seismic design code, an importance factor, I , depending on the occupancy of a building, shall be used to decide the design seismic force of the building. The values of I are different for different occupancies of a building. The importance factor intends to increase the design seismic force of buildings that are of high importance, store dangerous goods, or are used for public purposes. In terms of the requirements of Section 2.8 of the existing Seismic Design Code Requirements and Commentaries for Buildings, the importance factor for a mixed-use building with public and ordinary occupancies is incompletely defined. This article discusses the significance of an inadequately defined importance factor for mixed-use buildings and shows that, with minimal revision yet following the current stipulations, proposed amendments of the importance factor will cover all the applicable cases for these buildings.

Existing Stipulations

According to the existing code, the importance factor of a building is classified into the following four categories. Category I: buildings should operate normally after earthquake disasters, I value equal to 1.5. Category II: buildings storing a large amount of dangerous goods including toxic goods and explosives, I value equal to 1.5. Category III: buildings used for public purposes, I value equal to 1.25. Category IV: buildings other than those in Categories I, II, and III, I value equal to 1.0. Buildings in Categories I and II are generally simple to classify and generate little dispute. However, the situation for buildings of mixed use in Categories III and IV is more complex. In these cases, the I value depends on the floor areas occupied and the type of occupancy. The stipulations of Section 2.8 of the code regarding a public building, used individually or of mixed use and with ordinary occupancy, are stated below. *“For a building mixed with public and ordinary occupancies, when a cumulative floor area is larger than 3000 m² or exceeds 20% of its total floor area, the value of I takes 1.25. For a building with public occupancies individually, the value of I takes 1.25, if the total floor area is more than 1000 m².”* Based on these stipulations, values of I for buildings with a cumulative floor area between 1000 and 3000 m² are not clearly defined.

Revised Recommendations

In order to clarify the assignment of an I value to mixed-use public buildings with cumulative floor area between 1000 and 3000 m², two cases of revision are proposed below. Both are based on Section 2.8 of the existing code and involve minimal change. It is necessary to note the definition of the following two parameters before describing and illustrating the two cases:

A_{PC} , the cumulative floor area of a building used publicly

A_T , the total floor area of a building.

Case A

This case is based on the requirements: *“For a building mixed with public and ordinary occupancies, when a cumulative floor area is larger than 3000 m² or exceeds 20% of its total floor area, the value of I takes 1.25.”* and *“For a building with public occupancies individually, the value of I takes 1.25, if the total floor area is more than 1000 m²,”* considered separately and compounded without changing the original requirements. The only additional requirement is to define the value of I for buildings with the cumulative floor area between 1000 and 3000 m². The definition of I value in revised Case A is shown as Figure 1.

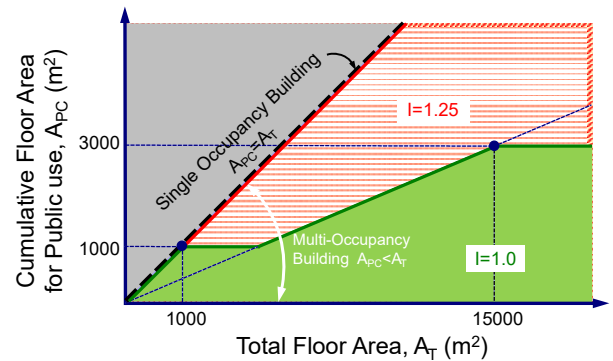


Fig. 1 Importance factor of mixed-use building for revised Case A

Case B

This case is also based on both requirements: *“For a building mixed with public and ordinary occupancies, when a cumulative floor area is larger than 3000 m² or exceeds 20% of its total floor area, the value of I takes 1.25.”* and *“For a building with public occupancies individually, the value of I takes 1.25, if the total floor area is more than 1000 m².”* However, it depends on specifying the two points A and B shown in Figure 2. For mixed-use buildings with a cumulative floor area between 1000 and 3000 m², their values of I are either 1.0 or 1.25 depending on their position in relation to the line AB.

