A Member of NARLabs
National Center for Research
on Earthquake Engineering

National Center for Research on Earthquake Engineering, National Applied Research Laboratories

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Outline

Through a joint effort of the Ministry of Science and Technology (MOST) and the National Taiwan University (NTU), the National Center for Research on Earthquake Engineering (NCREE) was officially established in 1990. In order to enhance the efficiency and performance of the national research laboratories which belong to MOST, the National Applied Research Laboratories (NARLabs) was established in June, 2003. Since then, NCREE has become a non-profit organization and is one of the ten laboratory members of NARLabs.

The NCREE has a faculty of about 183 divided into ten divisions including: Administration Division, Planning & Dissemination Division, Experimental Technology Division, Information Management Division, Geotechnical & Strong Ground Motion Division, Building Engineering Division, Bridge Engineering Division, Structural Control Division, Earthquake Disaster Simulation Division, and Branch Laboratory in Southern Taiwan.

The core technologies of NCREE:

- Seismic Testing and Numerical Simulation Technologies.
- Seismic Resistant Design, Evaluation and Retrofit Technologies.
- Earthquake Loss Estimation Technologies.

The mission of NCREE:

- Pre-quake preparation, emergency response and post-quake recovery.
- Integrate research capacities of various earthquake engineering research institutes in Taiwan to enhance the research capability of the nation.
- Promote international research cooperation for earthquake hazard mitigation.

3D earthquake simulator (5mx5m)

L-shape reaction wall and strong floor

Multi-Axial Testing System (MATS)

Research Achievements and Challenges

The major Research and Contributions of NCREE are:

- Development of seismic design, evaluation and retrofit technologies
- Development of innovative seismic technologies and systems
- Development and application of earthquake loss estimation technologies
- Advancement of experimental and numerical simulation technologies
- Development of geotechnical and strong ground motion research
- Dissemination of earthquake engineering knowledge to enhance earthquake awareness

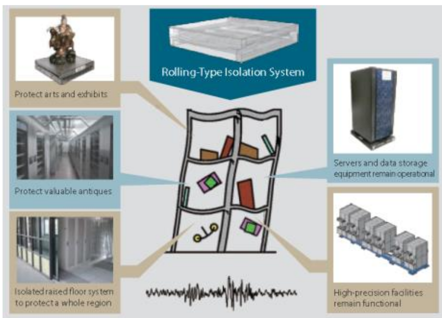
Many seismic design and retrofit codes have been proposed in the past years, and the scope includes building structures, highway bridges, railway bridges, seismic isolation and energy dissipation design, qualification for seismic isolation and energy dissipation devices. These codes are used to guarantee the minimum requirement of seismic safety of structures, hence reduce seismic loss in Taiwan. Moreover, NCREE has also devoted to perform seismic evaluation and retrofit of school buildings in Taiwan. A comprehensive strategy was proposed. A series of methods for simple survey, preliminary evaluation, detailed evaluation and retrofit design for school buildings have been well developed. Based on the well-prepared technology and document, the ministry of education has allocated US$ 587 million for seismic upgrading of elementary and secondary school buildings in four years, from 2009 to 2011.

In-situ pushover test to verify the proposed technology for seismic evaluation and retrofit of school buildings

NCREE have also developed many innovative seismic technologies and systems. Among them, the Buckling Restrained Brace (BRB) has been widely applied to the industry. More than 10000 pieces of Double-Core BRBs have been used in seismic retrofit and new construction projects in Taiwan. A Multi-Function Rolling-Type Isolation System with reduced and constant acceleration responses, excellent energy dissipation and self-centering capabilities has been applied as a seismic protection for high-precision equipment in high-tech factories, telecommunication industries, and valuable antiques, arts and exhibits in museums. The technology of precast segmental post-tensioned concrete bridge columns which can reduce environmental impact and traffic disruption has also been applied to Taichung Area Expressway No. 4. A comprehensive full-bridge fiber optic monitoring system are applying to various transportation systems with verdict bridges, such as the high-speed railway, the highways, the Metro, the railways.

