National Science Council

ISSN: 1607-3509

Science Bulletin

October 2002/Vol. 34, No. 10

Innovative Experiments and New Technologies at NCREE — Full-Scale RCS Frame Experiment, MR Damper Research, and FBG Sensor Array

Located at the junction boundary of the Philippine Sea Plate and the Eurasian Plate, Taiwan is one of the most earthquake-prone countries in the world. In order to meet such challenging environment, the NSC's National Center for Research on Earthquake Engineering (NCREE) was established in 1990 for the purpose to breakthrough the bottlenecks in earthquake engineering in Taiwan, and then to help improve the earthquake engineering research via theoretical and experimental work, expedite the development of seismic design codes, and mitigate earthquake disasters.

After the occurrence of 921 Earthquake, NCREE immediately identified the key issues aroused regarding earthquake engineering and, during the past few years, has established important achievements as countermeasures in order to further improve the seismic preparedness of the society. Firstly, NCREE has, in collaboration with the Ministry of Transportation and Communications (MOTC) and the Construction and Planning Administration, Ministry of the Interior (MOI), revised the seismic design codes for both bridges and buildings. Secondly, NCREE has assisted the Ministry of Education (MOE) to perform a comprehensive survey on the structural integrity of school buildings in Taiwan, and has for that reason developed the methodologies for evaluating and retrofitting school buildings seismically. Finally, NCREE has helped many local governments in Taiwan to draft regional plans for disaster mitigation and emergency response. All these work were done based upon new findings and lessons learnt from the Earthquake.

According to Dr. Chin-hsiung Loh, Director of NCREE, the Center was in charge of coordinating the efforts for damage data collection immediately, and had accordingly established an analysis/management platform called CEDAMS (Chi-Chi Earthquake Database Analysis and Management System) within half a year after the Earthquake. This is a highly specialized platform for further utilization of these priceless damage data by experts and researchers, only through which were more research works with good coordination and facilitation made possible. NCREE's experience during and after the Earthquake has tremendously raised its international reputation, and has made it a magnet for engineers and researchers around the world. NCREE has joined the ranks of the world's most successful research centers in earthquake engineering.

NCREE is currently performing four major innovative experiments and technology development projects. They are: (1) the full-scale testing of a 3-story 3-bay RCS frame, (2) the magneto-rheological (MR) damper project, (3) the FBG sensor array application, and (4) the research and development on structural health monitoring. Detailed descriptions on these research projects are as follows.

"RCS frames", which combine the merits of both conventional RC structures and steel structures, is a modern type of construction technology. While many research works have been conducted for studying their structural behavior on scaled models, these efforts have been hampered by lack of full-scale experimental data. NCREE's "Full-Scale 3-Story 3-Bay RCS Frame", of which each story will be 4 meters in height and each span 7 meters in length, will be the world's first full-scale experimental model for such kind of research work. The planned testing has attracted the interest of universities and companies from both the US and Japan, including the US's Pacific Earthquake Engineering Research Center (PEER) and the Nippon Steel Co. Many foreign personnel are now participating and working on this RCS frame. In addition, Internet-based technologies will be particularly developed at NCREE too to accommodate the capacities of real-time network experiment, test observation, and information sharing of this full-scale RCS testing with foreign professors, engineers, and scientists in the world. These efforts will further strengthen international cooperation between NCREE and foreign academics, and consolidate Taiwan's status as a hub of earthquake engineering research in the world.

The "magneto-rheological (MR) damper" is very similar to the conventional fluid damper, except that a special kind of oil containing tiny ferromagnetic particles is filled instead. The coil-generated magnetic field will switch the state of oil inside an MR damper from viscous fluid to semi-solid, and its stiffness depends on the current applied in coil. One of the most important features for MR dampers as active-control devices is that the damping force can be adjusted simultaneously by controlling the current in coil, and further, it consumes only a very few amount of DC electricity as energy for maintaining their functionality. MR dampers can be used in bridges to reduce excess vibrations, and further, to prevent collapse by reducing the displacement. They can also be used in high-rise buildings to make them more resistant to wind loads and earthquakes. To compare with the conventional tuned mass damper (TMD), MR damper could provide more effective control over the structures while meeting the requirements for reliability, economy, and ease of maintenance. NCREE is now working with Texas A&M University on a project to initiate the design and manufacture of such dampers in Taiwan. NCREE is also working to verify the MR dampers to various applications, and hopes to transfer this technology to the industrial sector in the future.

In contrast to electronic sensors in widespread use, optic fiber offers the advantages of compact size, easy systems integration, high signal-to-noise ratio, and combination of sensing and communication abilities. Therefore, in connection with its research on "FBG sensor array" and "structural health monitoring framework," NCREE has established intelligent monitoring systems by integrating the opto-electronic and fiber-optic technologies. These systems can be used in health monitoring for bridges, high-rise buildings, dams and facility towers, and in scouring monitoring, slope monitoring, and so forth. In fact, such systems have already been deployed on existed bridges in Taiwan to monitor the structural integrity continuously for the safety of vehicular traffic. Furthermore, based on the fiberoptic sensor system, NCREE has also established the structural health analysis modules and assessment indicators for the purpose of post-earthquake inspection.

