THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

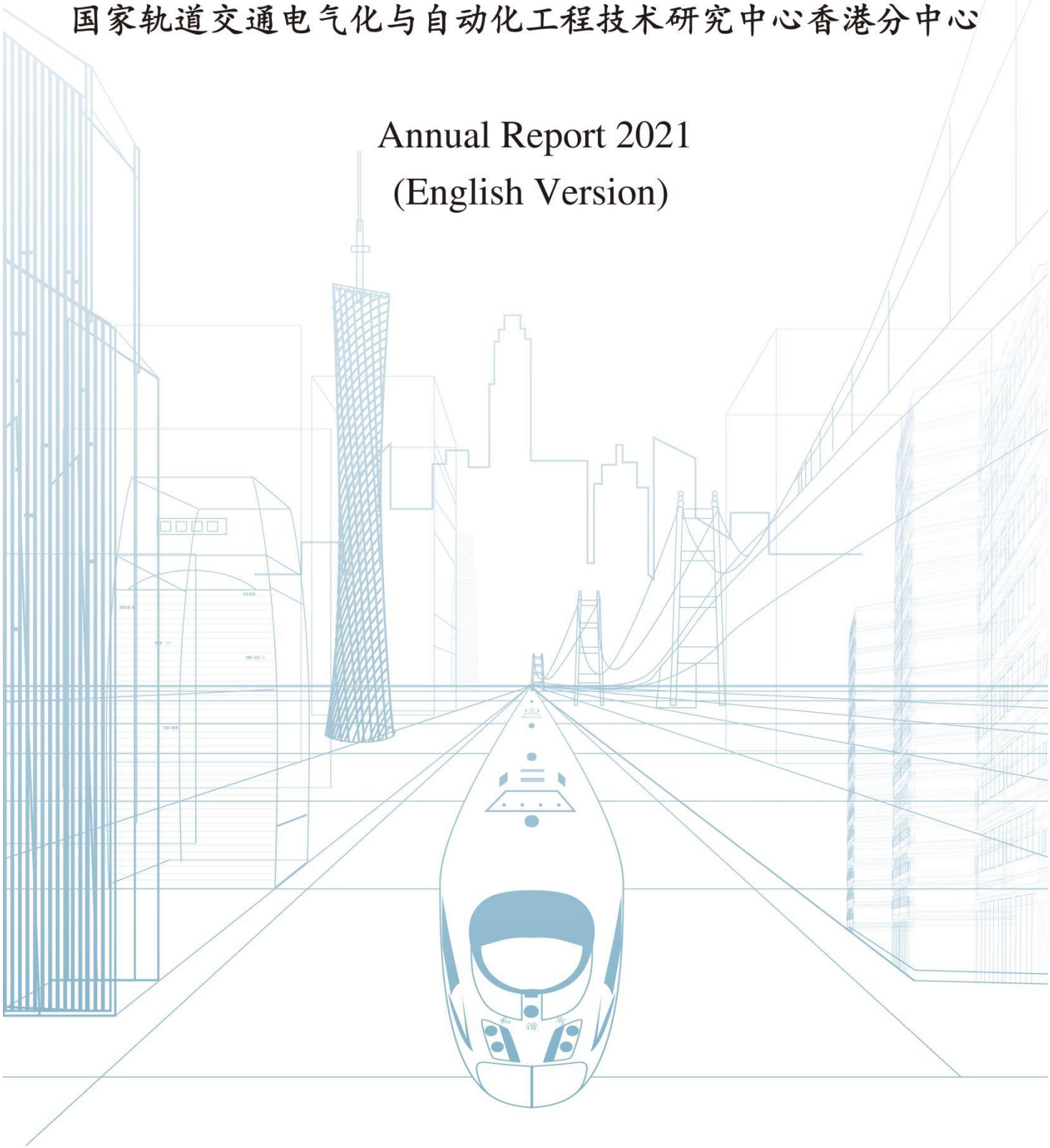
National Rail Transit Electrification and Automation Engineering Technology Research Center (Hong Kong Branch)
國家軌道交通電氣化與自動化工程技術研究中心(香港分中心)

Hong Kong Branch of National Rail Transit Electrification and Automation Engineering Technology Research Center

国家轨道交通电气化与自动化工程技术研究中心香港分中心

Annual Report 2021

(English Version)



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Director's Foreword

2022 has arrived and brought a new start, new opportunities and new challenges. Looking back on the past year, the Hong Kong Branch of the National Rail Transit Electrification and Automation Engineering Technology Research Center (CNERC-Rail) has achieved remarkable achievements with the joint efforts of all its members.

In 2021, the CNERC-Rail continued to closely follow the national strategy to strengthen the country in transportation and the development strategy of creating a "Greater Bay Area on Track", to actively integrate into the rail construction of the country and the Greater Bay Area, and promote the development of smart transportation. In the past year, the CNERC-Rail has signed cooperation agreements with the National Innovation Center of Advanced Rail Transit Equipment (Zhuzhou) CRRC Co., Ltd., Shenzhen Metro Group Co., Ltd., Hunan Maglev Technology Research Center Co., Ltd., MTR Co., Ltd. and other key enterprises in the industry. The CNERC-Rail has conducted in-depth cooperation with these enterprises in health monitoring of maglev, energy harvest technology for self-power, and vibration and noise control. Meanwhile, the CNERC-Rail has cooperated with various universities, research institutions, and enterprises to actively launch R&D projects such as National Key R&D Projects, Hong Kong Research Grants Council Theme-based Research Scheme, and Hunan Science and Technology Innovation Projects.

Over the past year, all members of the CNERC-Rail have overcome various difficulties during the COVID-19 epidemic and carried out a series of fruitful scientific research activities. Remarkable achievements have been made in maglev, metro, and urban railways. The on-board monitoring system and trackside monitoring have been independently developed by the CNERC-Rail to ensure the safe and stable operation of the Fenghuang Maglev, the first "Maglev + Culture + Tourism" special line in the world. In addition, the developed health monitoring system has been applied to the testing and research demonstrations of China's first

long-stator medium-speed maglev train. The developed modular rail particle damper (MRPD) has won the third prize of the "National Innovation Center of High-Speed Train Innovation and Entrepreneurship Competition" hosted by the National Innovation Center of High-Speed Train and Qingdao Rail Transit Industry Demonstration Zone. The developed MRPD has been authorized two Chinese inventions and utility models and installed in the Shenzhen Metro lines. In addition, aiming at the abnormal vibration and noise problems of the curved section in the metro line, the CNERC-Rail has carried out vibration tests and noise assessments in several lines of the Shenzhen Metro, and proposed effective solutions. These research activities conducted by the CNERC-Rail are closely related to the engineering needs of the project, and provide abundant and valuable data for scientific research.

At last, on behalf of all members of the CNERC-Rail, I would like to express my special gratitude to the National Ministry of Science and Technology, the Innovation and Technology Commission of Hong Kong S.A.R. and the Hong Kong Polytechnic University for their support to the CNERC-Rail. The CNERC-Rail has a long way to go, does not choose the place to rest, and will make persistent efforts in 2022 to reach a higher level.

Yi-Qing NI

Chair Professor

Yim, Mak, Kwok & Chung Endowed Professorship in Smart Structures

Director of

National Rail Transit Electrification and Automation Engineering Technology

Research Center (Hong Kong Branch)

Overview of CNERC-Rail in 2021

Introduction

The National Rail Transit Electrification and Automation Engineering Technology Research Center (CNERC-Rail) Hong Kong Branch is established in 2015 approved by the Ministry of Science and Technology of the People's Republic of China, with funding support from the Innovation and Technology Commission (ITC) of the Hong Kong SAR Government and the Hong Kong Polytechnic University for operation and research. Affiliated to the Hong Kong Polytechnic University (PolyU), the CNERC-Rail builds up an interdisciplinary research team taking advantage of advanced sensing, smart materials, and data-driven analysis techniques and incorporating the research resources from the university.

Mission: To develop state-of-the-art monitoring technologies embracing smart materials and advanced big data analysis methods for the rail transit system.

Vision: To accelerate the process of constructing intelligent rail transit including high-speed rail, metro, and maglev systems concerning safety and reliability, promoting innovative monitoring technologies for rail transit from Hong Kong to Asia and worldwide.

The CNERC-Rail has achieved fruitful outcomes in terms of academic, research, and engineering aspects in 2021 through applying key scientific research projects, conducting engineering and consultancy projects, and strengthening partnerships with research institutes and enterprises.

Specific work of the CNERC-Rail in 2021 is presented in detail in the following sections.

Research Team

The CNERC-Rail research team consists of 13 key members (Table 1. 1). To ensure efficient operation and management of the R&D projects, the CNERC-Rail also encourages

and supports collaborative members from different faculties in their participation of R&D projects (Table 1. 2), and actively recruits talents from worldwide (Table 1. 3).