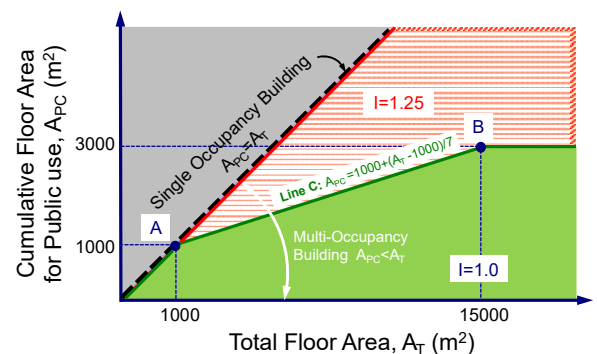


Fig. 2 Importance factor of mixed-use building for revised Case B

SmartES – 5D Smart City Platform

Ren-Zuo Wang, Researcher, NCREE
Chih-Shian Chen, Assistant Researcher, NCREE
Ming-Hua Tsai, Research Assistant, NCREE

SmartES is a research team within the NCREE of NARLabs in Taiwan. We developed 5D Smart City - the fifth virtual dimension beyond space-time - to simulate and monitor the real-landscape and real-time in the real world. Based on Geographical Information System (GIS), Satellite Imagery, unmanned aerial vehicle (UAV) 3D models, point cloud models, Building Information Modeling (BIM) and so on, SmartES integrates many types of 3D models to create a realistic simulated city.

The 5D smart city platform has applications in various fields. In disaster prevention, it regularly detects and reports on emergencies when disaster occurs. It applies not only to earthquakes but also to floods, landslides, fire disaster, and wind disaster. It helps administrators make decisions more efficiently and conduct rescue plans more completely. In civil IoT, it has applications in autonomous driving, shared vehicles, unmanned stores, sensor real-time detection, and cultural heritage preservation. It provides people with more comprehensive public infrastructure management and facilitates cities to become smarter.

At SmartES, we offer state-of-the-art techniques, cooperate with prominent seismology and civil engineering experts, and look forward to motivating Taiwan to become a world leader in hosting smart cities.

Taoyuan Smart Social Housing Platform

The aim of the research was to integrate the BIM of Taoyuan No.2 Zhong-Lu social housing and a GIS platform. The research utilized Satellite Imagery and Digital Terrain Models (DTM) to generate a base map of the housing estate, which covers an area of 2 km². Building models derived from UAVs were then used to create a real-landscape city. Components of the research included:

(1) Structural Time History Analysis

The research applied nonlinear dynamic analysis to investigate seismic responses to different earthquake intensities and displayed damage levels of buildings using different colors.

The following assumptions and simplifications were made. (a) The analysis objects were considered to be shear buildings. (b) Only nonlinear parameters of the building columns were considered. (c) The materials of the columns were reinforced concrete (RC). (d) Degrees of freedom in horizontal x and y-directions were considered.

Since the research emphasized developing a smart city platform, we did not consider the effects of different building types and materials. Because of the uncertainty of structural parameters, the results are only applicable to hypothetical seismic scenarios. In the future, research will focus on improvement of seismic structural analysis to enhance the accuracy of the simulation.

(2) Web-based Platform

The platform is based on the HTTP Streaming technique, and it allows a web server to continuously send data to a client over a single HTTP connection, which remains open indefinitely. Users can, merely through handheld devices, display the 5D smart city platform everywhere and anytime. It will report abnormal equipment readings in real-time, which allows administrators to take remedial actions quickly. As a result, the system will greatly boost monitor efficiency and the quality of living.

(3) Curved display wall and 3D display system

To enhance the visual and listening experience of viewers, we introduced the wide curved display wall, 5.5 meters in width and 2.8 meters in height, which provides immersive and sound-around ambiance. In addition, BIM models were available in the 3D display system, which permitted observation of the details of the buildings more directly. Regarding the inside details of buildings, users could zoom into them further and deeper. These powerful display systems allow administrators to manage efficiently and conveniently.

To conclude, the 5D smart city platform assists city management significantly and extensively. We regard Taoyuan No.2 Zhong-Lu social housing as a demonstration site and expect to expand it to the whole of Taoyuan City. The platform will assist management in many ways, including social housing and city infrastructure. We look forward to gradually cultivating Taoyuan City as one of Taiwan's top smart cities in the future.

First Place in the 2019 NARLabs Annual Presentation

The leader of SmartES team, Dr Ren-Zuo Wang, received the first prize at the annual presentation held by NARLabs on 18 December 2019. As the representative of NCREE, he shared the annual achievement of the 5D smart city platform and was highly commended by the other seven laboratories. At the end of the ceremony, the president of NARLabs, Dr Yong-Han Wang, presented the team with a certificate and a reward.