NSC – Sponsored Typhoon Special Emphasis Research

In light of the heavy damage done by typhoons in Taiwan year after year, the National Science Council, R.O.C., places a great premium on typhoon research, and therefore plans to provide NT$30 million in funding for the "Typhoon Special Emphasis Research" project over the next three years (from August 1, 2002 to July 31, 2005). This project, which is led by Prof. Wu Chun-chieh of the Department of Atmospheric Sciences, National Taiwan University, will enjoy the active participation of the Central Weather Bureau, MOTC, including considerable manpower and equipment support. The project is expected to improve our understanding of typhoon dynamics, increase the accuracy of typhoon track and rainfall forecasts, and enhance Taiwan's standing in the field of typhoon research, making it the typhoon research leader in the Northwestern Pacific and East Asia region.

With Taiwan severely affected by many typhoons in recent years and the loss of life and property has been staggering. The typhoons that battered Taiwan in 2001 alone caused 583 deaths and injuries, more than NT$13 billion in agricultural losses, nearly paralyzed the Taipei Rapid Transit System, and did incalculable damage to private and public sectors. Prompted by their sense of social responsibility and the NSC's emphasis on typhoon research, atmospheric science researchers initiated an inter-agency integrated research project on typhoons in September 2001. As the rudiment of the Typhoon Special Emphasis Research project was formed in July 2002, the NSC approved the necessary funding.

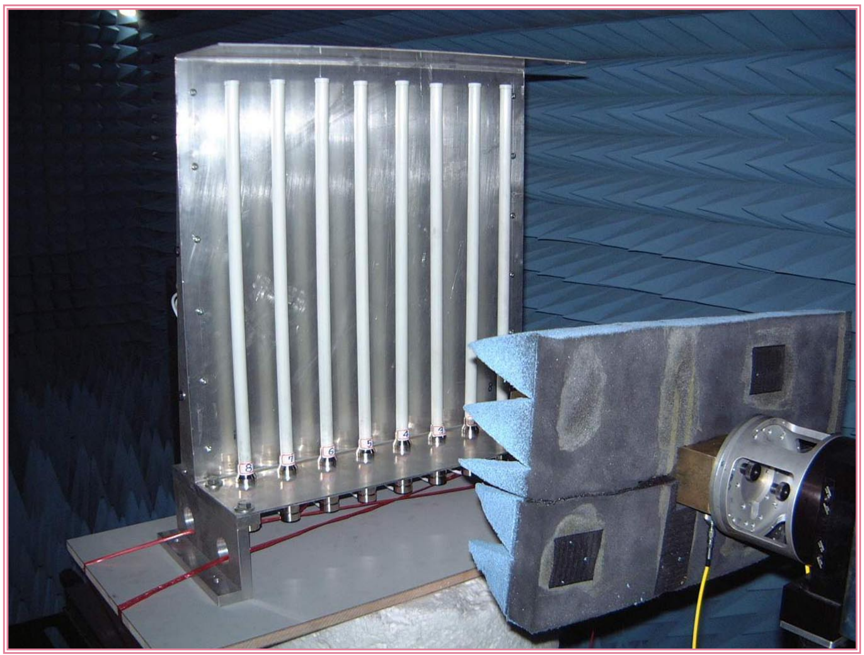
The Typhoon Focal Research project is being carried out by 18 Ph.D.-holding researchers from the Academia Sinica, Central Weather Bureau, and National Taiwan University and two other universities. Research goals include fine-tuning the theory of typhoon dynamics and improving typhoon forecasting. Particular attention will be paid to achieving new progress through the linkage of new typhoon observation systems and better numerical models. It should be mentioned that the project would use typhoon observation aircrafts to perform experiments on typhoons in the northwestern Pacific Ocean for the first time in up to 15 years. Researchers will fly above typhoons approaching Taiwan and release GPS dropsondes to obtain detailed information from within the typhoons' centers and gale-force wind radii, and collect environmental data from areas of interest around the typhoon periphery. Data will be transmitted to the Central Weather Bureau in real time and compared with the results of numerical prediction models. Apart from increasing understanding of the typhoon structure, the project will improve forecasting of typhoon track, intensity, and wind and rainfall distribution.

The project will be carried out in close cooperation with the Hurricane Research Division of the US National Oceanographic and Atmospheric Administration (NOAA). Four research personnel from Taiwan are currently taking part in a two-month Atlantic Ocean aircraft hurricane surveillance training operation conducted by the Hurricane Research Division. The typhoon surveillance with the GPS dropsondes will be conducted under the auspices of the project when the first typhoons of the 2003 season threaten Taiwan. The project is expected to yield impressive breakthroughs in typhoon research, forecasting, and observation when it is completed.

Telecom Equipment R&D Breakthroughs in Taiwan

Professor Chang Dau-chyrh, Department of EE, Da Yeh University, is leading a research team taking part in the NSC's "National Science and Technology Program for Telecommunications." Prof. Chang's team, whose members are affiliated with several universities in central Taiwan, has jointly developed an "Impulse Time Domain Antenna Measurement System," a "Multiple Purpose Hybrid Antenna Near Field Measurement System," and several kinds of "Multiple Beam Smart Antenna System." These achievements demonstrate that Taiwan is fully capable of developing the most advanced telecommunication equipments.