Table 1. 1 Key members of CNERC-Rail

No.	Name and Position	Department	Remark
1	Yi-Qing Ni, Chair Professor	Department of Civil and Environmental Engineering	Director
2	Kang-Kuen Lee, Professor	Department of Electrical Engineering	Deputy Director
3	Siu-Lau Ho, Chair Professor	Department of Electrical Engineering	Project Leader
4	Hwa-Yaw Tam, Chair Professor	Department of Electrical Engineering	Project Leader
5	Li Cheng, Chair Professor	Department of Mechanical Engineering	Project Leader
6	Jian-Nong Cao, Chair Professor	Department of Computing	Project Leader
7	Xiao-Li Ding, Chair Professor	Department of Land Surveying and Geo-informatics	Project Leader
8	Ka-Wai Cheng, Professor	Department of Electrical Engineering	Project Leader
9	Siu-Wing Or, Professor	Department of Electrical Engineering	Project Leader
10	Zhong-Qing Su, Professor	Department of Mechanical Engineering	Project Leader
11	Song-Ye Zhu, Professor	Department of Civil and Environmental Engineering	Secretary
12	Dan Wang, Associate Professor	Department of Computing	Project Leader
13	Xing-Jian Jing, Associate Professor	Department of Mechanical Engineering	Project Leader

Table 1. 2 Collaborative members of CNERC-Rail

No.	Name and Title	Department	Remark
1	Siu-Kai Lai, Associate Professor	Department of Civil and Environmental Engineering	Project Leader
2	Xu-Sheng Yang, Assistant Professor	Department of Industrial and Systems Engineering	Project Leader
3	Fang-Xin Zou, Assistant Professor	Department of Aeronautical and Aviation Engineering	Project Leader

Table 1. 3 Recruited staff of CNERC-Rail 2021

No.	Name and Title	Position	Period of Employment	
1	Lu Zhou	Research Assistant Professor	1 August 2020	28 February 2022
2	You-Wu Wang	Research Assistant Professor	4 January 2021	30 June 2024

3	Su-Mei Wang	Postdoctoral Fellow, Research Assistant Professor	1 April 2021	30 June 2024
4	Chuan-Rui Guo	Postdoctoral Fellow, Research Assistant Professor	28 August 2020	2 August 2021
5	Seyed Masoud Sajjadi Alehashem	Research Fellow	2 September 2020	9 September 2022
6	Chih-Shiuan Lin	Postdoctoral Fellow	29 February 2020	31 May 2022
7	Qiu-Hu Zhang	Postdoctoral Fellow	5 January 2021	4 October 2022
8	Zheng-Wei Chen	Postdoctoral Fellow	13 July 2021	12 July 2023
9	Wen-Qiang Liu	Research Associate, Postdoctoral Fellow	31 March 2021	5 October 2023
10	Chao Zhang	Research Assistant, Research Associate	17 December 2015	16 February 2023
11	Ghazaleh Soltanieh	Research Associate	23 August 2021	21 August 2022
12	Si-Xin Chen	Research Assistant, Research Associate	18 January 2021	17 July 2022
13	Tai-Tung Wai	Research Technical Assistant	23 January 2017	22 April 2024
14	Wing-Hong Kwan	Research Technical Assistant	4 October 2017	31 March 2024
15	Yuk Yee Chow	Research Administrative Assistant	3 June 2020	2 June 2022
16	Yang Lu	Research Assistant	1 April 2021	31 March 2022
17	Gao-Feng Jiang	Research Assistant	22 October 2020	21 October 2021
18	En-Ze Rui	Research Assistant	5 October 2020	23 August 2021
19	Yu-Ling Wang	Research Assistant	14 April 2021	13 April 2022
20	Qi-Fan Zhou	Research Assistant	8 March 2021	20 August 2022
21	Bei-Yang Zhang	Research Assistant	1 September 2021	28 February 2022
22	Ka-Kiu Ip	Research Assistant	2 August 2021	31 July 2022
23	Qi Zhu	Research Assistant	23 August 2021	21 February 2022
24	Chik-Wai-Jerry Yu	Research Fellow	1 January 2021	30 June 2021
25	Ho-Fai Ho	Research Fellow	20 December 2020	30 October 2021
26	Jie Mei	Research Assistant	1 March 2021	31 May 2021

27	Xin Yang	Research Associate	26 May 2021	31 October 2021
28	Xin Cheng	Postdoctoral Fellow	12 April 2021	31 March 2022
29	Hao-Ran Zuo	Postdoctoral Fellow	11 July 2021	28 February 2022
30	Ying-Pin Cao	Research Assistant	1 July 2021	16 October 2021
31	Zi-Qing Zhu	Research Assistant	1 July 2021	31 August 2021
32	Zi-Lin Li	Research Assistant	1 July 2021	28 February 2022
33	Si-Yuan Guo	Research Assistant	22 July 2021	21 January 2022
34	Jia-Heng Wang	Research Associate	2 August 2021	31 January 2022
35	Long-Hin Man	Research Assistant	15 July 2021	30 April 2022
36	Farhan Khalid	Research Assistant	25 July 2021	9 September 2021
37	Jun-Shu Zhou	Research Assistant	15 September 2021	31 March 2022
38	Qiu-Han Meng	Research Assistant	1 September 2021	31 March 2022
39	Yuan-Man Zhang	Research Assistant	1 October 2021	30 April 2022
40	Yang Song	Research Assistant	16 September 2021	30 April 2022
41	Xiang-Tao Sun	Research Assistant	25 September 2020	31 July 2021
42	Si-Qi Ding	Research Associate, Postdoctoral Fellow	6 September 2020	5 March 2021
43	Xiang-Yun Deng	Postdoctoral Fellow	1 March 2020	11 November 2021
44	Chen-Xing Zhang	Research Associate	17 February 2021	31 December 2021

Financial Report

In 2021, the financial breakdown is displayed as follows:

1. Income: 15,000,000 HK Dollars

ITC Funding	$10,000,000
PolyU Funding	$5,000,000

2. Expenditure: 15,000,000 HK Dollars

Research Projects	$3,220,000
Human Resource	$4,380,000
Equipment Purchase	$6,550,000
General Expenses	$850,000

R&D Activities of CNERC-Rail 2021

Research Projects

Applied Research Grants

In 2021, the CNERC-Rail has applied/jointly applied 11 research grants, among which 6 projects have successfully been approved for funding with a total funding amount of more than 6 million RMB, and the rest 5 projects are pending approval or waiting for oral defense. The funding schemes include a theme-based research scheme from the Research Grants Council (RGC) of the Hong Kong SAR Government, various international/Hong Kong-Macau-Taiwan collaborative projects in different levels of government, and the Large Equipment Fund of the Hong Kong Polytechnic University. Detailed project information is shown in Table 2. 1.

Table 2. 1 Applied research grants in 2021

No.	Title	Funding Source	Amount	Status
1	Research on Composite Energy Acquisition Technology for Self-Powered Online Health Monitoring in Rail Transit	Hunan Science and Technology Innovation Plan (2021)	RMB 500,000	Approved
2	Research on Sensing Mechanism of Two-Dimensional Flexible Materials under Multiple Field Coupling	Special Fund for Basic Research Project of Free Exploration in Shenzhen Virtual University Park	RMB 174,000	Approved
3	Nondestructive Detection and Intelligent Identification Method for Concealed Defects of Tunnel Structure based on Ground Penetrating Radar	Regional Joint Fund for Guangdong-Hong Kong-Macao Research Team Project	RMB 2,000,000	Approved
4	Research on Electromagnet-Rail Coupling Vibration Mechanism and Vibration Control of Maglev System based on Digital Twin	Research Start-up Fund for Research Assistant Professor of the Hong Kong Polytechnic University	HKD 250,000	Approved
5	Integrated Wireless Sensing Systems Designed for High-Speed Trains: System	Strategic Importance Program of the Hong	HKD 1,900,000	Approved

	Design and Field Testing	Kong Polytechnic University		
6	A Test Platform for Electromagnet-Rail Coupling Vibration of Medium-Speed Maglev	Large Equipment Fund of the Hong Kong Polytechnic University	HKD 2,430,000	Approved
7	INTACT: Intelligent Tropical Storm Mitigation System for Coastal Cities	Hong Kong Research Grants Council Theme-based Research Scheme 2022/23 (Twelfth Round)	HKD 50,100,000	Pending (Passed the first round)
8	Optical Fiber Shape Sensing System for Railway Condition Monitoring	Large Equipment Fund of the Hong Kong Polytechnic University	HKD 3,990,000	Pending
9	Multi-performance Test Platform of Railway Track Fatigue Crack Sensor based on Nanometer Materials under Service Conditions	Large Equipment Fund of the Hong Kong Polytechnic University	HKD 1,300,000	Pending
10	Defect Detection System of Rail Surface based on Machine Vision	Hong Kong-Macau Collaborative Research Fund, Wuyi University	RMB 500,000	Pending
11	Study on Dynamic Characteristics of Fluid-structure Interaction and Active and Passive Cooperative Control of Maglev Train under Unsteady Aerodynamic Loads	Hong Kong-Macau Collaborative Research Fund, Wuyi University	RMB 500,000	Pending

Established Research Projects

The CNERC-Rail has established 5 research projects in 2021 with project information listed in Table 2. 2.

Table 2. 2 CNERC-Rail established research projects in 2021

No.	Title	Principal Investigator	Department	Start-End Date
1	Digital-Twin-Enabled Artificial Intelligent Damage Detection and Localization for Train Axle Structures based on Quasi-Surface Waves	Prof. Li Cheng	Department of Mechanical Engineering	1 July 2021-30 April 2022
2	Smart Materials, Devices, and Control Technologies for Emerging Sensing,	Prof. Siu-Wing Or	Department of	

	Absorption, Conversion, and Storing of Energies in Railway Electrification Systems		Electrical Engineering	1 May 2021-30 April 2022
3	Development of Miniature High Magnetic-Field Optical Fibre Sensor	Prof. Hwa-Yaw Tam and Prof. Kang-Kuen Lee	Department of Electrical Engineering	1 May 2021-30 April 2022
4	Actively Controlled Secondary Suspension of High-Speed Train with Energy Harvesting Function	Prof. Song-Ye Zhu	Department of Civil and Environmental Engineering	1 March 2021 - 31 March 2022
5	A Highly Sensitive Nanocomposite Ultrasonic Sensor Fabricated from Polydopamine-Coated Carbon Nanotubes and Graphene	Dr. Fang-Xin Zou (Assistant Professor)	Department of Aeronautical and Aviation Engineering	1 September 2021 - 31 August 2022

Research Progress

Research Impact Fund (RIF) Project from the Research Grants Council

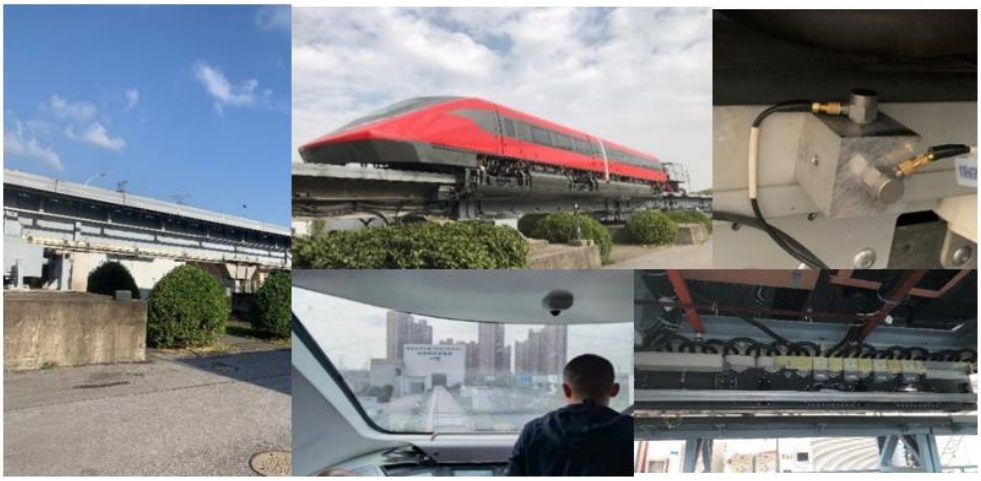
Under the Research Grants Council's Research Impact Fund (RIF) Research Scheme, the CNERC-Rail is leading a Research Impact Fund project entitled "Enhancing Safety, Punctuality and Ride Comfort of Railway Transportation: From Local Metro to Global High-speed Rail Network". This project lasts 48 months, from 1 June 2019 to 31 May 2023. In total, a budget of HKD 8,437,600 was approved for this project. The fund came from four different sources. Research Grants Council provided HKD 5,892,320, PolyU provided a matching fund of HKD 1,445,280, CityU Provided HKD 600,000, and China SWJTU Railway Development Co., Ltd., provided a matching fund of HKD 500,000.