Earthquake Engineering Communication between Taiwan and Mexico

Chung-Han Yu, Assistant Researcher, NCREE
Shiang-Jung Wang, Chairperson, NCREE

In 2018, the Chinese Taiwan Society for Earthquake Engineering signed an MOU with the Mexico Society of Earthquake Engineering (Sociedad Mexicana de Ingeniería Sísmica). The purpose was to establish a long-term and efficient collaboration in the earthquake engineering field between the countries. Through this collaboration, the technical, research, and practical application experiences of both sides could be shared and discussed frequently, so that creativity and technology in earthquake engineering could be significantly improved.

The chairperson, Prof. Shiang-Jung Wang, and assistant researcher, Dr Chung-Han Yu, from the structural monitoring and control division of NCREE and the assistant general manager, Chao-Hsin Chou, of Evergreen Consulting Engineering Inc., were invited to visit the Mexico Society of Earthquake Engineering during November 20 to 23, 2019. In the meantime, the major annual conference in earthquake engineering, XXII Earthquake Engineering Mexican Conference, was held in Monterrey City, Mexico. Assistant general manager Chou was invited to give a keynote address, in which he spoke about the architecture and structure design and construction experience of Taipei 101. During the conference, participating members from Taiwan met the current president, Dr Edgar Tapia Hernández, and past president, Dr David de León Escobedo, from the Mexico Society of Earthquake Engineering, and had a discussion, in which they shared the research results of both countries. Prof. Wang also shared on the experimental capacity of Taipei and Tainan laboratories.

Through the understanding of each country's practical requirements, the chance for joint research and joint conferences was significantly enhanced.

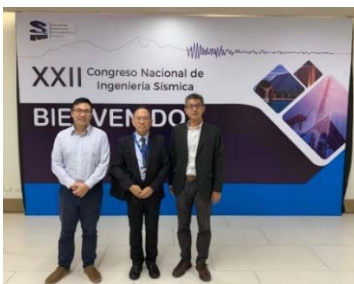


Fig.1 Members from Taiwan



Fig.2 Communication with Mexico Society of Earthquake Engineering

Expositions of the Hybrid Earthquake Early Warning Service (EWS) at Futex Taipei and IT Month during 2019

Ching-Hsien Huang, Associate Technician, NCREE
Meng-Huang Gu, Associate Researcher, NCREE
Pei- Yang Lin, Researcher, NCREE

In order to publicize the "hybrid EWS", NCREE held two exhibitions at the Taipei World Trade Center Exhibition Hall during December 5-8, 2019. The first, entitled "Smart Disaster Prevention System", was presented for Future Tech (FUTEX) 2019, and the second, "Earthquake Disaster Prevention Zone", was presented for IT Month.

The "Smart Disaster Prevention System" exhibition (Figure 1) provided visitors with a simple but clear explanation of how "hybrid EWS" works through the use of seismic animations combined with a working model. A screen show demonstrated the propagation of seismic waves and the way in which hybrid EWS issues alarms to affected areas. Models of factories, a hospital, a stadium, and residences subjected to shaking on a shake table showed the mechanisms of the alarm system during an earthquake. Vendors interested in hybrid EWS were able to obtain information on cooperation with NCREE in development of disaster prevention and related emergency response services.

The main goal of the "Earthquake Disaster Prevention Zone" exhibition was to interact with people. The "interaction wall" (Figure 2) was designed to explain the hybrid EWS service flow, from seismic detection to disaster prevention control. The "seismic simulation house" demonstrated the service provided by hybrid EWS in a M_w 7 earthquake scenario. People were able to experience the value of the earthquake disaster prevention service, and were given a good understanding of what to expect in different disaster situations.

The events attracted large crowds, which further promoted hybrid EWS and provided important public feedback.



Fig.1 Futex Taipei 2019.



Fig.2 Interaction wall(left) and seismic simulation house (right)

The 8th International Conference on Advances in Experimental Structural Engineering

Ming-Chieh Chuang, Associate Researcher, NCREE

The 8th International Conference on Advances in Experimental Structural Engineering (8AESE) was held in Christchurch, New Zealand during February 3-5, 2020. This conference provided an excellent opportunity to present research results and learn about recent advances in a broad range of topics related to experimental technologies for testing structures. It also provided a platform for discussion and networking between researchers in all aspects of structural testing.

