Homepage

- **Mission**

Over the past few years, Chinas economy has achieved rapid development. China's engineering construction ranks the first in the world in terms of volume, and the continued emergence of large and complex engineering structures requires better seismic control. Against this backdrop, we are required to build a public research platform with international competitive edge that is open to the whole industry and to carry out common and forward-looking technology research as well as applied basic research. We also need to improve national science and technology innovation system in this field and provide support in innovation and other respects in an effort to build our country into a pacesetter for vibration control technology in civil engineering. We will carry out basic research and key and common technology research with competitiveness by establishing research platforms. We will also establish technology of civil engineering shock absorption control system applicable to multi-object, multi-condition and multi-environment, develop support test technology and software technology with independent intellectual property rights, break up foreign technology monopoly, to meet the needs of national disaster prevention and mitigation construction plan and national development strategies. We will be committed to studying and formulating international, national and industrial standards, leading and driving the development of the industry, improving the overall technical performance of civil engineering disaster prevention and mitigation in China, gathering and cultivating outstanding talent, promoting scientific and technological exchanges, and providing a solid guarantee for future development of the industry. In all, we are working hard to build the Center into an international academic engine and technology center for shock absorption control and structural safety, and into one that is located in South China but serves the whole country.

- **About**

The Center for Earthquake Engineering Research & Test is one of the earliest research institutes in seismic isolation and mitigation engineering technology in China, and the only laboratory specializing in seismic isolation and mitigation technology in this country. The Center was founded in 1994. In 1996, it was awarded as one of the key university laboratories, and in 1997, it was designated as the research base for earthquake resistance and the testing base for isolation and seismic mitigation products by the Ministry of Construction. In 2003, it was rated as the key laboratory of earthquake engineering and application technology in Guangdong Province, and in 2005 the key laboratory of earthquake resistance and shock absorption and structural safety by Ministry of Education. The laboratory passed CMA in 2006, and was recognized as the cultivation base of national key laboratories in 2007. Since 2007, the Center has started to recruit PhD students. In 2012, it established a post-doctoral research station of civil engineering. In 2013, it

was awarded Structural Isolation and Vibration Reduction (Vibration) Control Innovation Team by Ministry of Education, and in 2017, it received support from the Innovative Team of Structural Isolation and Shock Absorption (Vibration) Control of Ministry of Education. The head of the center is Professor Zhou Fulin, a famous seismologist and an academician of the Chinese Academy of Engineering. With over 20-year development and leadership of Academician Zhou, the Center has become a first-class domestic research institute with distinctive features: a strong talent team, remarkable research progress, rich engineering experience, advanced test hardware and frequent academic exchanges.

At present, the Center has four main research areas: engineering isolation, energy dissipation and vibration reduction, engineering vibration control, and engineering explosion resistance. There are 42 permanent researchers, including 1 academician of Chinese Academy of Engineering (Academician Zhou Fulin), 1 dual-employed academician of Chinese Academy of Engineering (Academician Xie Lili), and 1 leading talent of the National Ten Thousand Plan. There are 1 innovative leading talent of Ministry of Technology, 1 Pearl River Scholar, 2 new-century talent of Ministry of Education, 1 innovative team of Ministry of Education, and 10 national registered structural engineers. Ninety percent of the research team has senior technical titles or doctoral and masters degrees. The research areas cover seismic isolation, seismic resistance, wind resistance, explosion resistance, health monitoring and other fields related to structural safety.

In recent years, the Center has made remarkable achievements in the frontiers of seismic engineering - seismic isolation and energy dissipation control technology, contributing to Chinas economic development and social progress. It lies in the leading position in China, and enjoys great influence and reputation in the international arena. Over the past few years, the Center has won 6 national science and technology awards and 34 provincial and ministerial science and technology awards and several other government awards. It has undertaken 16 major national research projects, more than 30 National Natural Science Foundation projects, and more than 40 provincial and ministerial projects. It has published 37 monographs and compiled 54 international/national/industry standards, including Chinas first Technical Regulations for Isolation of Laminated Rubber Bearings, Chinas first product standard for isolation bearings, Building Rubber Isolation Bearings and the worlds first national standard for isolation technology-Design Standards for Building Isolation. It has been awarded more than 50 patents for technical inventions, developed more than 10 software products and published 30 SCI- and EI-indexed papers.

The center closely follows the needs of national and social development, and actively provides scientific and technological support for national construction and all sectors of society. The center overtook the research and design of the largest story isolation project in the world-Tonghui Home in Beijing, the earthquake and wind control system of the worlds tallest TV tower-Guangzhou Tower, and the isolation and seismic reduction project of the longest bridge project in the world-Hong Kong-Zhuhai-Macao Sea-Crossing Bridge. A total of 14 items were

awarded The Best in China.

After a period of preliminary construction, the center has become a first-class laboratory for seismic mitigation and control and structural safety with sufficient scientific research rooms, advanced instruments and equipment, and complete supporting facilities in the country. A delegation of the National Seismological Research Center of the United States acclaimed the Center as an advanced experimental research center even in the United States. The center currently has an office space of 2,000 square meters and a test hall of 6,000 square meters. A new laboratory building with a total floor area of 20,000 square meters, with a total investment of 356 million RMB yuan is under construction. The new laboratory building has 4,000 square meters of office space and 16,000 square meters of experimental area. The experimental hall is designed to be 15 m + 9 m wide, 48 m long and 13 m high. It owns advanced instruments and complete equipment. It has the first large-tonnage, high-speed and long-distance compression-shear test machine in China, a 3-dimensional and 6-DOF simulated seismic shaking table made by MTS Company of the United States, a 1500t electro-hydraulic servo compression-shear test system, a 200-ton hydraulic loading system test set and a creep test system, a 3-channel hydraulic servo test system, a 100 mm diameter primary air gun, and 40 mm Hopkinson rod, high performance numerical calculation center, etc.

The center is secretariat for the Chinese Committee of Seismic Control for Structures . It is member of International Association for Earthquake Engineering and Asian Pacific Network of Centers for Earthquake Engineering Research (ANCER). It is in long-term cooperative relationships with organizations in the U.S, Japan and other countries. It is dedicated to the development of the economy and society, making an impact at home and abroad.