This project aims to use new technologies including advanced sensing techniques, big data analysis, and artificial intelligence methods to enhance railway safety, punctuality, and ride comfort. It consists of six main tasks, including wheel/rail wear prediction, advanced train suspension system development, smart sensing, wheel damage monitoring, rail short-pitch corrugation identification, and development of a hybrid long-range monitoring system for rail crack detection. The developed new technologies will be applied to different railway systems and networks to develop smart railway systems.

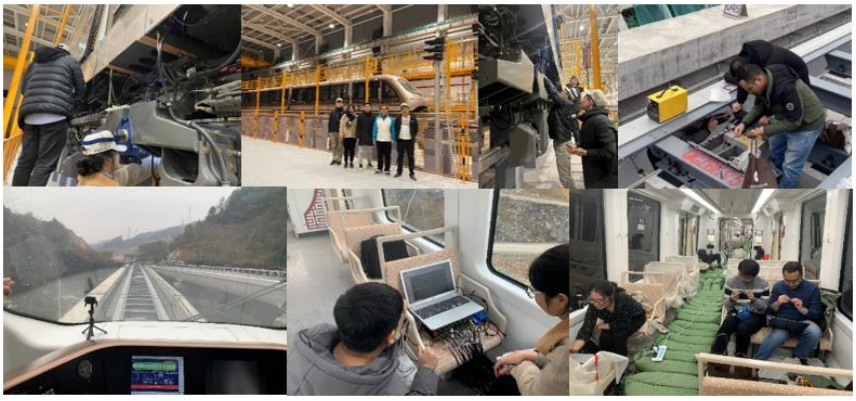
In the second year (from 1 July 2020 to 30 June 2021), the research team has conducted extensive theoretical and experimental research and achieved fruitful outcomes on wheel-rail contact, machine learning algorithms for health monitoring of railway systems, energy collecting devices, train suspension system, new technologies for railway electrification systems, vibration and noise control technologies in rail transit systems and fiber Bragg grating accelerometer-based rail crack detection. To connect the research output with practice, the project team has established collaborations with different railway industries and universities all over China. These activities made a big step forward in the potential commercialization of technology in the railway industry, as well as helping to improve the safety, punctuality, and riding comfort of the railway. Several in-situ tests and investigations were conducted in the second year, including health monitoring of maglev systems in Shanghai Jiading high-speed

maglev test line and Hunan Fenghuang maglev line, a survey on rail wave grinding of Zhengtai High-Speed Railway, track detection and vibration and noise control of Shenzhen and Hangzhou Metros, and rail status inspection of the MTR of Hong Kong (Figure 2. 1). As for research output, the research team has submitted 26 research papers that directly arose from this project in the second year, among which 17 papers have been accepted for publication. Furthermore, 4 patent applications have been approved.

On 25 June 2021, the project team held the second annual progress meeting (Figure 2. 2). All project team members from the Hong Kong Polytechnic University and City University of Hong Kong including the PC, Prof. Yi-Qing Ni, and all Co-PIs, Prof. Song-Ye Zhu, Prof. Siu-Wing Or, Prof. Kwok-Leung Tsui, Prof. Siu-Ming Lo, Dr. Siu-Kai Lai, and Dr. Heung-Fai Lam attended the meeting and reported the research progress on the project. Ten other researchers and students, Dr. Lu Zhou, Dr. Xiang-Yun Deng, Dr. Su-Mei Wang, Dr. Masoud Sajjadi, Dr. You-Wu Wang, Dr. Chih-Shiuan Lin, Dr. Wen-Qiang Liu, Dr. Ying-Yu Hua, as well as Mr. Lei Yuan and Mr. Enze Rui from PolyU, attended the meeting. After the meeting, the second annual progress report was submitted to the Research Grants Council on 31 August 2021.



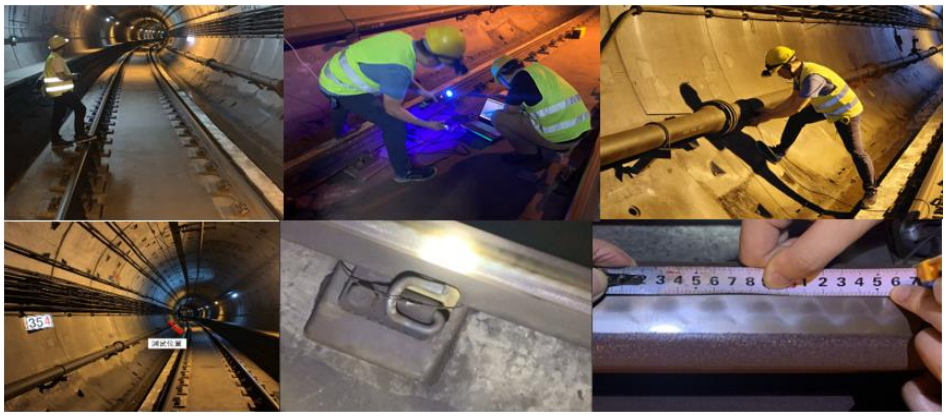
Monitoring test, Jiading maglev test line, Shanghai



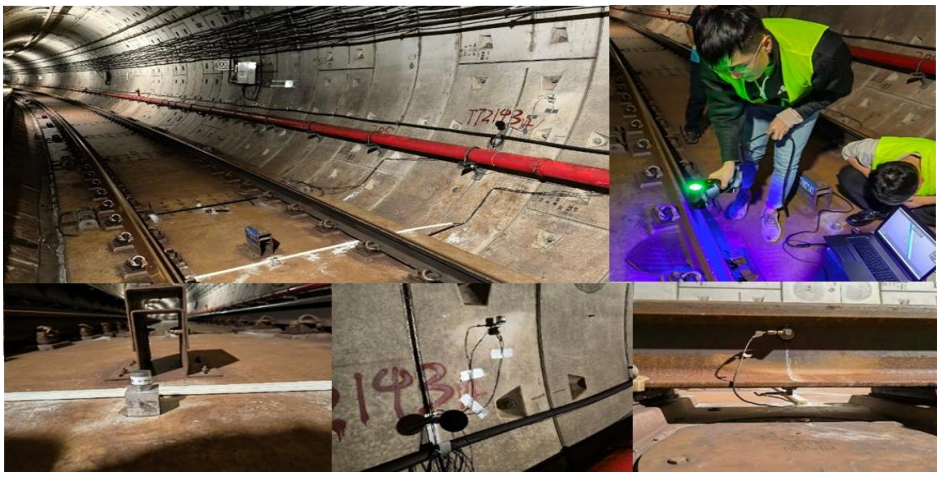
In-situ test, Fenghuang maglev, Hunan

Vibration control of rail system, Hangzhou Metro Line 3

Survey of rail wave grinding, Zhengtai High-Speed Railway

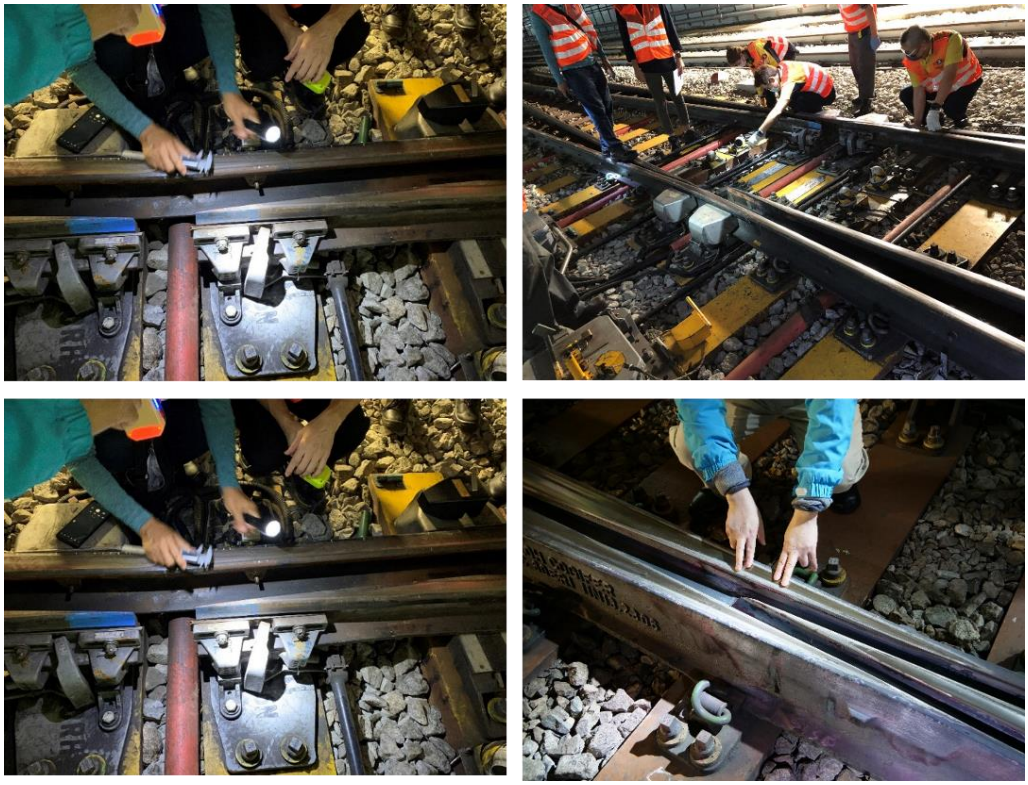


Inspection of rail defection, Shenzhen Metro Line 11



Inspection of steel rail, Shenzhen Metro Line 9

Inspection of vibration and noise control for the rail system, Shenzhen Metro Line 5