The 8AESE conference was jointly organized by the Department of Civil and Natural Resources Engineering at the University of Canterbury (UC) and the Department of Civil and Environmental Engineering at The University of Auckland (UA). The University of Canterbury was the venue for the conference and is located close to the heart of Christchurch. A guided walk through the central business district was arranged for participants and this enabled them to learn how existing buildings have been retrofitted to withstand earthquakes and what technologies are used in newly constructed buildings.

The director of NCREE, Prof. Shyh-Jiann Hwang, was invited to deliver the keynote address, which was entitled “The Advanced Experimental Technologies Developed at NCREE in Taiwan”. Through Prof. Hwang’s speech (Figure 1) and other presentations by the NCREE delegation, the latest advances in experimental technologies at NCREE were introduced to the attendees. It was shown that, by using these advanced technologies and cutting-edge testing facilities, NCREE would be able play a leading role in enabling the earthquake engineering community to explore technological frontiers that have not yet been visited.



Fig. 1 Keynote address given by Prof. Shyh-Jiann Hwang

Visitors from the Seoul National University

Xiao-Qin Liu, Assistant Researcher, NCREE

On January 13, 2019 NCREE welcomed a delegation from Seoul National University (Figure 2). The delegation consisted of one academic advisor, Prof. Je Won Yang, and eighteen outstanding undergraduate students from the Global Leadership Program in the college of Natural Science. These students were from different majors, including mathematics, statistics, physics, chemistry, biology, and earth and environmental science. In the morning, Dr Lap-Loi Chung, the deputy director of NCREE, and Dr Xiao-Qin Liu, a research assistant from the Bridge Division, warmly greeted the guests. Then, Dr Chung and Dr Liu introduced the NCREE’s establishment and development, administrative structure, major research accomplishments, and future prospects to the guests. During the subsequent informal discussion session, the guests showed strong interest in the core technology and major achievements of NCREE, such as earthquake early warning technology, IoT-enhanced disaster mitigation technology, and building post-earthquake retrofit technology. Dr Chung and Dr Liu responded to questions from the guests in a humorous and straightforward manner and attempted to inspire the students from an engineering perspective. After the discussion, Dr Liu led the guests to the Taipei laboratory of NCREE. Dr Liu, who is associated with ongoing experiments, introduced the main experimental equipment and devices, and demonstrated their functions and application efficiency in an easy-to-understand manner. In addition, Dr. Liu highlighted NCREE’s primary contributions to Taiwan’s earthquake-related research and emphasized NCREE’s role in linking the academic, research, and industrial sectors for the purpose of shaping Taiwan to be a center of international earthquake engineering research.



Fig. 1 Visitors from the Seoul National University

Visit to the Indian Institute of Technology, Roorkee, India

Che-Min Lin, Research Fellow, NCREE
Chun-Hsiang Kuo, Research Fellow, NCREE

NCREE is cooperating with the Department of Earth Science, Indian Institute of Technology, Roorkee (IIT Roorkee) in a three-year India-Taiwan joint research project. The project title is “Soil Amplification and Site Response for a Potential Great Earthquake in Northern Himalayas in the Light of the 2015 Gorkha Nepal Earthquake”. It is the second three-year cooperative project and was funded by the Department of Science and Technology (DST), India and the Ministry of Science and Technology (MOST), Taiwan, from 2017 to 2020. The aim of this second phase project is to collect various site response and soil amplification data for the Ganga Plain in India and apply them to ground motion prediction of potential great earthquakes in the northern Himalayas using a semi-empirical technique.

As part of the joint project, the NCREE research team visited IIT Roorkee from December 3 to 10, 2019 (Figure 1). During the visit, we discussed and exchanged research data and results with the Indian team, which included Prof. Anand Joshi and Prof. Sandeep Singh. In addition, we had several meetings with Prof. M. L. Sharma of the Department of Earthquake Engineering (IIT Roorkee), during which we had discussions focusing on Seismic Hazard Analysis in Taiwan and India. We also visited the office of International Relations at IIT Roorkee, where we had discussions promoting future cooperation with the associate dean, Prof. Paramasivan Arumugam. A draft MOU was prepared for further consideration by NCREE. Towards the end of the visit, Prof. Joshi invited us to join him at the High Performance Computing Scientific and Engineering Applications Group, Centre for Development of Advanced Computing (C-DAC) in Pune, India on December 9. There, we met Dr Richa Rastogi and her team and had a half-day introduction to their research and the applications of their supercomputer in various fields.