Addressing the threat of electromagnetic pulse (EMP) weapons, Prof. Chang's team successfully developed the first "Impulse Time Domain Antenna Measurement System" to be built in democratic country (seventh in the world). This system can be used to help the Armed Forces develop EMP weapons and defense measures. In addition, the team also completed the first "Multiple Purpose Hybrid Antenna Near Field Measurement System" to be developed in Asia. This system can measure the power pattern and performance of mobile phone antennas and base station and satellite antennas.



According to Prof. Chang, while multiple purpose hybrid antenna near field measurement systems are for use indoors, and impulse time domain antenna measurement systems are used outdoors, both have the purpose of measuring the spectrum and intensity of antenna RF emissions. Because impulse time domain antenna measurement systems are relatively costly, while multiple purpose hybrid antenna near field measurement systems are less expensive, there are currently only seven impulse time domain antenna measurement systems in existence, and six are in communist countries. Taiwan is thus the first democratic country to have developed an impulse time domain antenna measurement system.

Prof. Chang's impulse time domain antenna measurement system was based on acquired military technology, and was improved by reducing the power. This system is able to alleviate the effects of electromagnetic interference from the environment and reflection from buildings or topographical features, while accurately measuring key antenna parameters. It can be used to measure third-generation and future spread spectrum communications systems, and has such military applications as measurement of the scope and performance of EMP weapons and defense systems.

As for the "multiple purpose hybrid antenna near field measurement system," Prof. Chang notes that the system has been used to perform measurement and inspection services on 330 occasions for 33 domestic communications firms and research organizations over the past year and a half. In fact an American company even shipped a "Multiple Beam Smart Antenna System" to Taiwan for measurement, incidentally providing a good test of Taiwan's antenna measurement capability.

Prof. Chang stated that the antenna measurement equipment and systems developed by his team are needed by mobile phone manufacturers, telecom firms, and wireless network operators. Since single pieces of equipment may cost tens or even hundreds of thousands of dollars, the opportunities in this field are huge. Prof. Chang's team is now transferring technology to commercial firms, which will give a significant boost to Taiwan's communications industry.

Finally, the "multiple beam smart antenna system" developed by the research team, ahead of competing Korean researchers, will be able to resolve the problems of dead angles and electromagnetic interference affecting mobile phone systems with conventional base station antennas, while increasing the communications volume that can be handled by a single base station. Technology transfer has recently been completed, enhancing the competitiveness of Taiwan's telecom industry.

The beamwidth of conventional base station antennas is approximately 65 degrees per antenna. Since these base stations typically suffer from multi-path interference, quality is less than ideal, and there are dead angles in mobile phone signals. Moreover, communications capacity is limited. Because of these problems, researchers in the US and Korea are actively trying to develop multiple beam smart antenna systems, and Taiwan has joined in this quest with the NSC's support.

The goal of this effort is to surpass the 65° emission angle, increase communications capacity, provide good signal quality, and enable compact antennas. The technology that has been developed thus far can generate four to eight narrow beams (9° or 18°) using the same area as one conventional antenna.

Thanks to its narrow beams, this multiple beam smart antenna system offers superior communications quality. In addition, its multiple beams alleviate the dead angle problem. Since the system aims emissions only in the desired directions, it can conserve energy and lessen the RF pollution problem. At the same time, communications capacity is four to eight times that of conventional antennas. Able to replace conventional base stations, the system is well suited to use in the third-generation communications systems of the future.

Firms to Move in to Central Taiwan Science-based Industrial Park by July 2004

The Council for Economic Planning and Development (CEPD) has passed the "Central Taiwan Science-based Industrial Park Taichung and Yunlin Site Plan," and has decided to speed up implementation. Firms are slated to start establishing plants by July 2004.

The NSC estimates that development of the Central Taiwan Science-based Industrial Park (SIP) will require expenditures totaling close to NT$30.6 billion. Of this figure, NT$25.9 billion will be needed to develop the Taichung site and nearly NT$4.7 billion to develop the Yunlin site. A focused effort will be made to attract firms specializing in the areas of nanometer precision machinery, nanomaterials, biotechnology, communications, and electro-optics.

The NSC has announced a plan to develop more than 160 hectares of the approximately 304-hectare Taichung site as a special precision machinery and aerospace zone. A similar plan calls for 46.5 hectares at the 98-hectare Yunlin site to be set aside for the precision machinery, aerospace, biotechnology, communications, and optoelectronics industries. Buildings and land belonging to the SIP will generally be leased, not sold, but firms must only pay management and leasing fees relative to their development costs.

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http://nr.stic.gov.tw/ejournal/SciNews/scibulletin.htm
Subscription price for each copy: US$1.00
Payment must be made in US dollars by a check payable to National Science Council.

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戶　名：行政院國家科學技術發展基金

ISSN 1607-3509
9 771607 350003
GPN: 2009100242