Rail status inspection of the MTR of Hong Kong

Figure 2. 1 In-situ tests of the RIF project in 2021

Figure 2. 2 Second RIF progress meeting in PolyU (25 June 2021)

Research on Smart Health Monitoring of Maglev Train Suspension System

(1) Monitoring test of the Fenghuang magelv system

Fenghuang maglev is the first “maglev + culture + tourism” project in the world. Fenghuang maglev project seamlessly connects Zhangjihuai high-speed rail and in a total length of 9.121 km. It starts from Fenghuanggucheng Station of Zhangjihuai high-speed railway, passes through the Tourist Service Center in the North of the City, and finally reaches the tunnel entrance of Folklore Park in the direction of 209 Around City Line. Four stations namely Maglev high-speed railway station, North city tourist center station, Guchenglansheng station, Folklore park station are set at present, with a depot setting near the high-speed railway station.

To ensure the safe and stable operation of the Fenghuang maglev line, team members of the CNERC-Rail have carried out a series of research related to vehicle-rail-bridge coupling vibration and deformation in the line since December 2021 by using an independently developed health monitoring system. The main purpose is to analyze the vehicle-rail-bridge dynamic relationship of the maglev train under different operation conditions, evaluate the ride comfort of the vehicle, and assess the structural performance of each section of the line (including viaduct section, tunnel section, turnout section, and station section). The dynamic feature of the vehicle when passing through different sections of straight and curved lines at different speeds is systematically analyzed and evaluated. The recorded data for analysis is from online monitoring systems installed on moving vehicles, tracks, and bridges. The following specific studies are carried out:

1) In-situ survey on 15 November 2021 (Figure 2. 3)

Main tasks: Inspect in-situ route construction and design rail monitoring scheme; Monitor vehicle structure and design vehicle monitoring plan; Ride on the maglev train, and be familiar with the operation status of the maglev vehicle and stations of the line.

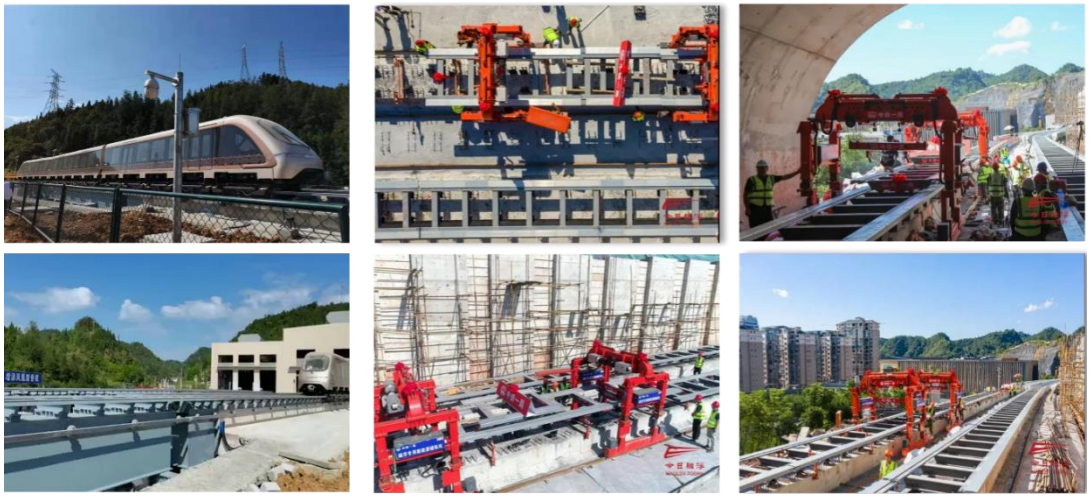


Figure 2. 3 In-situ survey of the Fenghuang Maglev system

2) Install maglev train sensor system from 17 December to 21 December 2021 (Figure 2. 4)

Main tasks: Install sensors in the carriage and on the suspension bogie to acquire relevant data for monitoring vibration of carriages, suspension bogies, and suspension airgap change during train in operation.

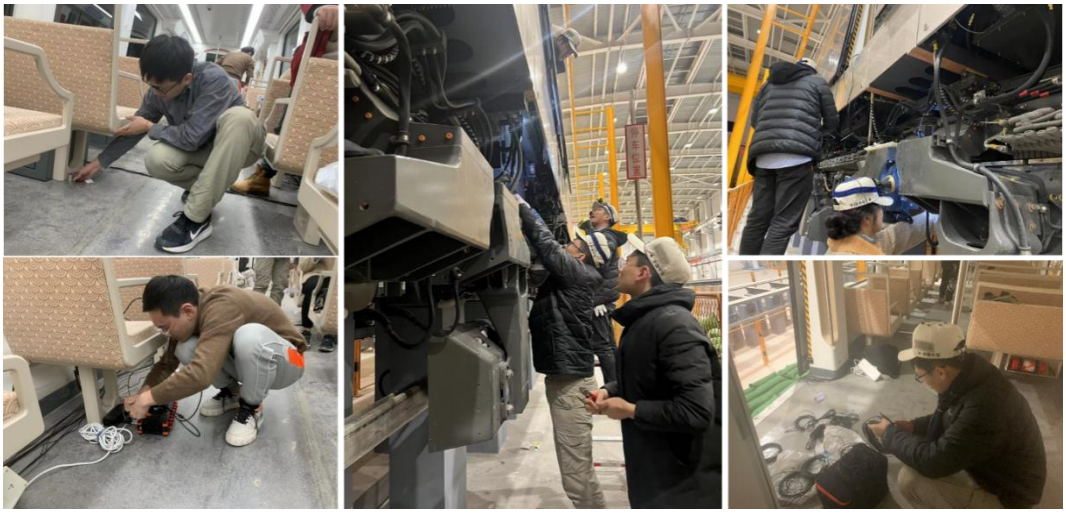


Figure 2. 4 Installation of sensor system on the maglev vehicle

3) Install sensors on the guideway from 22 December to 23 December 2021 (Figure 2. 5)

Main tasks: Install sensors on the track and bridge in several special sections of the railway line such as tunnel section, straight section, and curved section to acquire relevant data for monitoring the guideway vibration condition when the maglev vehicle passes through those

sections.

Figure 2. 5 Installation of the railway sensor system

4) Online monitoring of maglev train and guideway from 24 December to 31 December 2021 (Figure 2. 6)

Main tasks: Monitor ride comfort of the maglev vehicle, vibration of the suspension bogie, malfunction of the suspension controller, and vibration and deformation of the track under different operation conditions. Collect the vibration and deformation data when the maglev train travels from a high-speed railway station to the north station with the train speed as 20 km/h, 30 km/h, 40 km/h, 50 km/h, and 60 km/h.

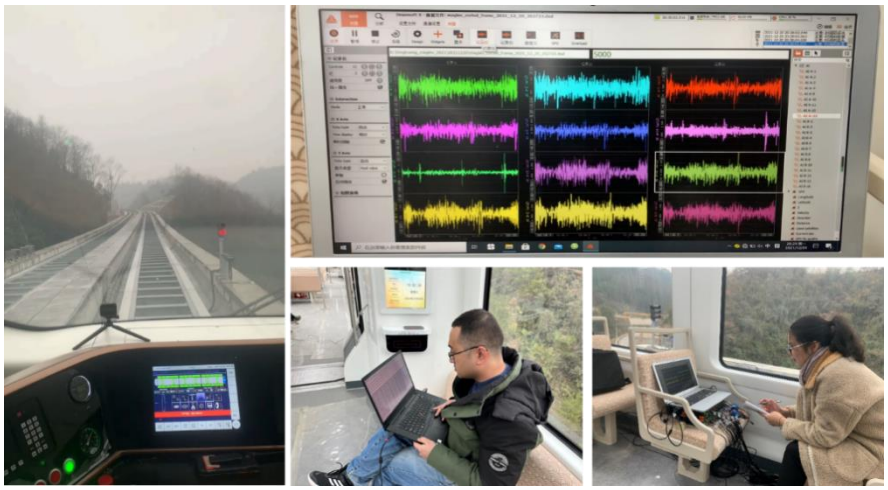


Figure 2. 6 On-line monitoring of the maglev train and guideway

(2) Dynamic performance test of Maglev system in the Jiading high-speed maglev test line (Shanghai)

The total length of the high-speed maglev test line in the Jiading Campus of Tongji University is about 1.5 km, including a steel beam turnout, a straight-line section (concrete beam), a small radius curve (concrete beam), and a ramp section (concrete beam). In 2021, team members of the CNERC-Rail participated in the relevant dynamic test and research demonstration of China's first long-stator medium-speed maglev train in the Jiading high-speed maglev test line. Through the online monitoring system designed by the CNERC-Rail and installed on the medium-speed maglev train, dynamic data of the vehicle and track under different operating conditions is collected to evaluate the performance of the maglev vehicle and suggestions are proposed for improvement of monitored maglev vehicle design.

From September to November in 2021, team members of the CNERC-Rail conducted a maglev vehicle vibration test to obtain data for dynamic performance assessment of the long stator medium-speed maglev vehicle under different operating conditions. The data includes maglev vehicle body vibration (longitudinally, laterally, and vertically), suspension electromagnet vibration (laterally and vertically), and suspension and guidance gap of suspension bogie under different running speeds. The data will be used for the analysis of the ride comfort of the maglev vehicle and the dynamic performance of the suspension bogie. The following specific studies are carried out:

1) Install maglev train sensor system from 11 September to 17 September 2021 (Figure 2. 7)

Main tasks: Install sensors in carriages and on suspension bogies to monitor vibration states of carriages and suspension bogies and suspension gap change during vehicle operation.