About

- **Experts & scholars**

Zhou Fulin, born in Chaoyang, Guangdong Province in 1939, is Academician of the Chinese Academy of Engineering and Director of the Center for Seismic Research of Engineering Structures and Director of the Key Laboratory of Seismic Engineering and Applied Technology of Guangdong Province. Academician Zhou also serves as Technical Advisor of the United Nations Industrial Development Organization (UNIDO), Chairman of the International Society for Seismic Control (Assisi), Executive Director of the Earthquake Resistance and Disaster Prevention Research Association of the Chinese Architectural Society and Chairman of the Professional Committee of Structural Damping Control.

Academician Zhou is a world-famous isolation and damping control expert and one of the trailblazers in structural damping and vibration control in China. He has been engaged in the research and teaching of building structural seismic for a long period of time, and has blazed a trail of new seismic isolation and damping technology which is different from traditional seismic technology. He has laid a

foundation for Chinas engineering structural isolation and damping control technology system. In recent years, he has published 4 books and nearly 100 papers in Chinese and English. He has won more than 10 awards, including the second prize in the National Science and Technology Progress Award, the first and second prizes in the Science and Technology Progress Award of the Ministry of Construction, and the first prize of the Science and Technology Progress Award of Guangdong Province. He has been awarded the National May 1st Labor Medal, the labor model conferred by the Ministry of Construction, one of the experts with outstanding contributions in Guangdong Province, the May 1st Labor Medal by Guangdong Province. He enjoys State Council special allowance. He was awarded the first Innovation Award of South Guangdong in Guangdong Province in 2011, the outstanding contribution award of Scientific and Technological Progress of Guangdong Province in 2015, and the National Excellent Scientific and Technological Workers in 2016.

The first new technologies in the area of construction, such as multi-story building isolation, interlayer isolation, three-dimensional isolation, and hybrid tuning, have been applied to many large and complex buildings, bridges, facilities, antiquities and practical projects, with the investment remaining unchanged and safety factor increased by 4 to 8 times. The first isolated residential building built in Shantou in 1993 was appraised as the third milestone of the development of isolation technology in the world by UNIDO. He was in charge of the design of Beijing Home of Tonghui, the largest building isolation project in the world, covering an area of 240,000 square meters. With his isolation technology and products, 27 six story buildings originally designed on the large platforms of subways were raised to nine stories, creating a direct economic value of 600 million RMB yuan in 2005 alone. In addition, the first subway Isolation Bridge (Buguzi Bridge in Xinjiang Autonomous Region, 2000) and the first highway isolation bridge (Shijinqu Bridge in Shijiazhuang, 2001) have been built in China. The new products developed by his isolation and damping technology have created a new industrial chain for Chinese enterprises. More than 10 enterprises have established high-level isolation product lines.

● Departments

1. Division of Engineering Seismic and Analysis

The Division of Engineering Seismic and Analysis carries out research and concurrence of seismic theory of new structures and systems as well as research on seismic performance of new structure components and joints; seismic performance of new structures and systems and super high-rise, high-rise and large-scale complex structures; shock absorption of industrial products and equipment; the design theory and method of structural seismic and geotechnical seismic engineering. It develops the best components and joint forms, and promotes their application.

2. Division of Engineering Seismic Isolation

The Division of Engineering Seismic Isolation is engaged in theoretical and technological

research of engineering seismic isolation and control for buildings and bridge structures. Our professional areas include isolation techniques for earthquake engineering or environmental vibration problem, covering theory, design, experiment and device development of high-rise structural isolation, inter-story isolation, three-dimensional isolation and multi-functional isolation technologies. We concentrate on technological standardization, tests and engineering application.

3. Division of Engineering Vibration Reduction and Monitoring

The Division of Engineering Vibration Reduction and Monitoring conducts research on the theory and technology system of engineering structure vibration reduction and control, structural performance monitoring and evaluation, explores new ideas of energy dissipation device design and application of various energy dissipation devices in different types of structures, studies the theory and algorithm of semi-active control, active control and hybrid control, laws of vibration and noise pollution, causes, transmission ways, control methods and harm to human body of roads, subways, bridges, etc.

4. Division of Blasting-Resistant Engineering

The Division of Blasting-Resistant Engineering researches the anti-explosion performance of buildings and structures, various explosion loads, material responses and structure responses under explosion load, anti-explosion rating evaluation, accident analyses, anti-explosion design and reinforcement. It also conducts research on the safety of explosion and impact, explosive detection, safety evaluation of explosive system, armor protection and bunker design, human impact damage and protection and dynamic mechanical properties of buildings and engineering materials, constitutive relationships under high strain rate and high temperature, dynamic damage, dynamic fracture, etc.

5. Division of High Performance Computing

The Division of High Performance Computing studies the control mechanics model and numerical analysis method of isolation and damping structures based on high performance numerical calculation platform. It also covers high performance analysis, optimization and control algorithm for large-scale structural dynamic and static nonlinear problems; development of refined design and analysis software technology for isolation and damping (vibration) control structure based on high-performance calculation; establishment of numerical simulation of complex seismic dynamic action and site conditions; simulation method for key mechanical problems of large-scale practical engineering projects; etc.

6. General Office

The General Office is responsible for daily businesses of the center. It keeps in touch with units of the school, checks attendance of employees, and manages safety of the center. It consists of an administrative group, a financial group, and a logistics group.

Platforms

1、Laboratory of Seismic Control and Structural Safety (national key laboratory incubation base jointly established by Guangdong Province and Ministry of Science and Technology)

2、Laboratory of Earthquake Resistance, Earthquake Mitigation and Structural Safety (key laboratory jointly established by Guangdong Province and Ministry of Education)

3、Provincial Key Laboratory of Earthquake Engineering & Applied Technology (key laboratory of Guangdong Province and its Department of Science and Technology)

4、Laboratory of Earthquake Resistance, Earthquake Mitigation and Structural Safety (key laboratory of Guangdong Universities, Department of Education of Guangdong Province)

5、Center for Earthquake Resistant, Seismic Isolation and Blasting-Resistant Engineering (Engineering Technology Research and Development Center of Guangdong Universities, Department of Education, Guangdong Province)