The long-term cooperation between NCREE and IIT Roorkee is well established and has published several research results. In addition to this, NCREE has signed an MOU with the Institute of Seismological Research (ISR) (Gandhinagar, Gujarat India) and installed the first “demo on-site” Earthquake Early Warning System (EEWS) at the Vamka Observatory of ISR. Another demo on-site EEWS installation for the Delhi region has been planned between NCREE and the National Center of Seismology (NCS), Ministry of Earth Sciences (MOES), New Delhi, India. NCREE is actively promoting more and more cooperation with India.

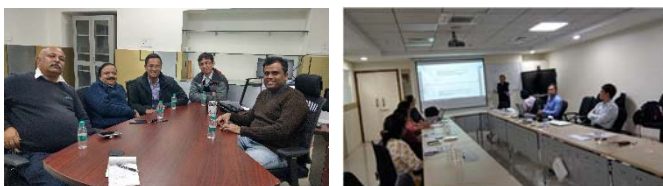


Fig. 1. Visit and discussions in IIT Roorkee and C-DAC, India

2019 NCREE Conference on Experiments (II)

Kung-Juin Wang, Technologist, NCREE

To facilitate developments in the field of earthquake engineering, a conference entitled “2019 NCREE Conference on Experiments (II) (2019NCE (II))” was held at NCREE on December 9, 2019. Several research groups that conducted experimental projects using the NCREE Taipei and Tainan facilities (the shake tables, the Reaction Wall and Strong Floor Test Systems, and the Multi-axial and Bi-axial Testing Systems (BATS)) in 2018 were invited to disseminate their latest findings via oral presentation. This conference provided a unique opportunity for sharing knowledge and experience among academic researchers and industry experts in the field. In addition, it served as a vehicle for facilitating the exchange of relevant details regarding planning and execution of experimental projects.

A total of nineteen oral presentations were made at this event. The research covered a plethora of interesting topics, including the seismic resistance capacity of new materials and new elements under more realistic loading conditions, novel technologies of anti-collapse of buildings under the threat of near-fault ground motions, structural elements constructed by high-strength reinforced concrete (RC), *etc.* Simulation techniques such as modeling of plastic hinges in RC members under near-fault ground motion were included. The dynamic properties of testing equipment (large-scale sandbox and BATS itself) also formed part of the research presentations. A novel research project presented at 2019NCE (II) was the development of a useful application (for smart phones) for the purpose of alerting the public to earthquakes.

Approximately one hundred attendees participated in the event, including more than forty engineers from industry, many NCREE staff members, and other individuals from the academia. Participants at the conference indulged in vibrant discussions focusing on the mechanical behaviors and application examples of several newly developed structural components. Abundant engineering experiences were also communicated and exchanged. These activities attracted considerable interest and raised expectations held by society of research at NCREE. The proceedings of this conference (NCREE report No.: NCREE-19-015) can be downloaded from the NCREE official website.

Interim Seismic Retrofit Seminars, Workshops and Seeded Lecturer Training

Yu-Shu Hsiao, Project Assistant Technologist, NCREE
Yu-Hua Lee, Project Senior Technician, NCREE
Tsung-Chih Chiou, Associate Researcher, NCREE

NCREE was commissioned by the Construction and Planning Agency to implement the technical service case initiated by the “Interim Seismic Retrofit of Private Building Project Office” (hereafter referred to as “the case”), and establish the Interim Seismic Retrofit Project Office (referred to as the “project office”) in order to assist promotion of Interim Seismic Retrofit.

In addition to announcing and promoting the Interim Seismic Retrofit plan, the project office invites participation from professionals, experts, and scholars in the field of civil engineering. The aim of this participation is to share practical experience of Interim Seismic Retrofit and impart expertise in lecturing in order to improve teaching quality.

In order to effectively implement the case, promotional seminars are divided into two kinds: those aimed at professional technicians, (including government employees) and those aimed at ordinary people. The original plan was to host ten seminar sessions, and six of these were completed by the end of February 2019. In addition, it is estimated that 550 seminars will be given to the general community. In order to improve capacity, the project office invites lectures from professional civil engineers, architects, and experts from disaster-prevention deep-cultivating teams. It is expected that establishment of counselling teams will spread to counties, cities, neighborhoods, and residential communities. This will expedite the process of briefing people and propagating the phased reinforcement program for earthquake resistance. By the end of February 2020, sixty-three sessions had been completed.