Figure 2. 7 Installation of the maglev train sensor system

2) In-situ test of the maglev train from 18 September to 25 October 2021 (Figure 2. 8)

Main tasks: Test the suspension performance of the maglev train moving on the different sections along the track at different speeds (40 km/h, 55 km/h, and 85 km/h), as well as the vibration state of the train and track.

Figure 2. 8 In-situ test of the maglev train

Research and Development of a Modular Rail Particle Damper

The research members of the CNERC-Rail, Prof. Yi-Qing Ni, Dr. Masoud Sajjadi, Dr. Chih-Shiuan Lin, Mr. Chao Zhang, Mr. Xin Ye, Mr. Yu-Ling Wang, developed a modular rail particle damper (MRPD) (Chinese patent: ZL 2021 1 0466428.5, Chinese Utility Model: ZL 2021 2 0908352.2）for rail corrugation control and broadband vibration and noise mitigation in railways. The research progress of this year is as follows.

1) MRPD performance test in the Hangzhou Metro Line 3

On 17 August 2021, team members of the CNERC-Rail, Mr. Chao Zhang, and Mr. Guang Zhou installed modular rail particle dampers (MRPD) in the Hangzhou Metro Line 3 to investigate the performance of the MRPD (Figure 2. 9). The test results indicated that the MRPD can suppress broadband noise and vibration when trains pass by.

Figure 2. 9 In-situ test of MRPD in the Hangzhou Metro Line 3

2) Awarded in innovation and entrepreneurship competition of national innovation center of high-speed train

The CNERC-Rail team won the 3rd prize in the national innovation center of high-speed train innovation and entrepreneurship competition, co-hosted by the National Innovation Center of High-Speed Train and Qingdao Rail Transit Industry Demonstration Zone. Team members of the CNERC-Rail, Dr. Masoud Sajjadi, Mr. Chao Zhang, Dr. Chih-Shiuan Lin, Mr. Xin Ye, and Mr. Yu-Ling Wang participated in the innovation group (Title: Development of a Modular Rail Particle Damper to Control the Corrugation and Mitigate Broadband Noise and Vibration in Railways).

Figure 2. 10 National innovation center of high-speed train innovation and entrepreneurship competition

This competition aims to solicit high-tech, high-innovation, high-potential projects in the field of rail transit from around the world. It was divided into innovation and entrepreneurship groups and attracted a total of 377 teams worldwide ranging from social research institutes, universities, enterprises and institutions, and scientific and technological innovation centers.

Figure 2. 11 The CNERC-Rail team participated in the online roadshow and Q&A

In October 2021, 78 teams competed in the semi-finals and 20 teams advanced to the finals, including the CNERC-Rail team. The top 20 finalists attended an online roadshow on 17 December 2021, during which our team impressed the judges with an outstanding response during a Q&A session. Finally, after three rounds of fierce competition, the CNERC-Rail team

was awarded the 3rd prize in the innovation group (Figure 2. 12).

Figure 2. 12 The CNERC-Rail team won the third prize in the innovation group

3) Installation of MRPD in the Shenzhen Metro Line

Since September 2021, team members of the CNERC-Rail and Mr. Bo Sun, Deputy Chief Engineer of the Shenzhen Metro Group Co., Ltd. together with his colleagues have conducted technology exchanges on vibration mitigation and noise reduction of railways. Mr. Bo Sun also led a delegation team to visit the CNERC-Rail and the research facilities of Shenzhen Research Institute of PolyU to discuss the feasibility and key technical challenges of MPRD implementation in the Shenzhen Metro operating lines. Both parties agreed to apply MPRD technology on a viaduct of one of the Shenzhen Metro operating lines. In December 2021, team members of the CNERC-Rail completed in-situ vibration and noise measurements and monitoring of the proposed viaduct for a feasibility assessment of MRPD implementation. In early January 2022, MRPD was installed in the Shenzhen Metro Line. The installation of the MRPD in the Shenzhen Metro Line has started since the end of December (Figure 2. 13).

Figure 2. 13 Installation of MRPD in the Shenzhen Metro Line

Comprehensive Research on Vibration and Noise Reduction of the Shenzhen Metro Line

With the rapid development of urban rail transit, the life of urban residents has become convenient and efficient, and the living standard has significantly improved. However, the vibration and noise problems caused by train operation are attracting more and more attention. Abnormal vibration and noise during train operation will not only cause damage to the track structure and key components of vehicles, resulting in operational safety problems, but also seriously affect passenger comfort and the life quality of residents along the railway line. Research on vibration and noise reduction of urban rail transit has become an essential topic in urban rail transit development planning.

To improve the quality of Shenzhen metro operation, the Shenzhen Metro Group Co., Ltd. and the vibration noise reduction research team of the CNERC-Rail have carried out a series of investigations on abnormal vibration noise and test research in several Shenzhen metro lines since September 2021, hoping to provide solutions for vibration and noise control of the existing line and technical support for future line construction planning. By now, the CNERC-Rail has completed in-situ tests in the Shenzhen Metro Line 5, Line 9, and Line 11, and will carry out relevant work in the Shenzhen Metro Line 6 and other lines. The work carried out is as follows:

1) Analysis of the vibration and noise characteristic of the curve section in the Shenzhen Metro Line 11

In November 2021, Mr. Chao Zhang, Mr. Yu-Ling Wang, Mr. Xiang-Xiong Li, and Mr. Guang Zhou carried out in-situ tests on corrugation and elastic fatigue problems of the “North Airport - Fuyong Section” of the Shenzhen Metro Line 11 (downline) (Figure 2. 14).

The test contents include 3D laser corrugation scanning, fastener spring modal test, and passing vibration acceleration and noise test. The purpose of the test is to evaluate and analyze the noise and vibration of the “North Airport–Fuyong Section” curve section of the Shenzhen Metro Line 11 during operation, the level of environmental noise and vibration, explore the development law of wave mill and put forward the corresponding regulation scheme, and

analyze the reason of fastener spring fatigue.

2) Effect analysis of noise characteristic and vibration and noise control for small curve radius section of the Shenzhen Metro Line 9

In November 2021, Mr. Chao Zhang, Mr. Yu-Ling Wang, Mr. Xiang-Xiong Li, and Mr. Guang Zhou carried out in-situ monitoring on the noise phenomenon of the curve section from "Gao Xin South to Mangrove Bay South" (downline) of the Shenzhen Metro Line 9 (Figure 2. 15).

The test contents include 3D laser wave grinding scanning, hammer test for rail decay rate and vibration acceleration, and noise test of the passing-by train. The purpose of the test is to obtain 3D spatial wave grinding data of rail for theoretical analysis of rail damage, quantify the attenuation ability of rail to vibration propagation and master the noise level of rail side when the train passes, and analyze the rail vibration and secondary vibration characteristics of surrounding structures.

Figure 2. 14 In-situ test of the Shenzhen Metro Line 11

Figure 2. 15 In-situ test of the Shenzhen Metro Line 9

3) Analysis of vibration and noise characteristics for viaduct line of the Shenzhen Metro Line 5

In December 2021, Dr. Masoud Sajjadi, Mr. Chao Zhang, Mr. Yu-Ling Wang, Mr. Xin Ye, Mr. Xiang-Xiong Li, and Mr. Guang Zhou carried out in-situ monitoring of vibration and noise problem of the viaduct line near Tanglang City East and Baoneng City West of the Shenzhen Metro Line 5 (Figure 2. 16).

The test contents include hammer test for rail decay rate, structure secondary vibration test, and environmental noise test. It aims to evaluate the source of vehicle noise and its influence on the comfort of surrounding residents and propose the corresponding control measures.

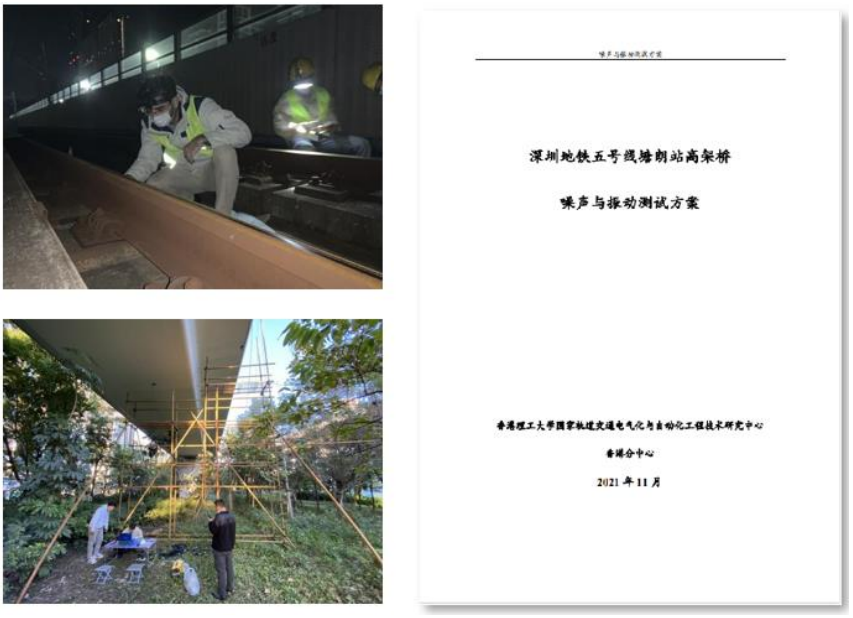


Figure 2. 16 In-situ test of the Shenzhen Metro Line 5

4) Dynamic monitoring and testing of track irregularity based on vehicle-mounted monitoring system in the Shenzhen Metro Line 9

In December 2021, Dr. Masoud Sajjadi, Dr. Xiang-Yun Deng, and Mr. Chao Zhang visited the Zhuzilin depot of the Zhenshen metro and carried out an in-situ survey for the operation vehicle of line 9 (Figure 2. 17).