Achievements

Awards

NO.	Name of Project	Reward Level	Awarded by	Date
1	Theory, method and application of behavior- based building structure seismic design	First prize of National Science and Technology Progress Award	The State Council of the P.R.C.	2015. 12
2	Key Technologies of Guangzhou Tower	Second prize of the Scientific and Technological Progress of the State	The State Council of the P.R.C.	2016. 12
3	Isolation and damping method of building structures and its engineering application	Second prize of the Scientific and Technological Progress of the State	The State Council of the P.R.C.	1998. 01
4	Mechanism, technology, characteristics and application of bombardment synthesis of Ultrafine Diamond	First prize of Science and Technology Progress of Ministry of Education	Ministry of Education of the P.R.C.	2015. 02
5	Key technology of isolation and vibration reduction of	First prize of Guangdong Science and Technology	Guangdong Provincial	2020. 01

	Hong Kong-Zhuhai-Macao Bridge	Progress Award	Government	
6	Active and passive compound tuning control technology of Guangzhou Tower	First prize of Guangdong Science and Technology Progress Award	Guangdong Provincial Government	2014. 04

- **Patents**

NO.	Name of Patent	Patent Category	Patent Number	Date
1	A horizontal railing device used in isolation joints	Invention	ZL201820079978. 5	2018-10-26
2	A new type of three-dimensional isolation bearing	Invention	CN106285152 B	2018-09-18
3	A bridge damper based on lever principle	Invention	ZL201611196548. 3	2018-09-18
4	A vertical railing device used in isolation joints	Invention	ZL201820080288. 1	2018-09-14
5	A dynamic testing method for deflection of main girder of cable-stayed bridge	Invention	ZL201610887535. 4	2018-09-14

- **Standards & Monographs**

The center edited the first *Technical Specification for Seismic-Isolation with Laminated Rubber Bearing Isolators*, the first trade standard *Rubber Isolation Bearings for Buildings*, Chapter 12 of *Code for Seismic Design of Buildings*, the first set of national standard of rubber bearings including three sub-standards which were awarded second prize for innovation and contribution of national standards and the national standard *Code of Design for Seismic Isolated Buildings*. The University was designated as the first chief editorial organization and Prof. Zhou Fulin is the first chief editor. This specification was issued in 2001. The national standard *Elastomeric Seismic-protection Isolators* chiefly edited by Prof. Zhou Fulin was approved in 2007.

NO.	Name	Category	Publisher	Date
1	*Elastomeric Seismic-protection IsolatorsPart 1Test Methods* (participant)	International Standard	ISO International Rubber Products Standardization Association	2010. 11
2	*Robber Bearings-Part 5: Elastic Sliding Seismic-protection Isolator for Buildings* (Editor)	National Standard	China Standards Press	2015. 10
3	*Technical Code for Energy Dissipation and Shock Absorption of Buildings* (Editor)	Industry Standard	China Construction Industry Press	2013. 12
4	*Technical code for Building Isolation and Energy Dissipation* (Editor)	Local Standard	Shenzhen housing and Construction Bureau	2019. 05
5	*Technical Code for Base Isolation of*	Enterprise	CGN Nuclear	2015. 03

	Buildings (Structures) in Nuclear Power Plants (Editor)	Standard	Engineering Co., Ltd	

- **Research Projects**

: The Center has undertaken more than one hundred projects supported by UNIDO, National Natural Science Foundation of China (NSFC), Natural Science Foundation of Guangdong Province, and Guangzhou Municipal Construction Committee. In recent years, the Center has undertaken three programs of National Key Research and Development Program (including sub-programs), two projects of National Basic Research Program of China (973 Program), one project of Key Research Plan of National Natural Science Foundation of China (NSFC), two projects of Key Points, Special Instruments, Joint Funds Program of NSFC, nine programs of General Project of NSFC, one project of National Science and Technology Supported Plan, one project of Provincial Science and Technology Supported Plan, three key horizontal cooperation projects, etc.. Recently, one project was awarded the first prize for national science and technology advancement. Four projects were awarded the second prize for national science and technology advancement. Three projects were awarded the first prize for science and technology advancement of the Ministry of Education. Another two projects were awarded other provincial and ministerial awards.

NO.	Name of Project	Source of Project	Funds (RMB)	Date
1	Key technologies of isolation and energy dissipation of industrial buildings	Key Special Projects of National Key R & D Plan	13, 270, 000	2017. 07~2020. 12
2	Optimization design theory and key technology of performance analysis for isolation structure of industrial building	Key Special Subjects of National Key R & D Plan	2, 170, 000	2016. 07~2020. 12
3	Failure mode identification of kilometer level super tall buildings under random address	Key Special Subjects of National Key R & D Plan	1, 840, 000	2016. 07~2020. 12
4	Seismic failure mechanism and seismic toughness design method of cross sea tunnel in unfavorable geological section	Major Projects of NSFC	3, 800, 000	2020. 01~2024. 12
5	Design and control of damage and life cycle performance of high-speed railway bridge under strong earthquake	Key Projects of NSFC	3, 000, 000	2014. 01~2017. 12
6	Structure isolation and shock absorption control	Innovation Team Plan of Ministry of Education	3, 000, 000	2018. 01~2020. 12

Academic Activities

- **The Committee and Its Academic Activities**

Our Center is attached to the Committee of Seismic Mitigation and Control for Structures and

Seismic Disaster Prevention Branch of Architecture Society of China (SDPASC), of which Professor Zhou Fulin serves as Director. Many issues of *Seismic Control of Structures*, the notes of the Committee, have been published. In 1994, the center organized The International Workshop on Use of Rubber Base Bearing for Earthquake Protection of Building jointly hosted by United Nations Industrial Development Organization (UNIDO) and relevant departments. Approximately 120 participants from 18 countries attended this Workshop. In 1995, the 3rd National Conference on Seismic Control of Structure was held in Guangzhou. Altogether 74 participants from 56 institutions attended this conference. From May 6 to 8, 1999, the International Workshop on Seismic Isolation, Energy Dissipation and Control of Structures was held in Guangzhou, which was jointly organized by Guangzhou University and the University of Notre Dame, U.S.A. Specialists and scholars from Japan, Italy, Canada, China, and other countries attended the Workshop. In 2006, the 7th National Conference on Earthquake Engineering was held in Guangzhou. In 2009, the 11th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures was held in Guangzhou. In 2010, the 11th International Symposium on Structural Engineering was held in Guangzhou. In 2017, the 10th National Conference on Structural Seismic Vibration Reduction and Control was held in Dalian.