The Buckling Restrained Brace applied to Taichung City Government Building

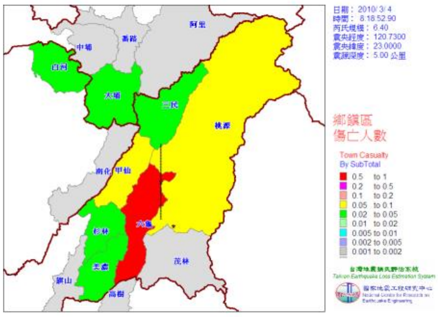
The use of isolation technology is currently the most feasible and effective means of increasing the seismic resistance of important equipment and facilities. The rolling base isolation system developed at NCREE offers an excellent energy-dissipation mechanism and self-centering ability, and can effectively reduce the transmission of seismic forces to upper-level structures. The system is also able to meet the seismic performance design requirements of various equipment and facilities; it can be applied to data storage and communications equipment in the high-tech, communications, and financial industries,



Applications of rolling-type isolation systems

communications facilities in hospitals, disaster relief units, and the energy industry, and important art works at museums and galleries.

The Taiwan Earthquake Loss Estimation System (TELES) developed by NCREE can estimate complete seismic loss automatically within short time after receiving e-mail from the Central Weather Bureau, and the send messages to emergency response personnel of Central Emergency Operation Center to assist in casualty and loss control. The TELES can provide informative estimates (damages, injuries, casualties, rescue & medical-caring demands, etc.) for disaster reduction plans. It has also been applied to Taiwan Residential Earthquake Insurance Fund for improving residential earthquake insurance scheme in Taiwan, as well as applied to the prioritization of seismic retrofit scheme of highway bridges.



Typical casualty estimation results of TELES

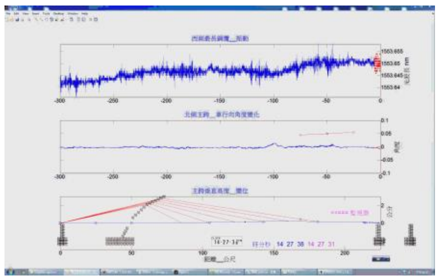
A On-site Earthquake Early Warning System (EEWS) has been developed by NCREE. The On-site EEWS extracts some P-wave features from the first few seconds of vertical ground acceleration of a single station to predict the coming seismic intensity of the earthquake. Therefore, the system can provide more lead-time at the region close to an epicenter since only the seismic information on the target site is required. The system has been verified as reliable and efficient for seismic emergency response, especially with the support of automatic control devices and systems. This technology has also been applied to some schools, train stations, and Taiwan SECOM building in Taiwan, and is going to be implemented to about 3,000 elementary and junior high schools in Taiwan, and also some buildings in the high-tech science park.

Typical lead-time of On-site EEWS of the Chi-chi earthquake

The flooding that occurred on August 8, 2009 caused the destruction of more than 100 bridges, which cut off numerous mountain communities from the outside world and prevented emergency disaster relief supplies and personnel from reaching these areas. In this type of situation, the "lightweight composite bridge for emergency disaster relief" can facilitate evacuation operations, enable the transport of foodstuffs to stricken areas, and minimize loss of life and property losses, and take advantage of the golden period for relief work. NCREE developed a lightweight composite bridge system for emergency disaster relief. The proposed bridge can be assembled within 6 hours, and possesses the advantages of (1) quick assembly, (2) do-it-yourself use by residents, and (3) reusability.

A lightweight transportable emergency bridge made of composite materials

NCREE has originated an "all-round full-bridge fiber-optic monitoring system" that is economically efficient and suitable for most long river bridges in Taiwan. This system is capable of performing 24-hour all-round bridge monitoring during both ordinary times and natural disasters; monitoring items include key parameters that may indicate damage to the bridge, such as the gaps between bridge plate expansion joints, tilting and settling of bridge columns, the water level below the bridge, and the tension in the cables of cable-stayed bridges. Once any abnormality is detected, the system can immediately notify the bridge management unit of the location and cause of the



The system could monitor the real-time vertical deflection of bridge

problem by means of computer or smartphone via the cloud, allowing emergency measures can be taken. The system has been applied to cable-stayed bridges and Taiwan High-Speed Railway bridges.