Figure 2. 17 In-situ inspection of the Zhuzilin depot of the Shenzhen Metro

According to the demand of the Shenzhen Metro Vehicle Center, the CNERC-Rail plans to develop a dynamic monitoring system of track irregularity based on vehicle-mounted monitoring equipment according to the condition of the Shenzhen metro line. The purpose of this in-situ survey is to determine the in-situ installation condition of the vehicle-mounted monitoring system. In the future, the CNERC-Rail plans to conduct performance tests of the system in the Shenzhen Metro Line 9 in February 2022.

Construction Monitoring of Zengjiang Bridge of the Guangzhou-Shantou High-Speed Railway

Guangzhou-shantou high-speed railway (from Guangzhou to Shanwei) is in a total length of 206.2 km with 7 new stations, and the designed railway speed is 350 km/h. Zengjiang Bridge is a key project of the Guangzhou-Shantou high-speed railway line. It is a concrete cable-stayed bridge with two towers and two cable planes, with a total length of 526 m and a main span of 260 m. The CNERC-Rail is in charge of “Key technology research on long-span segment of precast concrete cable stayed bridge in Guangshan high-speed railway”. Full-station laser scanning technology is used for feature scan of the segment of precast concrete main beam of Zengjiang Bridge, and monitoring the line of main beam and tower in construction. The results are compared with the monitoring results of the traditional total station and the efficient monitoring technologies are investigated (Figures 2. 18 and 2. 19). In addition, the whole construction site is scanned by an unmanned aerial vehicle (UAV) to explore the technical problems like measuring accuracy, measuring stability and the UAV endurance method.

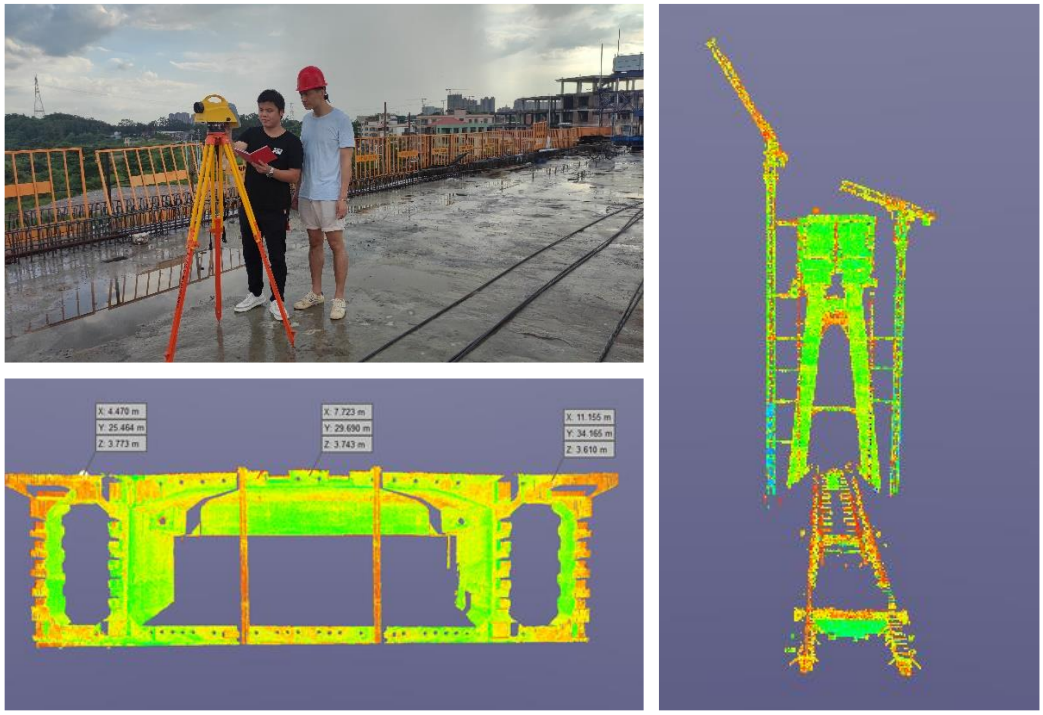


Figure 2. 18 Laser scanning result of bridge deck and tower

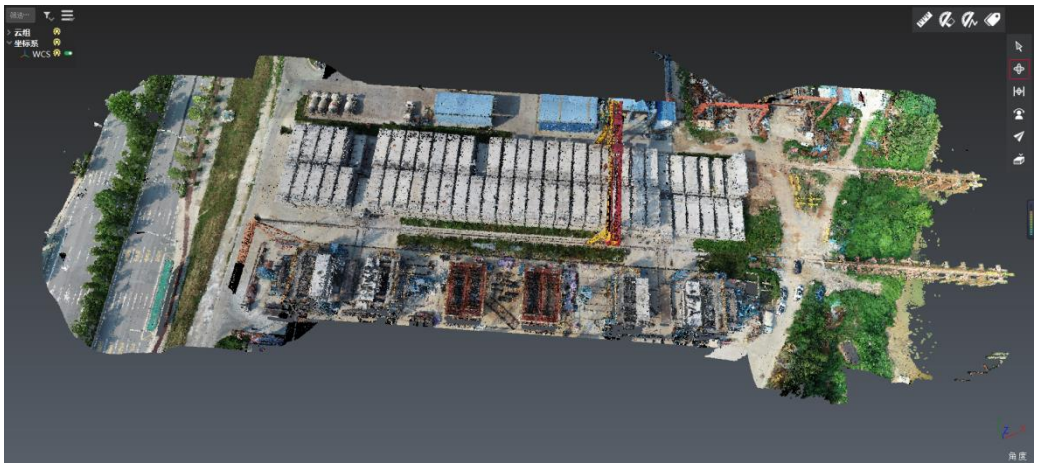


Figure 2. 19 UAV scanning result of the construction site

Chemical Vapor Deposition Laboratory

Chemical vapor deposition is a chemical technology, that mainly uses one or several gas-phase compounds or elemental substances to perform chemical reactions on the surface of the substrate to form thin films. The CNERC-Rail has set up a chemical vapor deposition laboratory for depositing single-layer graphene on copper substrates. The chemical vapor deposition system (Figure 2. 20) mainly includes air inlet control parts, quartz tubes, a heating

furnace, and a vacuum pump. With this equipment, large-area single-layer graphene can be grown on copper substrates at 1000 ℃. Single-layer graphene has extremely high electrical conductivity. The single-layer graphene grown on the copper substrate can transfer to long-period grating fibre for better electrical conductivity, which can apply in the development of corrosion sensors based on long-period gratings fibre.

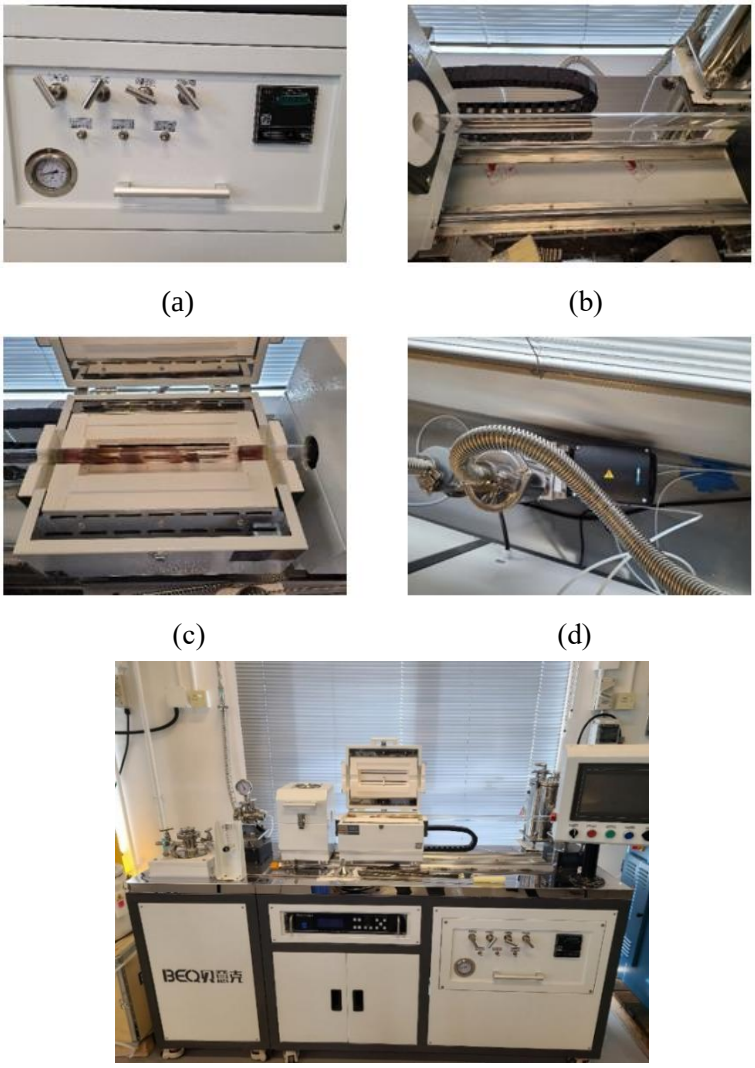


Figure 2. 20 Chemical vapor deposition system (a) air inlet parts, (b) quartz tubes, (c) the heating furnace, (d) the vacuum pump, (e) the whole system

A Test Platform for Electromagnet-Rail Coupling Vibration of the Medium-Speed Maglev

The electromagnet-rail coupling vibration and its control are crucial to the maglev train-guideway dynamic interaction. The CNERC-Rail has set up a test platform for electromagnet-rail coupling vibration of medium-speed maglev (Figure 2. 21) supported by the Large Equipment Fund of PolyU (HKD 2,430,000) and it is the first test platform in the Hongkong for electromagnet-rail coupling vibration of the medium-speed maglev. The test platform is mainly composed of a vibration testbed, power system, air spring system, frequency test system, frequency modulation system, and data acquisition system. It can be used to explore the maglev electromagnet-rail coupling vibration mechanism, study influence factors for maglev electromagnet-rail coupling vibration, develop suspension control algorithms for inhibition of electromagnet-rail coupling vibration, verify and test new maglev technology, validate new damage monitoring and assessment algorithms suitable for the maglev system, and establish the digital twin model of the maglev system.