Meetings hosted by the Center:

- The International Workshop on Use of Rubber Base Bearing for Earthquake Protection of Building

International Workshop on Seismic Isolation, Energy Dissipation and Control of Structures (1999)

- The 7th National Conference on Earthquake Engineering Held in Guangzhou in 2006
- The 11th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures
- The 11th International Symposium on Structural Engineering
- The 199th Engineering Technology Forum of Chinese Academy of Engineering, the 8th National Symposium on Disaster Prevention and Mitigation Engineering (2014)
- The 10th National Conference on Structural Seismic Vibration Reduction and Control

- **International Technical Cooperation and Exchange**

EERTC has close relationships with foreign institutions and universities, and has made international exchange and cooperation at both EERTC and personal levels.

EERTC has successfully conducted joint research projects on seismic isolation and structural control with its counterparts in the US, Japan and UNIDO. Scholars and experts from Canada, the US, Japan, Russia, Hong Kong and Taiwan have paid visits to EERTC, and the center's staff have also paid visits for conferences and training programs overseas. Such exchanges and cooperation have benefited both parties. EERTC actively supports UN in establishing international and regional isolation techniques and test centers in it.

In 1996, Guangzhou University and Fujita Corporation of Japan signed an agreement on joint research. According to the agreement, EERTC conducted rubber-bearing tests for Fujita Corporation. EERTC aims at becoming a seismic testing base of engineering structures in Southeast Asia and the world. In 2003, EERTC was accepted as member of the Asian Pacific

Network of Centers for Earthquake Engineering Research (ANCER). In 2011, Prof. Zhou Fulin was elected President of ASSISi in the 12th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures.

Exchange and cooperation programs

- Prof. Zhou Fulin, seismic isolation technique advisor of UNIDO, chairs an international workshop
- Prof. Zhou Fulin in the International Workshop on Atomic Energy Structure Seismic Isolation in Italy as member of presidium
- EERTC accepted as member of the Asian Pacific Network of Centers for Earthquake Engineering Research (ANCER) in 2003
- Staff of EERTC in the United Nations development agency conference (2007)
- Prof. Zhou Fulin elected President of Anti-Seismic System International Society(ASSISi) in the 12th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures in Sochi, Russia (2011)
- staff of EERTC in an international conference in Turkey (2014)
- Academician Mark Bradford from the University of New South Wales, Australia gives a lecture in EERTC (2017)
- Professor Billie f. Spencer Jr. from the University of Illinois at Urbana-Champaign pays a visit to the Center (2108)
- EERTC Staff conduct academic exchanges in the University of Padova, Italy (2018)
- The first working meeting of the world seismic isolation structure design code preparation group held in Prague (2018)
- The International Research Center for the Protection of Cultural Heritage from Earthquake-Induced Risk established (2018)

- **Postgraduate and PhD Education**

For many years, EERTC has jointly nurtured a number of postgraduate and PhD students with Hunan University, Harbin University of Engineering and Architecture, Xian University of Architecture and Technology, etc. In 2001 and 2005, EERTC was authorized to initiate masters and PhD programs independently respectively. In 2012, the Civil Engineering Postdoctoral Station of the Center was established. Nearly 100 students have received Masters or doctoral degrees in the center so far.

Equipment

Certification

- China Metrology Accreditation
- Key Extension and Supporting Institution of Technological Achievements by State Scientific and Technological Commission
- Key Extension and Supporting Institution of Scientific Achievements by Ministry of Construction
- Certifying Body of Seismic Isolation Bearing Testing, Ministry of Health and Welfare, Japan

Equipment

1. Seismic simulation shaking table system and real-time hybrid simulation system

The supply scope includes one set of seismic simulation system and one set of real-time hybrid simulation test system. The seismic simulation system consists of one 8m10m 6-DOF seismic simulation shaking table (big table system), one 4m4m 6-DOF seismic simulation shaking table (medium table system), and the existing MTS 3m x 3m seismic table should be upgraded to a 4m x 4m (medium table system). The two 4m x 4m medium table can be set up to seismic matrix system and can be integrated with a 4m x 10m 6-DOF seismic simulation system. Real time hybrid simulation system, including one set of 250kN high-performance actuator and real time hybrid simulation software, is capable of working with OpenSees and OpenFresco for hybrid simulation.

Specification of 8m x 10 seismic table

Dimensions of table face:	8m10m	Maximum overturning moment:	500kNm
DOF:	6	Maximum eccentricity:	2240kN m
Working frequency:	0.1--30Hz	Max. loading	160^{t}

Maximum acceleration of full load sinusoidal vibration of the table:

Maximum acceleration of full load of the table for duration of 10 seconds: Horizontal direction X 1.6g, horizontal direction Y1.6g, vertical direction 1.0g;

When reaching the maximum acceleration of table at X&Y direction simultaneously for duration of 4 seconds: X&Y acceleration 1.0g;

When reaching the maximum acceleration of table at X or Y and Z direction simultaneously for duration of 4 seconds: X or Y acceleration 1.6g, vertical direction 1.0g.

Shaking wave: various giving waves, random and simulated earthquake waves

Specification of 4m x 4 seismic table

Dimensions of table face:	4m4m	Maximum overturning moment:	500kNm
DOF:	6		
Working frequency:	0.1--50Hz	Max. loading	160^{t}

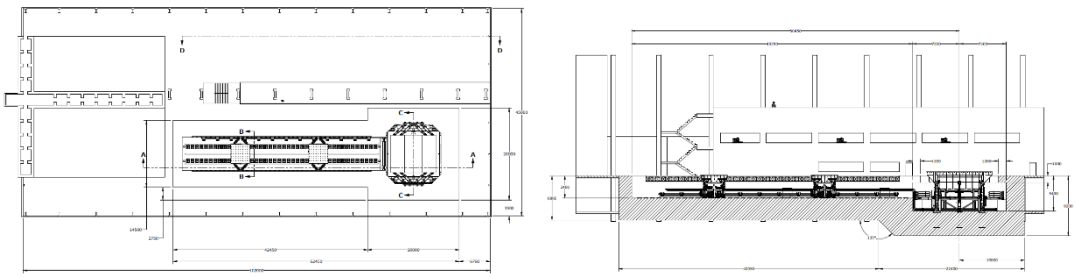
Maximum acceleration of full load sinusoidal vibration of the table:

Maximum acceleration of full load of the table for continuous duration: Horizontal direction X 1.5g, horizontal direction Y1.5g, vertical direction 1.0g;

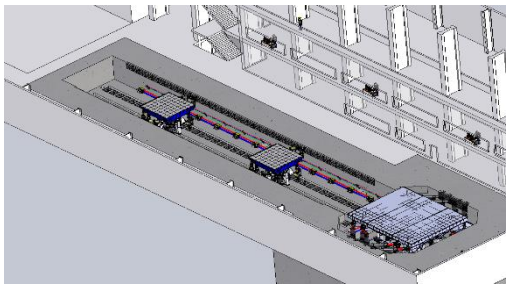
When reaching the maximum acceleration of table at X&Y direction simultaneously for duration of 50 seconds: X&Y acceleration 1.06g;

When reaching the maximum acceleration of table at X or Y and Z direction simultaneously for duration of 50 seconds: X or Y acceleration 1.5g, vertical direction 1.0g.

