Research Center for Urban Hazards Mitigation at The Hong Kong Polytechnic University

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ABSTRACT

This paper first gives a brief description on the mission, organization, and focused research areas of the Research Center for Urban Hazards Mitigation at The Hong Kong Polytechnic University. The current activities of the Center are then introduced, which include Area Strategic Development Program in Mitigation of Urban Hazards, technology transfer, publications and research grants, national and international collaboration, and selected research projects in earthquake engineering. Finally, the existing facilities in the Center and the contact information are provided. As a full member of the Asian-Pacific Network of Centers for Earthquake Engineering Research (ANCER), the Center looks forward to further cooperation with other centers in the ANCER.

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INTRODUCTION

The Research Center for Urban Hazards Mitigation (RCUHM) of The Hong Kong Polytechnic University was established in May 2002 as a university approved research center within the Faculty of Construction & Land Use, aiming to be an important contributor to the human's ability to understand, mitigate, and respond to natural and man-made hazards in urban areas. The mission of the Center is to:

(a) Conduct focused and multidisciplinary research to investigate the consequence of natural and man-made hazards in urban areas and to develop innovative engineering methods and new technologies for monitoring and mitigating damages to urban infrastructures; and

(b) Facilitate knowledge dissemination and technology transfer to the Government and the related industries through specialist consultancy, continuing professional training as well as undergraduate and postgraduate education.

The Center focuses on the effects of windstorms and earthquakes on tall buildings and long-span bridges and the effects of landslides. Its activities will also include other areas related to urban natural and man-made hazards mitigation that are important to Hong Kong and the Mainland China.

ORGANIZATION

Urban hazard mitigation needs new multidisciplinary approaches to finding the best solutions to protect modern urban infrastructures and human lives. To this end, the Center is established as a faculty-based establishment to combine and utilize the strength mainly from the Department of Civil and Structural Engineering (CSE) and the Department of Land Surveying and Geo-Informatics (LSGI) in the Faculty of Construction and Land Use (FCLU). It comprises 20 members of academic staff with expertise and interests covering a wide range of urban hazards mitigation. The research activities of the Center are undertaken principally by the involvement of research personnel (fellows, associates, and assistants) and research students, full-time and part-time, supervised by the academic staff of the Center.

The management of the Center is conducted by a Management Committee. The implementation of the decisions made by the Management Committee and the day-to-day operation of the Center is undertaken by the Director and Deputy Director.

FOCUSED RESEARCH AREAS

Hong Kong is one of the most congested urban centers located in one of the most active typhoon regions in the world. The probability of having a typhoon directly hitting Hong Kong

with an hourly mean wind speed of 32m/s or more is estimated more than once in 10 years. Hong Kong is also classified by the China Seismological Bureau as an area of earthquake intensity 7.5 and design peak ground acceleration 0.15g at bedrock for a return period of 475 years. However, there is no provision for seismic design of building structures in Hong Kong because of historical reasons. The new integrated design philosophy of building structures against both wind and seismic loads is urgently needed in Hong Kong. Furthermore, the special topographic and geological settings in Hong Kong make it very prone to serious landslides, particularly under heavy rains. In recent decades, typhoons and landslides in Hong Kong have caused the losses of hundred lives and billions of dollars of property.

Large existing stock of civil engineering structures in Hong Kong has such problems as physical aging and deterioration, functional obsolescence, high-cost of maintenance, and huge outlays required for renewal and upgrading. Many new large civil engineering structures such as tall buildings and long span bridges are being built near large man-made or natural slopes. These facts significantly increase the risk of damages to infrastructures in urban areas during windstorms, earthquakes, and landslides.

A complete and systematic plan for urban hazard mitigation may have to involve many disciplines including meteorology, seismology, geology, geophysics, geodesy, engineering, psychology, and sociology. At its current capacities and to maximize achievement with limited resource, the activities of the Center are focused on the research, development, and implementation of innovative engineering methods and new technologies for urban infrastructure hazards mitigation with priorities given to

The natural hazards that threaten Hong Kong most:

(1) Strong typhoons
(2) Moderate earthquakes
(3) Severe landslides

The infrastructures that are most important to Hong Kong:

(1) Tall buildings
(2) Long span bridges
(3) Large slopes

The innovative engineering methods and new technologies that are most relevant to the mission of the Center:

(1) New methods and techniques for investigating high wind structures in dense urban areas caused by typhoons;
(2) New approaches for assessing ground motions in dense urban areas caused by earthquakes;

(3) New methods and techniques for monitoring and preventing landslides in dense urban areas with complex topography and reclamation land;
(4) Performance-based design of tall buildings and long span bridges against wind and earthquakes;
(5) System identification, health monitoring, and damage detection;
(6) Seismic retrofitting of tall buildings and long span bridges;
(7) Smart materials, structural control, and intelligent buildings;
(8) Specialized GPS hardware, software and data analysis algorithms for monitoring infrastructures;
(9) InSAR algorithms and software for accurate and reliable measurement of earthquake related ground deformations;
(10) GIS for management of health information of infrastructures;
(11) Integrated geodetic techniques for infrastructure monitoring and hazards mitigation; and
(12) Vulnerability and risk analysis of infrastructures in urban areas to strong typhoons, moderate earthquakes, and severe landslides.