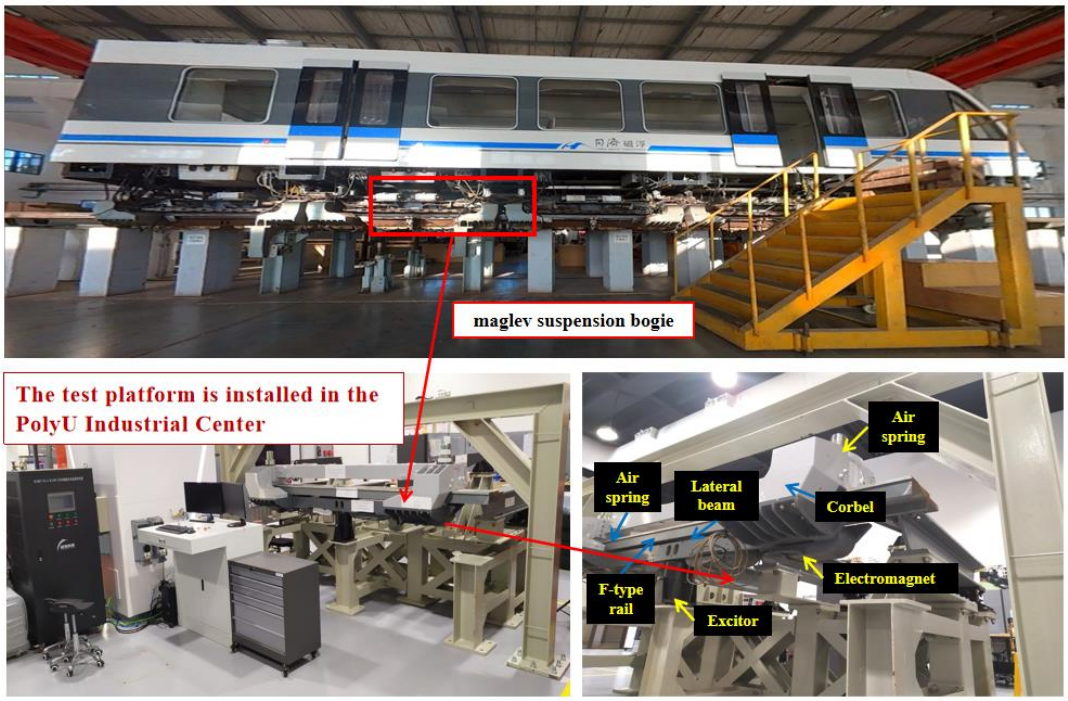


Figure 2. 21 A test platform for electromagnet-rail coupling vibration of the medium-speed maglev

Research Outcomes

In 2021, the CNERC-Rail participated in the preparation of 2 chapters of 1 monograph, published/submitted 30 papers (30 SCI articles), won 2 awards, granted 7 patents, and applied for 9 patents. Key members were invited to give the keynote speech at 7 international conferences.

Monograph

1. Zhou, L., Liu, X.Z., and Ni, Y.Q. (2021), "Sensing solutions for assessing and monitoring high-speed railroads", Chapter 10 of *Sensor Technologies for Civil Infrastructures*, 2nd Edition, edited by M.L. Wang, J.P. Lynch, and H. Sohn, Woodhead Publishing, Cambridge, UK.
2. Ni, Y.Q., and Wang, Y.W. (2021), "Sensing solutions for assessing and monitoring super-tall towers", Chapter 2 of *Sensor Technologies for Civil Infrastructures*, 2nd Edition, edited by M.L. Wang, J.P. Lynch, and H. Sohn, Woodhead Publishing, Cambridge, UK.

International Journal Publications

1. Wang, S.M., Ni, Y.Q., Duan, Y.F., and Yau, J.D. (2021), "Vector form intrinsic finite element method for stochastic analysis of train–track–bridge coupling system", *International Journal of Structural Stability and Dynamics*, Vol. 21, No. 14, Paper No. 2140012. (SCI)
2. Ying, Z.G., and Ni, Y.Q. (2021), "Vibration localization and anti-localization of nonlinear multi-support beams with support periodicity defect", *Symmetry*, Vol. 13, No. 12, Paper No. 2234. (SCI)
3. Zhang, B.Y., and Ni, Y.Q. (2021), "A hybrid sequential sampling strategy for sparse polynomial chaos expansion based on compressive sampling and Bayesian experimental design", *Computer Methods in Applied Mechanics and Engineering*, Vol. 386, Paper No. 114130. (SCI)
4. Ying, Z.G., and Ni, Y.Q. (2021), "Vibrational amplitude frequency characteristics analysis of a controlled nonlinear meso-scale beam", *Actuators*, Vol. 10, No. 8, Paper No. 180 (16pp). (SCI)

5. Sajjadi Alehashem, S.M., Ni, Y.Q., and Liu, X.Z. (2021), "A full-scale experimental investigation on ride comfort and rolling motion of high-speed train equipped with MR dampers", *IEEE Access*, Vol. 9, 118113-118123. (SCI)
6. Ying, Z.G., Wang, Y.W., Ni, Y.Q., and Xu, C. (2021), "Model-free identification of multiple periodic excitations and detection of the structural anomaly using noisy response measurements", *Smart Structures and Systems*, Vol. 28, No. 3, 407-423. (SCI)
7. Chen, S.X., Zhou, L., Ni, Y.Q., and Liu, X.Z. (2021), "An acoustic-homologous transfer learning approach for acoustic emission-based rail condition evaluation", *Structural Health Monitoring*, Vol. 20, No. 4, 2161-2181. (SCI)
8. Ni, Y.Q., and Zhang, Q.H. (2021), "A Bayesian machine learning approach for online wheel fault detection using track-side monitoring", *Structural Health Monitoring*, Vol. 20, No. 4, 1536-1550. (SCI)
9. Ding, S., Xu, C., Ni, Y.Q., and Han, B. (2021), "Extracting piezoresistive response of self-sensing cementitious composites under temperature effect via Bayesian blind source separation", *Smart Materials and Structures*, Vol. 30, No. 6, Paper No. 065010 (18pp). (SCI)
10. Wang, C., Lai, S.K., Wang, J.M., Feng, J.J., and Ni, Y.Q. (2021), "An ultra-low-frequency, broadband and multi-stable tri-hybrid energy harvester for enabling the next-generation sustainable power", *Applied Energy*, Vol. 291, Paper No. 116825. (SCI)
11. Wang, S.M., Liao, C.L., and Ni, Y.Q. (2021), "A machine vision system based on driving recorder for automatic inspection of rail curvature", *IEEE Sensors Journal*, Vol. 21, No. 10, 11291-11300. (SCI)
12. Fu, C., Ni, Y.Q., Sun, T., Wang, Y., Ding, S., and Vidakovic, M. (2021), "Strain, torsion and refractive index sensors based on helical long period fibre grating inscribed in small-core fibre for structural condition monitoring", *Advances in Structural Engineering*, Vol. 24, No. 6, 1248-1255. (SCI)
13. Wang, Y.W., Ni, Y.Q., Zhang, Q.H., and Zhang, C. (2021), "Bayesian approaches for evaluating wind-resistant performance of long-span bridges using structural health monitoring data", *Structural Control and Health Monitoring*, Vol. 28, No. 4, Paper No. e2699. (SCI)

14. Zhou, L., Chen, S.X., Ni, Y.Q., and Choy, A.W.H. (2021), "EMI-GCN: A hybrid model for real-time monitoring of multiple bolt looseness using electromechanical impedance and graph convolutional networks", *Smart Materials and Structures*, Vol. 30, No. 3, Paper No. 035032 (20pp). (SCI)

15. Ni, Y.Q., and Chen, R. (2021), "Strain monitoring based bridge reliability assessment using parametric Bayesian mixture model", *Engineering Structures*, Vol. 226, Paper No. 111406. (SCI)

16. Shi, X., Zhao, F., Yan, Z., Zhu, S., & Li, J. Y. (2021). "High-performance vibration isolation technique using passive negative stiffness and semiactive damping", *Computer - Aided Civil and Infrastructure Engineering*, Vol. 36, 1034-1055. (SCI)

17. Cai, Q., Hua, Y., & Zhu, S. (2021). "Energy-Harvesting Adaptive Vibration Damping in High-Speed Train Suspension using Electromagnetic Dampers", *International Journal of Structural Stability and Dynamics*, 2140002. (SCI)

18. Hua, Y., Zhu, S., & Shi, X. (2021). "High-performance semiactive secondary suspension of high-speed trains using negative stiffness and magnetorheological dampers". *Vehicle System Dynamics*, published online, DOI: 10.1080/00423114.2021.1899251. (SCI).