Shaking wave: various giving wave, random and simulated earthquake waves



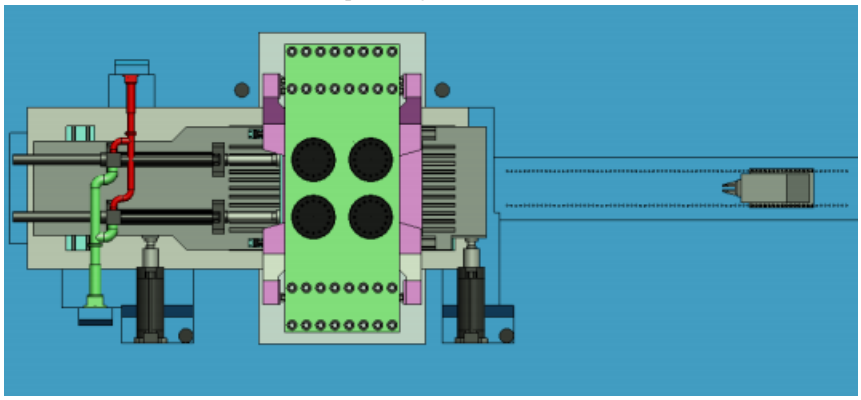
Tables Layout Scheme

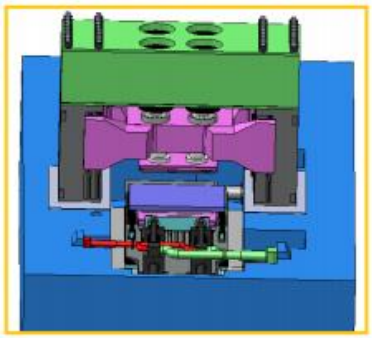


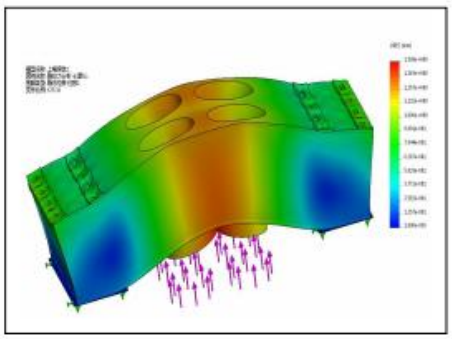
Tables Layout Scheme

2. Pressure-Shear Testing System with Ten Thousand Tons Capacity in Vertical Direction

Max. vertical loading is 80000~100000 kN ($P_{max,v}$=80000~100000 kN). Max. horizontal loading in X direction is 10000 kN ($P_{max,h}$=10000 kN). Press-shear deformation in X direction is ±1500 mm. Max. horizontal loading in Y direction is 5000 kN ($P_{max,h}$=5000 kN). Press-shear deformation in Y direction is ± 600 mm. The working frequency of the test system is 0.001~5 Hz. The x-direction working space is reserved for energy dissipation experiment with a space length of 12 m, and the y-direction can be used for isolation bearing tests with a diameter of D2000 mm. External control interface is reserved for quasi-dynamic tests.







Design Scheme of Pressure-Shear Testing System with Ten Thousand Tons Capacity in Vertical Direction

$P_{max,v}$=80000~100000 kNX$P_{max,hx}$=10000 kNX1500 mmY$P_{max,hy}$=5000 kNY600 mm0.001~5 HzX12 mYD2000 mm

3. Technical parameters of fatigue test system for 250 tons electro-hydraulic servo structure

Number of single cycle	Ten thousand times	600Constant voltage and constant frequency
maximum load	dynamickN	2500
	statickN	2500
accuracyofmeasurement	load	better than0.5% of the indicating value static better than1.0% of the indicating value dynamic
dynamic test	test freq.(Hz)	0.0110Hz
	test wave	Sine wave, triangle wave, square wave, oblique wave, trapezoidal wave and custom function
	test amplitude	Determine frequency and amplitude according to displacement of hydraulic servo pump station. Under force control, the displacement is not less than 250kn and 10mm
mechanical parameter	structural type	upright
	Vertical actuator strokemm	1000
control mode		closed loop control, smooth switching
test software		Using Windows2000/XP Chinese environment to work and the test process is collected into the computer control.

Maxi. specimen installation space: 3600mm in length, 1500mm in width and 1000mm in height;
The long direction can achieve 100mm migration (under the action of 10 tons of thrust);
The horizontal displacement is 100mm in 0.33hz.

4. 3m3m three-direction and six-degree-of-freedom earthquake simulating shaking table

3m x 3m shaking table made by MTS Corp. is one of the most technically advanced shaking table in South China. The shaking table is used to conduct model or prototype tests of various structures, industrial equipment and other products.

5. Energy dissipation device electro-hydraulic servo loading system

We have upgraded the existing two sets (100 tons and 350 tons) of electro-hydraulic servo loading systems so that the maximum dynamic loading capacity achieves 600 tons with a speed of 1.0m / s. We are equipped with two sets of self-assembly frames and full digital servo control systems. The systems are used to conduct various types of energy dissipation device performance tests for building and bridge engineering and for research.

6. Three-channel coordinating loading system

Controlled by elector-hydraulic servo valves includes a set of servo action apparatus 500kN with travel 200mmtwo sets of 250kN, 250mm. Three sets of coordinate loading are controlled by

a computer, whose working frequency is ranged from 0 to 15 Hz. The system can be smoothly transferred from force control to displacement slide.

The loading system may be used to conduct cyclic loading and pseudo-dynamic tests, input sinusoid waves, triquetrous waves, quadrate waves and earthquake waves. It is suited for the anti-seismic test of large-scale structural model or prototype structural components. This system has been used to test the kinetic characteristic of various size laminated rubber bearings (vertical load acted by jack (10000kN)).