CURRENT ACTIVITIES

Area of Strategic Development in Mitigation of Urban Hazards (ASD:MUH)

The Hong Kong Polytechnic University has launched an initiative seeking to establish a position of preeminence in Hong Kong and in the international arena. In this connection, some of areas of particular strength have been identified as strategic development areas for priority funding support. The ultimate objective is that these areas can reach "Area of Excellence" standard on a regional and/or international basis. "Mitigation of Urban Hazards" is one of the areas designated by the University as an ASD under this initiative.

The Area of Strategic Development in Mitigation of Urban Hazards (ASD:MUH) has been undertaken mainly by the Center since July 2002. In accordance with the "Management and Monitoring Mechanism for the Areas of Excellence and Areas of Strategic Development (ASD)" adopted by the University, the Advisory Committee for ASD: MUH was formed in 2002 and plays the role of guiding and supporting the internal Management Committee in the development of the ASD and ensuring that it maintains the highest standard of academic enquiry while also meeting the needs of the profession, industry and the community as whole.

The funding supported by the University for ASD:MUH has been allocated to the seven research projects listed in the following:

(1) Global positioning system and geographic information system for urban hazards monitoring
(2) Wind effects on structures
(3) Seismic and landslide hazards in dense urban areas

(4) Performance-based building design against wind, earthquake and fire
(5) System identifications, health monitoring and damage detection
(6) Enhancement of seismic resistance of RC structures through the use of FRP composites
(7) Structural control and intelligent structures

Technology Transfer

Center members sit on several Hong Kong and international design code committees. Specialist consultancy services related to urban infrastructures, which transfer the member's research expertise and results to the construction industry, exceeded over HK$ 8 million in the two-year period. Some representative examples in this regard are "Consultancy Study on Structural Use of Steel using a Limit State Approach in Hong Kong", "3-D Finite Element Based Buffeting Analysis of Stonecutters Bridge in Hong Kong", and "Structural Health Monitoring System of the Sutong Bridge in Mainland China". Technology transfers also take place through many short courses, seminars, and MSc programmes in civil engineering, structural engineering, and geomatics provided for local engineers and surveyors. The computer software developed by Center members has been licensed to a number of companies and universities.

Publications and Research Grants

Center members and research personnel have published extensively in refereed international conference proceedings and journals in the relevant fields, with over 158 papers published in international journals indexed by SCI in the past two years. Several leading scientific and technical books written by Center members have been published by international publishers.

Staff members of the Center have been conspicuously successful in winning research grants under the competitive RGC CERG scheme. For the two awarding years, 2003 and 2004, 20 projects were successful, amounting to a total sum of HK12.7M.

National and International Collaboration

Center members are very active in serving various national and international specialist committees. They also serve on the editorial boards of top national and international journals. They have been invited to give keynote lectures and to chair sessions at many national and international conferences and also as international conference scientific committee members and organizing committee members. The Center's members have also edited a number of special issues for international journals.

The Center has been admitted as a full member of the Asian-Pacific Network of Centers for Earthquake Engineering Research (ANCER) in 2003. ANCER aims to coordinate and leverage limited research resources in respective countries to develop and implement, on a center-to-center cooperative basis, innovative engineering methods and new enabling

technologies needed to design, construct, maintain, monitor, manage and renew the built environment for reduced seismic hazards.

The members of the Center have strong links with many Mainland Chinese institutions. For example, the members have organized several short courses jointly with the Ministry of Construction of China to introduce Chinese seismic design codes to Hong Kong engineers. They are the only Hong Kong representatives invited to participate at two recent Sino-US workshops in structural engineering held in the Mainland, and have collaborative research projects with many institutions including the China Seismological Bureau, Tongji University, and Harbin Institute of Technology.

Selected Research Projects in Earthquake Engineering

(1) To quantify the seismic ground motions of Hong Kong for the design of buildings in Hong Kong.
(2) Advanced analysis and design of steel frames allowing for beam-column inelastic buckling
(3) FRP composites with intelligent sensors for applications in the civil infrastructure
(4) Nonlinear seismic pounding between adjacent structures, incorporating soil-pile interaction: shaking table tests and theoretical analyses
(5) Strengthening of reinforced concrete beam-column joints and columns by passive dampers
(6) Novel techniques for system identification and damage diagnosis of large civil structures
(7) Monitoring of surface deformations with ERS/ENVISAT Synthetic Aperture Radar Interferometry
(8) Change point analyses of KSP VLBI and GPS baselines for cursory variations prior and post seismic activity at Izu islands in the summer of 2000.

LABORATORIES AND FACILITIES

Research activities of the Center are supported by four well-equipped laboratories: Heavy Structures Laboratory, Dynamics Laboratory, Soil Laboratory, and Geo-informatics Laboratory.

The major facilities include (1) a MTS 3m x 3m seismic simulation table, (2) 4 servo-loop controlled MTS actuators, (3) a 270 tons universal testing machine, (4) a MTS 810 universal material testing system, (5) a dSPACE control system, (6) 2 electric-magnetic shakers, (7) a computer-controlled 2Hz cyclic and stress-path triaxial testing system, (8) a multi-stage dead weight triaxial compression creep system with automatic arm level balance, (9) a hollow cylinder apparatus, (10) 3 GPS receivers, (11) a GLONASS receivers, and (12) a number of software licenses for different GIS products.

A new structure laboratory of a 400 m^2 floor area with a strong reaction wall of 18 m wide and 8m high is being built in addition to the existing Heavy Structures Laboratory.

CONTACT INFORMATION

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