Shaking table competition of IDEERS

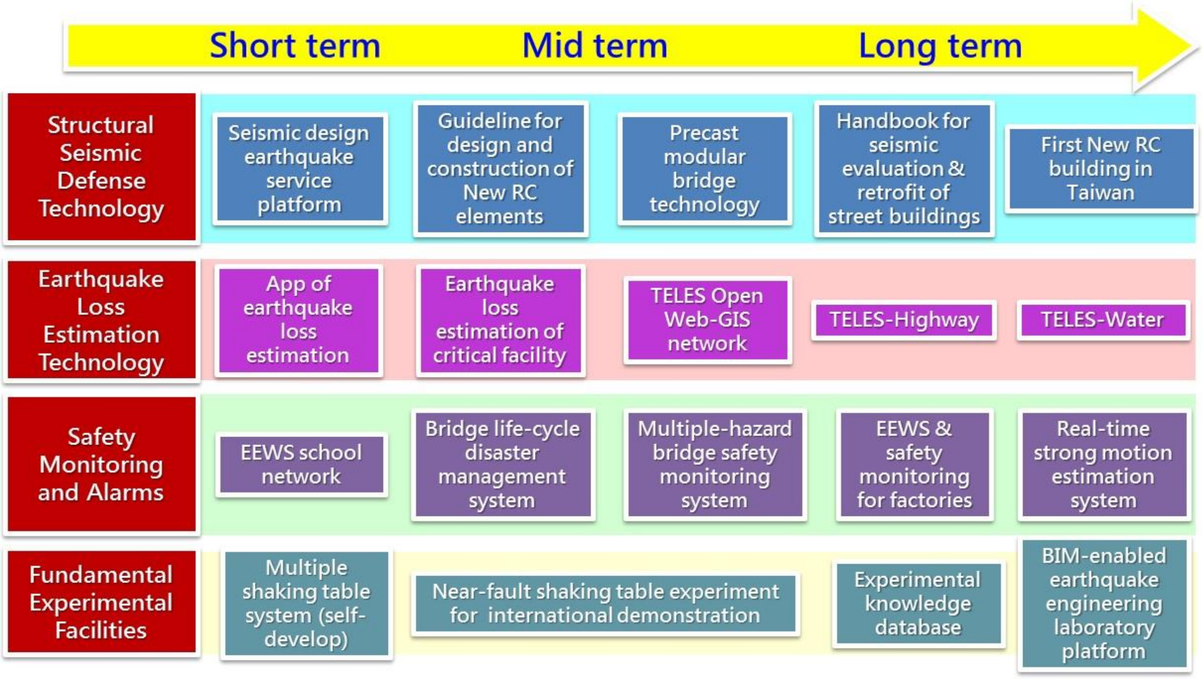
Since 2001, NCREE host the Introducing and Demonstrating Earthquake Engineering Research in Schools (IDEERS) every year. This international educational program is designed for high school, undergraduate and graduate students. Approximately 500 participants from Taiwan and other countries join the program each year. Besides, the International Training Program (ITP) for Seismic Design of Structures has been host by NCREE annually since 2002.

Approximately 28 percipients from 13 countries attend the ITP each year. These programs distribute the developed seismic disaster prevention technology and knowledge to both engineering and students from the countries under seismic threat, and hence help reduce seismic loss.

The major research challenges for the future are how to improve the resilience of the whole community to ensure a sustainable country. In recent decades, the NCREE mainly focus on how to improve the seismic capacity in a reasonable and economic way for existing and new structures, and most of them are buildings and bridges individually. Recent years, the NCREE started to spend more efforts on the research relating to critical facilities such as hospital and nuclear power plants, as well as lifeline systems such as water system, electric system, and traffic system. The NCREE aims to provide a total solution for seismic disaster prevention of the whole community in the future. For this purpose, the NCREE needs to cooperate with other research domains to enhance the ability to counter more complex and challenging research topics.
Moreover, due to the structures could be damaged not only by earthquakes but also by the interaction of scouring. For example, bridges with scoured foundation is expected to collapse due to loss of strength of the structure member or bearing capacity of soil when subjected to large seismic excitations. Therefore, research topics dealing with multiple disasters are also considered as a challenging issue by the NCREE.
The high density of both seismic faults and human activities in Taiwan is a problem to be solved, and this probable is also quite unique in the whole world. More than 8 million people living within 10 km distance from the active faults in Taiwan are suffering the threat of near-fault earthquakes. Due to the large displacement and velocity of near-fault earthquakes, the existing shaking table of NCREE cannot simulate the earthquake properly. The research for technology to cope with near-fault earthquakes is also a challenging in the future for NCREE.