7. Laminated rubber bearing press-shear system

Controlled by electro-hydraulic servo valves. Max. vertical loading is 15000kN (Pmax, v=15000kN). Max. horizontal loading is 2000kN (Pmax, h=2000kN). Press-shear deformation is +500mm.The system is used to study and verify the kinetic characteristics of laminated rubber bearing whose diameter is from 200mm to 1500mm. Laminated rubber bearings with larger diameter (70080090010001100) have been tested on this system for the first time in China. EERTC has tested many laminated rubber bearings for Fujita Corporation of Japan and Shanton Vibro-Tech Industrial and Development Co. Ltd, which have been put into practical isolation engineering in Japan.

8. Vibration test equipment

To carry out more effective in-site monitoring, EERTC has purchased a series of measuring instruments, such as SPIDER dynamic measuring system, which lay a foundation for in-site monitoring, safety assessment and vibration testing of structures.

Social Services

- **Tests**

1. Energy dissipation and seismic isolation of Hongkong-Zhuhai-Macao (HZM) Bridge in China

HZM Bridge is the largest cross-sea bridge in the world. It is approximately 50 kilometers long. It is a major channel connecting Hongkong Special Administrative Region, Zhuhai city of Guangdong province, and Macao Special Administrative Region. It is also an important construction project in the National Highway System Plan. The bridge connects the western highway system of Guangdong Province via Tai-ao high speed highway, forming a rapid and convenient transportation channel between Hong Kong, Macao, and southwest China. This connection is significant because it makes full use of regional advantages, diversification development of large areas and promotes industrial restructuring of Pearl River Delta. The university’s team of earthquake engineering and testing proposed a seismic isolation design for the bridge and adopted 1,500 isolation bearings including the largest high damping rubber bearing in the world.

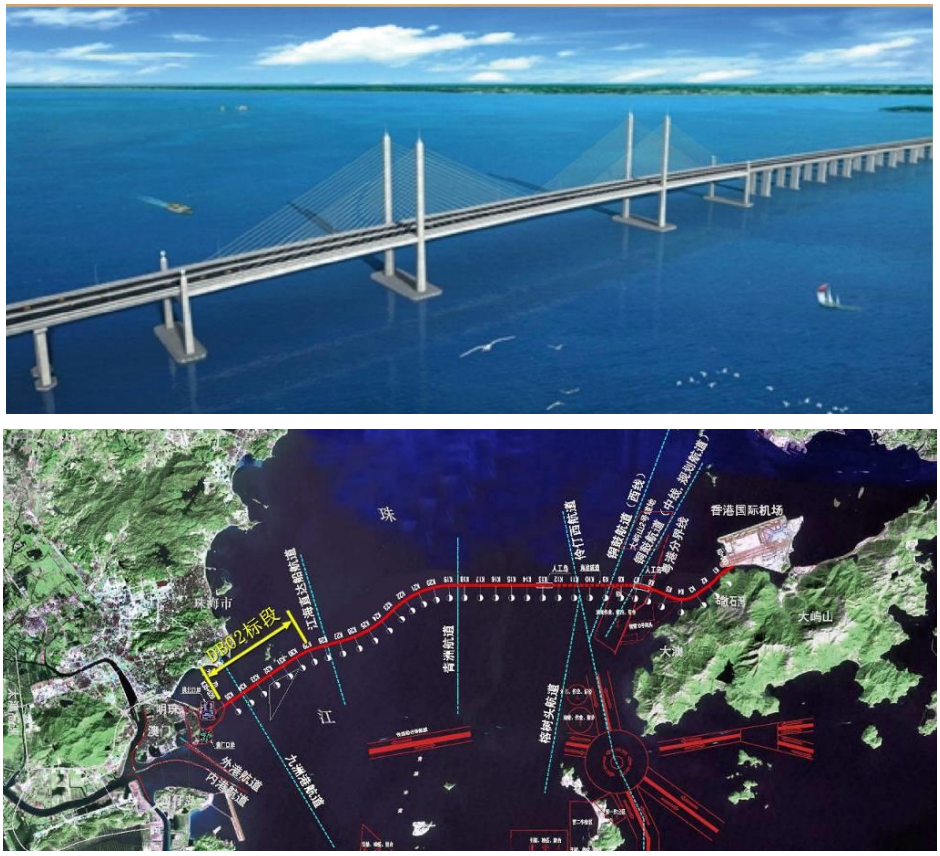


Fig.1 Hong-Zhuhai-Viaduct bridges

2. Seismic isolation research of historical relic in National Palace Museum and Xian Stele Forest Museum

The Center for Earthquake Engineering and Testing (CEET) has conducted a number of fundamental research and engineering application in seismic protection of historical architectures and cultural relics. Recognized by National Administration of Cultural Heritage, the centers seismic isolation techniques have been successfully applied to National Palace Museum and Xian Stele Forest Museum for seismic isolation of cultural relics. The National Palace Museum was constructed within the imperial palace in two consecutive dynasties - the Ming Dynasty (1368-1644) and the Qing Dynasty (1644-1911). It is one of themost famous and prestigious museums in China and around the world. The seismic isolation technology of historical relic in the National Palace Museum was awarded Technical Progress Award for world architectures in 2017.

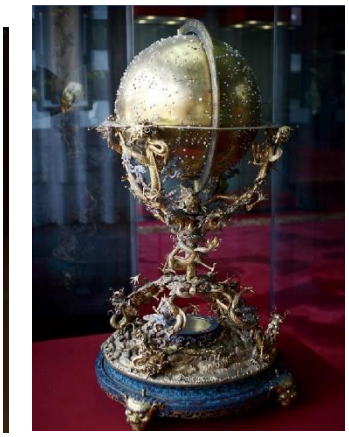


Fig 2. The National Palace Museum **Fig. 3 Xian Stele Forest Museum**

3. Seismic Design and Performance Optimization Research of the Panama Canal 3rd Bridge

The Panama Canal, located in the middle of the Republic of Panama in America, is an important shipping route connecting the Atlantic and the Pacific Oceans. It is 81.3 kilometers long, 150 to 304 meters wide, and 13 to 15 meters deep. Its water level is 26 meters higher than that of the two nearby oceans, and it possesses 6 navigation locks. The project of Panama Canal 3rd Bridge is near Cologne and crosses the Canal. The team carried out the energy dissipation device design and the seismic and damping performance of Panama Canal 3rd Bridge under rare earthquake. This project is the first project in America obtained by international bidding.