Workshops and Seminars on Technical Operation of Interim Seismic Retrofit

The workshops and seminar sessions on Interim Seismic Retrofit were intended for architects, civil engineers, structural engineers, other professionals, and vendors in seismic retrofit engineering. They described the operation of procedural rules and construction notes generated by Interim Seismic Retrofit. Participation in this activity and sharing of opinions and experiences, promoted the work of Interim Seismic Retrofit on existing buildings.

The workshops included an introduction to the Interim Seismic Retrofit private building plan, standard operation procedures (SOP) regarding subsidies, and procedures relating to evaluation design. In addition, the Interim Seismic Retrofit technical service case and its construction notes were introduced. Six seminars were held between August 2019 and January 2020 and attended by a total of 439 people, as shown in Table 1.

Table 1 Hosting progress of Interim Seismic Retrofit seminars

Date	Event	Place	Attendance
2019.08.08	Interim Seismic Retrofit Seminar	Taipei City NCREE	32
2019.09.24	Interim Seismic Retrofit Seminar	Taipei City NCREE	78
2019.10.25	Interim Seismic Retrofit Seminar and <i>in-situ</i> observation	Hualien City F HOTEL	80
2019.10.31	Interim Seismic Retrofit Seminar	Taichung City Yong-Chun Elementary School	96
2019.11.07	Interim Seismic Retrofit Seminar	Tainan City NCREE	73
2020.01.14	Interim Seismic Retrofit Seminar	Taipei City NTU	80
Total			439

The success of the workshops is illustrated in Figure 1, which shows attendance at the workshop held in Hualien City on October 25, 2019, and Figure 2, which shows attendees at a seminar in Taipei City on January 14, 2020.



Fig. 1. Interim Seismic Retrofit Seminar in Hualien City



Fig. 2. Interim Seismic Retrofit Seminar in Taipei City

Four planned events are listed in Table 2. The project office will continue to provide services to experts in the engineering industry and promote the relevance of Interim Seismic Retrofit to businesses.

Table 2 Plan of Interim Seismic Retrofit Seminars in the following months

Date	Event	Place
2020.03.26	Interim Seismic Retrofit Seminar and <i>in-situ</i> observation	Hualien City F HOTEL
2020.03.30	Interim Seismic Retrofit Seminar	Taichung City Taichung City Hall
2020.04.09	Interim Seismic Retrofit Seminar	Taoyuan City Taoyuan City Hall
2020.04.23	Interim Seismic Retrofit Seminar	Tainan City Jeong-shin Center

Training Program for Promoting Lecturers of Interim Seismic Retrofit

In order to support the instructors and instructor teams in delivering lectures, the project office hosted the "Interim Seismic Retrofit reinforcement knowledge seminar and lecturer training" program on January 10, 2020 (Figure 3). Like the workshops, this program included an introduction to the Interim Seismic Retrofit plan for private buildings, SOP regarding subsidies, details of procedures relating to evaluation design, and introductions to the case and construction notes of Interim Seismic Retrofit and Earthquake Insurance. There were thirty participants at this event. The participating members were the director of the center, the earth science team, the earthquake disaster simulation team, the structure control team, the strong ground movement team, the building team, and the enterprise promotion team.

The workshop provided participants with an understanding of the Interim Seismic Retrofit plan, campaign skills, and lecturer reinforcement qualifications. After the sessions, thirteen new lecturers were inducted. Through the participation of lecturers, it

was possible to accelerate the promotion of retrofitting private buildings and help people improve their living safety.

The briefing session (Figure 4) was conducted by Dr Wen-Yu Jian, whose use of friendly Taiwanese language to communicate received a warm response from the public.

After the lectures, the project office compiled a database of lecturers who would be able to teach throughout Taiwan from January to April, 2020. Twenty three lectures given by the seed lecturers were planned, the first of which was held in Taoyuan on January 16, 2020.



Fig. 3. Training of lecturers by Interim Seismic Retrofit



Fig. 4. Dr Wen-Yu Jian lecture in Taoyuan City

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