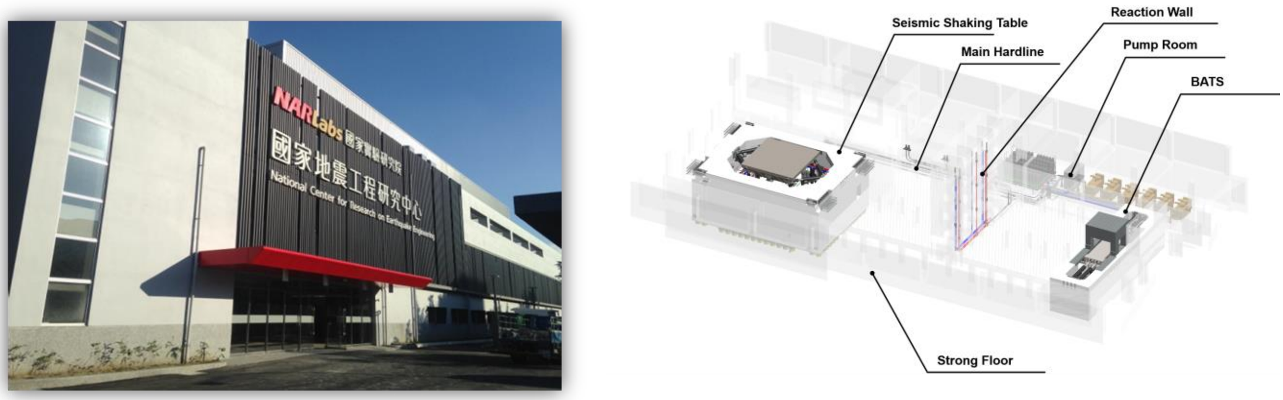
Suggestions for the Disaster Research Roadmap

The roadmap of seismic disaster research in NCREE consists of four parts: (1) structural seismic defense technology; (2) earthquake loss estimation technology; (3) safety monitoring and alarms; and (4) fundamental experimental facilities, as shown in the figure below. The main goals of the structural seismic defense technology is to develop the New RC building technology for Taiwan structures, the precast modular bridge technology, and seismic evaluation and retrofit of street buildings in Taiwan. The earthquake loss estimation technology will develop Taiwan Loss Estimation System for highway systems, water systems, and critical facilities. In case of safety monitoring and alarms, Earthquake Early Warning Systems for school network and factories will be developed. The disaster management system and multi-hazard safety system will also be constructed for bridges. Fundamental experimental facilities will be constructed and the efficiency of laboratories will be improved in order to support the research topics on the above-mentioned roadmap.



Roadmap of NCREE

In order to develop necessary technologies to withstand near-fault earthquakes, the NCREE started at 2014 to construct a high-speed long-stroke shaking table system in a new laboratory located at the campus of National Chen-Kung University in Tainan. The specification of the shaking table system is summarized in the table below. The horizontal one-side maximum displacement of the shaking table is almost 2 meter if the shaking table move to the other side in the beginning of a test, with a maximum velocity 2 meter per second and a maximum payload 100 ton. The new shaking table system and the new laboratory will start to operate in August 2017. Special conferences to demonstrate the capability of the new shaking table system and to cooperate with international specialists about the research on novel near-fault seismic technologies will be host by NCREE.



Appearance of the new shaking table system and the new laboratory

Specification of the new shaking table system

Item	Specification				
	Size (m)	Max. Displacement (mm)	Max. Velocity (mm/sec)	Max. Acceleration (g)	Max. Payload (ton)
High-speed long-stroke shaking table system	8 x 8	H±1000 V±400	H±2000 V±1000	H±1.2 V±0.8	100

In accordance with the national need for pre-earthquake preparedness, emergency response, and post-earthquake recovery, NCREE brings together academic resources and researchers to carry out joint projects to upgrade seismic technologies and to reduce life and property losses resulting from earthquakes. NCREE also encourages international collaborations in selected fields, especially the near-fault topic, to initiate consolidation and innovation in academic research and engineering practice; thus promoting Taiwan's academic reputation in the related fields all over the world.