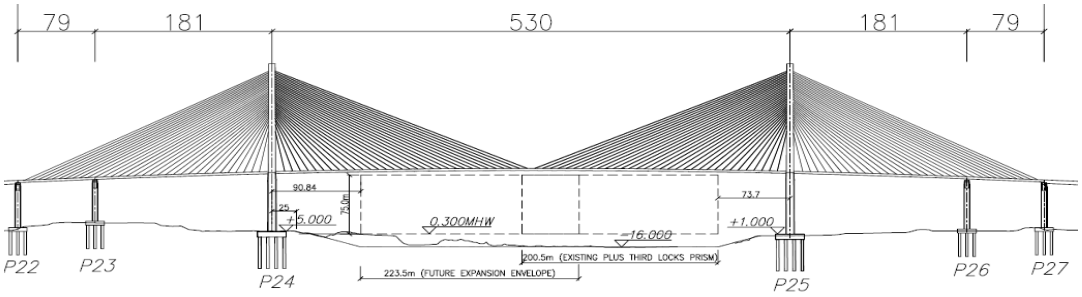


Fig.1 Elevation view of main bridge (m)

4. Vibration Control of Canton Tower

The Canton Tower, located in Guangzhou, China, is a landmark with a total height of 600 meters. The main tower is 454 meters high with a 146-meter Antenna mast . The total weight of Canton Tower is 194,000T. The main structure of the tower consists of a reinforced concrete inner structure with an elliptic cross-section of 14 m by 17 m, and a steel lattice outer structure with its cross-section being a varying oval throughout the height of the tower. The middle of tower is fairly thin compared with the bottom and top, which makes the tower aesthetically attractive. Since the Canton Tower is an ultra-high slender structure with low damping, it is dynamically wind sensitive, which potentially increases acceleration level under strong wind. The persistent

wind-induced vibration can result in not only fatigue damage of the structure, but also discomfort among visitors. Therefore, the research team proposed a novel strategy of hybrid vibration control in which an active-passive Hybrid Mass Dampers (HMD) is applied with the fail-safe function. This strategy is successfully applied to Canton Tower to decrease wind response and improve human comfort in the event of strong typhoons. This project was awarded the first prize of science and technology progress of Guangdong Province in 2014 and the second prize of national scientific and technological progress in 2016.

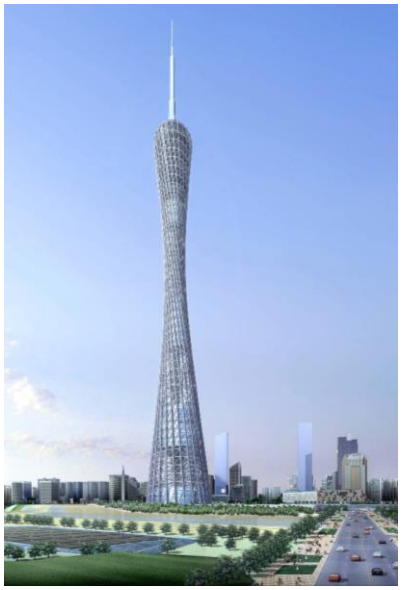


Fig.1 Overall view of Canton Tower

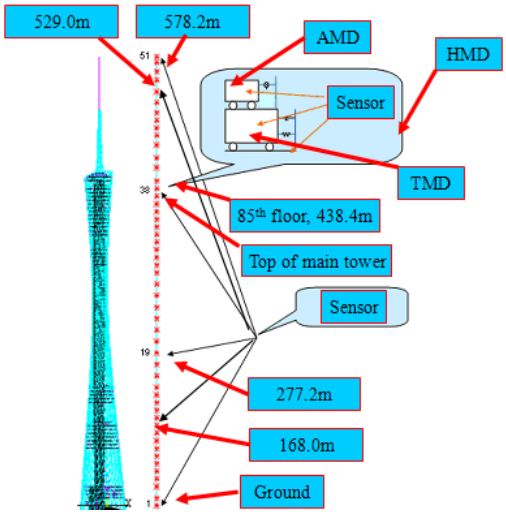


Fig.2 HMD control system

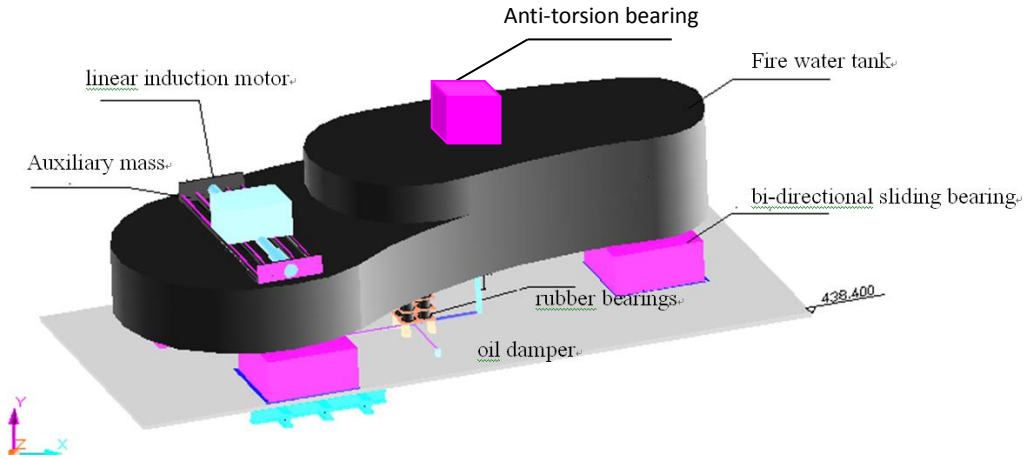


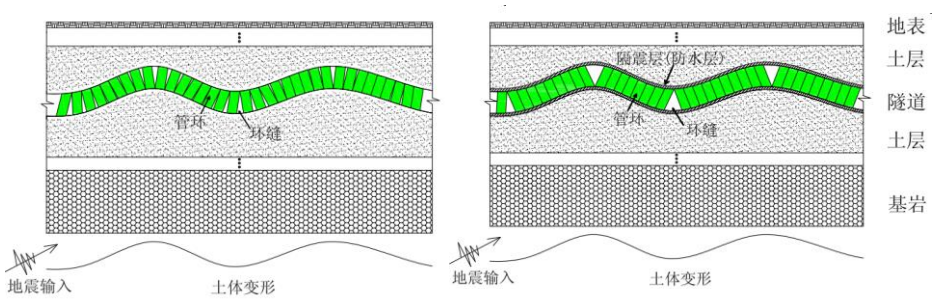
Fig.3 Novel Hybrid Mass Dampers

Fig.4 Bi-directional sliding bearing

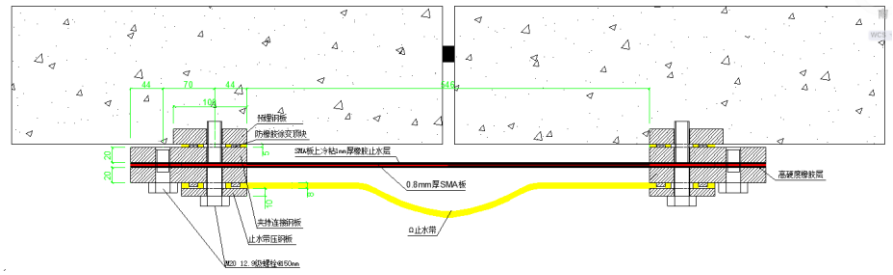
5. Shaking Table Test Research on Seismic Response of Submarine Super Large Diameter Shield Tunnel in High Intensity Seismic Area

The Suai Tunnel in Shantou City is a large-scale cross-sea engineering that spans the inner bay of Shantou covering a length of 3,500 meters under the sea. The tunnel is an ultra-long extra-large-diameter shield subsea tunnel, and the area where the tunnel is located is VIII-degree seismic zone, and it traverses complex formation such as extremely soft soil, sandy soil (liquefiable layer), hard rock, and boulder and different high and low fault soil layers, which is rare not only in China but also in the world. The total length of the route is 6.68 km and the length of the tunnel is 5.35 km. The length of the shield tunnel in the sea is 3.047 km, the outer diameter of the shield tunnel is 14.5 meters and the inner diameter is 13.3 meters. With the Suai Tunnel as its research object, this project studies specifically the dynamic response rules of the super-large diameter shield tunnel in the high-intensity seismic zone and the seismic absorption performance of the tunnel with shape memory alloy energy dissipation joints. With a study of the seismic response laws of the undersea super-large diameter shield tunnel, a new type of self-reset pressure-bearing water-stop earthquake-resistant flexible joint has been developed, and its mechanical performance test has been completed. Wtih a clear mechanism, the flexible joint effectively reduces the tunnel opening during earthquakes, thus greatly improving the seismic safety of the undersea tunnel. It fills a gap in the field, and provides technical support and demonstration for the seismic and waterproof problems of underwater tunnels in high seismic intensity areas in China.

Shaking Table Test of Suai Passage **Su-ai Channel of Shantou**



Mechanism of seismic mitigation and isolation



Self-reset Pressure-bearing Water-stop Earthquake-resistant Flexible Joint

6. Research on New Seismic Mitigation and Control System of Giant Substructure

In the giant substructure, the giant main structure often carries all vertical and horizontal loads, while the substructure only carries the local vertical loads but assumes the main functions of the building. To optimize the design of the giant sub-structure, the safety under strong earthquakes as well as the functional adaptability and accommodation comfort under small or medium earthquakes or wind loads must be taken into account. Our research team systematically studied the seismic mitigation mechanism of the vibration control system of the giant sub-structure in the full frequency domain, and by setting up a new type of intelligent control device between the main and sub-structures in parallel with the original connection device, formed a new intelligent hybrid control system of the giant sub-structure, which meets different performance requirements of the structure system. The seismic vulnerability and dynamic reliability of the new structure system were analyzed, the seismic design method based on the properties of the giant sub-structure was proposed, and the vibration table simulation research was completed.

Vibration Table Test of the Seismic Mitigation and Control of the Giant Substructure

7. Study on Vibration Control of Permanent-magnet Eddy Current Mass Tuned Damper (TMD) for Zhaoqing Landscape Tower

The 168-meter high Zhaoqing Landscape Tower is the landmark of Zhaoqing city. It adopts a tube-in-tube structure type. The diameter of the cylinder is 12.6 m. The sightseeing layer is located on the 28th floor, at the height of 165.2 m and with a diameter of 32.8 m. This tower is a wind-sensitive structure. In order to improve the comfort of the structure, a 258-ton fire water tank is installed at the elevation of 152.1~157.5 m as the mass of the TMD. With this, the two-stage permanent-magnet eddy current mass tuned control system with bidirectional slide support was developed, and related theoretical and experimental studies were carried out.

Zhaoqing Landscape Tower

Shaking table test of Zhaoqing Landscape Tower

- **Technology Service()**

At present, there are thousands of isolated buildings in Guangdong, Yunnan, Shanxi, etc. Provinces , designed and technically guided by EERTC. Most of these buildings have withstood

real earthquakes and demonstrated their outstanding performance in seismic isolation and mitigation. EERTC is making greater contributions to the widespread use of seismic isolation technology at home and abroad.

Our seismic isolation techniques have been used in the following provinces, cities and autonomous regions: Guangdong, Fujian, Shanxi, Shanxi, Yunnan, Sichuan, Ningxia, Neimenggu, Xinjiang, Hebei, Henan, Jiangsu, Taiwan, Beijing, Shanghai, Tianjin, etc. Approximately 10,000 buildings have adopted our techniques.

Year	**Project Name**
2019	Key technology of vibration reduction and isolation of shield tunnel in Suae Tunnel of Shantou City
2019	Shaking table test of seismic performance of semi-rigid immersed tunnel
2018	Research on seismic performance and damping technology of immersed tunnel in Shantou Bay New Channel Project
2018	Study on seismic performance of prefabricated bridge pier structure of railway bridge
2017	Design and test of the damping (earthquake) control system of the wetland landscape tower in Zhaoqing New District of China Railway
2017	Numerical simulation of seismic and shock absorption performance of tunnels and bridges in Dalian bay cross sea traffic engineering
2016	Structural monitoring of block A, China Resources Building, Nanning China Resources Center
2016	Physical simulation test of seismic dynamic response of super large diameter shield tunnel with high intensity