19. Wen, F., Shan, S., & Cheng, L. (2021). "Third harmonic shear horizontal waves for material degradation monitoring", *Structural Health Monitoring*, Vol. 20, No.2, 475-483. (SCI)

20. Shan, S., Wen, F., & Cheng, L. (2021). "Purified nonlinear guided waves through a metamaterial filter for inspection of material microstructural changes", *Smart Materials and Structures*, Vol. 30, No.9, 095017. (SCI)

21. Wen, F., Shan, S., Radecki, R., Staszewski, W. J., & Cheng, L. (2021). "Shear-lag modelling of surface-bonded magnetostrictive transducers for shear horizontal wave generation in a non-ferromagnetic plate", *Smart Materials and Structures*, Vol. 30, No. 3, 035026. (SCI)

22. Zheng, L., Zhou, B., Or, S. W., Cao, Y., Wang, H., Li, Y., & Chan, K. W. (2021). "Spatio-temporal wind speed prediction of multiple wind farms using capsule network", *Renewable Energy*, Vol. 175, 718-730. (SCI)

23. Cao, Y., Zhou, B., Or, S. W., Chan, K. W., Liu, N., & Zhang, K. (2021). "An interactive tri-level multi-energy management strategy for heterogeneous multi-microgrids". *Journal of Cleaner Production*, Vol. 319, 128716. (SCI)
24. Zhu, Z., Chan, K. W., Bu, S., Or, S. W., Gao, X., & Xia, S. (2021). "Analysis of Evolutionary Dynamics for Bidding Strategy Driven by Multi-Agent Reinforcement Learning, *IEEE Transactions on Power Systems*, Vol. 36, No.6, 5975-5978. (SCI)
25. Zhang, K., Zhou, B., Or, S. W., Li, C., Chung, C. Y., & Voropai, N. I. (2021). "Optimal coordinated control of multi-renewable-to-hydrogen production system for hydrogen fueling stations", *IEEE Transactions on Industry Applications*, published online, DOI:10.1109/TIA.2021.3093841. (SCI)
26. Li, Z., Chan, K. W., Hu, J., & Or, S.W. (2021). "An Adaptive Fault Ride-Through Scheme for Grid-Forming Inverters under Asymmetrical Grid Faults", *IEEE Transactions on Industrial Electronics*. (SCI)
27. Zhang, L.H., Lai, S.K., Wang, C., & Yang, J. (2021). "DSC regularized Dirac-delta method for dynamic analysis of FG graphene platelet-reinforced porous beams on elastic foundation under a moving load", *Composite Structures*, Vol. 255, Paper No. 112865. (SCI)
28. Zhou, B., Duan, H.R., Wu, Q.W., Wang, H.Z., Or, S.W., Chan, K.W., & Meng, Y.F. (2021). "Short-term prediction of wind power and its ramp events based on semi-supervised generative adversarial network", *International Journal of Electrical Power and Energy Systems*, Vol. 125, Paper No. 106411. (SCI)
29. Zhang, Q.H., and Ni, Y.Q. (2021), "Reconciling frequentist and Bayesian hypothesis testing with consistent type I error probabilities", submitted to *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*. (SCI)
30. Zhang, Q.H., and Ni, Y.Q. (2021), "Revisiting the Jeffreys-Lindley paradox on testing a point null hypothesis", submitted to *Statistics and Computing*. (SCI)

International Conference Papers

1. Lai, S.K., Wang, C., Zhang, L.H., and Ni, Y.Q. (2021), "Realizing a self-powered real-time monitoring system on high-speed trains", *Proceedings of the 50th International Congress and Exposition on Noise Control Engineering*, 1-5 August 2021, Washington, DC, USA.

2. Ying, Z.G., Ni, Y.Q., and Ruan, Z.G. (2021), "Damping effect of a controlled nonlinear meso-scale beam under periodic excitation", *Proceedings of the International Conference on Intelligent Automation and Soft Computing*, 26-28 May 2021, Chicago, IL, USA.
3. Wang, S.M., Jiang, G. F., Ni, Y.Q. (2021), "Intelligent multiple damage detection of maglev rail joints", *Proceedings of the 2nd ZHITU Symposium on Advances in Civil Engineering*, 28-29 September 2021, UNIST, Ulsan, South Korea.
4. Zhang, B.Y., Ni, Y.Q. (2021), "A hybrid sequential sampling strategy for sparse polynomial chaos expansion based on compressive sampling and bayesian experimental design", *Proceedings of the 2nd ZHITU Symposium on Advances in Civil Engineering*, 28-29 September 2021, UNIST, Ulsan, South Korea.
5. Ye, X., Ni, Y.Q. (2021), "Experimental study on a particle damper for high-frequency vibration mitigation", *Proceedings of the 2nd ZHITU Symposium on Advances in Civil Engineering*, 28-29 September 2021, UNIST, Ulsan, South Korea.
6. Chen, Z.W., Ni, Y.Q. (2021), "Study on the aerodynamic characteristics of double-unit trains with different types", *Proceedings of the 2nd ZHITU Symposium on Advances in Civil Engineering*, 28-29 September 2021, UNIST, Ulsan, South Korea.
7. Li, J.Y., Zhu, S.Y. (2021), "Novel self-powered active isolation: case study on a single-degree-of-freedom system", *Proceedings of the 2nd ZHITU Symposium on Advances in Civil Engineering*, 28-29 September 2021, UNIST, Ulsan, South Korea.

Awards and Patents

1. Recipient of the Third Prize Award of National Innovation Center of High-Speed Train Innovation and Entrepreneurship Competition, 2021 (CNERC-Rail Project, "Development of a Modular Rail Particle Damper to Control the Corrugation and Mitigate Broadband Noise and Vibration in Railways"). (Figure 2. 22)
2. Recipient of the First Prize Award of Science and Technology, China Society for Highway, 2021 (Ni, Y.Q. (2021), "Key technologies of vibration reduction, corrosion prevention, and monitoring and early warning of long span bridges in coastal environment").

3. Ni, Y.Q., Wang, S.M., Lu, Y., “Maglev controlling system”, Chinese Utility Model No. ZL 2020 2 2201131.X, Issued on 5 January 2021. (Figure 2. 23)
4. Zhu, S.Y., Shi, X., “Electromagnetic apparatus for generating negative stiffness and method of vibration control”, Chinese Patent No. ZL 2017 1 0113005.9, Issued on 12 January 2021. (Figure 2. 24)
5. Zhu, S.Y., Cai, Q.L., “A tunable low-frequency wave energy converter”, Chinese Utility Model No. ZL 2020 2 2154730.0, Issued on 23 February 2021. (Figure 2. 25)
6. Ni, Y.Q., Wang, J.F., “A rail crack monitoring system using fiber optic based ultrasonic guided wave detection technology”, Chinese Patent No. ZL 2017 1 0116980.5, Issued on 2 March 2021. (Figure 2. 26)
7. Wang, B., Zhu, S.Y., “A superelastic shape memory alloy-based self-centering coupling beam”, Chinese Patent No. ZL 2016 1 1175145.0, Issued on 9 March 2021. (Figure 2. 27)
8. Wang, S.M., Liao, C.L., Ni, Y.Q., “Image analysis system and apparatus for track detection”, Chinese Utility Model No. ZL 2020 2 2201131.X, Issued on 18 June 2021. (Figure 2. 28)
9. Wang, B., Zhu, S.Y., “Self-centering energy dissipation support device”, Chinese Patent No. ZL 2018 1 0166828.2, Issued on 10 September 2021. (Figure 2. 29)
10. Sajjadi Alehashem, S.M., Ni, Y.Q., Lin, C.S., Zhang, C., “A novel methodology for vibration and noise control using modular rail particle damper in rail transit systems”, Chinese Patent submitted, Application No. 2021 1 0466428.5.
11. Sajjadi Alehashem, S.M., Ni, Y.Q., Lin, C.S., Zhang, C., “Modular rail particle damper (MRPD) and damper’s fixture for noise and vibration mitigation of railways”, Chinese Utility Model submitted, Application No. 2021 2 0908352.2.
12. Guo, S., Hong, Z.C., Xie, X., “A method and system for submitting cross-shard transactions under shard block chain”, Chinese Patent submitted.
13. Guo, S., Wu, F.J., Wang, H.Z., “A federated learning approach based on machine heterogeneity”, Chinese Patent submitted.

14. Ni, Y.Q., Zhu, Q., Wang, S.M., “A dynamic control method for suspension system of maglev train based on deep reinforcement learning”, Chinese Patent submitted.
15. Wang, Y.W., Ni, Y.Q., Zhang, C., “An intelligent power supply free monitoring method for the arch deformation of ballastless track slab”, Chinese Patent submitted.
16. Ni, Y.Q., Wang, Y.W., Zhang, C., “An intelligent power supply free monitoring system for the arch deformation of ballastless track slab”, Chinese Utility Model submitted.
17. Ni, Y.Q., Lai, S.K., Wang, Y.W., Zhang, C., “A new design of bumpers embedded with high damping materials for bogie frame of high-speed trains”, Germany Utility Model submitted.
18. Ni, Y.Q., Lai, S.K., Wang, Y.W., Zhang, C., “A new design of bumpers embedded with high damping materials for bogie frame of high-speed trains”, Japanese Utility model submitted.

Figure 2. 22 Third prize award of national innovation center of high-speed train innovation and entrepreneurship competition

Figure 2. 23 Authorized patent: Maglev controlling system


证书号第4199723号

发明专利证书

发明名称：用于产生负刚度的电磁设备和振动控制的方法

发明人：朱松晔;石翔

专利号：ZL 2017 1 0113005.9

专利申请日：2017年02月28日

专利权人：香港理工大学

地址：中国香港九龙

授权公告日：2021年01月12日　　授权公告号：CN 107795631 B

局长
申长雨

第1页(共2页)

其他事项参见续页

Figure 2. 24 Authorized patent: Electromagnetic apparatus for generating negative stiffness and method of vibration control


证书号第12573651号

实用新型专利证书

实用新型名称：一种低频且频率可调的浮子式波浪发电装置

发明人：朱松晔;蔡荣霖

专利号：ZL 2020 2 2154730.0

专利申请日：2020年09月27日

专利权人：香港理工大学

地址：中国香港九龙红磡香港理工大学

授权公告日：2021年02月23日　　授权公告号：CN 212583871 U

局长
申长雨

2021年02月23日

第1页(共2页)

其他事项参见背面

Figure 2. 25 Authorized patent: A tunable low-frequency wave energy converter


证书号第4279140号

发明专利证书

发明名称：一种基于光纤超声导波技术的铁轨裂纹监测系统

发明人：倪一清;王俊芳

专利号：ZL 2017 1 0116980.5

专利申请日：2017年02月28日

专利权人：香港理工大学

地址：中国香港九龙红磡

授权公告日：2021年03月02日　　授权公告号：CN 108508097 B

局长
申长雨

第1页(共2页)

其他事项参见续页

Figure 2. 26 Authorized patent: A rail crack monitoring system using fiber optic based ultrasonic guided wave detection technology


证书号第4286678号

发明专利证书

发明名称：一种基于超弹性形状记忆合金的自复位连梁

发明人：王斌;朱松晔

专利号：ZL 2016 1 1175145.0

专利申请日：2016年12月15日

专利权人：香港理工大学

地址：中国香港九龙红磡

授权公告日：2021年03月09日　　授权公告号：CN 108222369 B

局长
申长雨

第1页(共2页)

其他事项参见续页

Figure 2. 27 Authorized patent: A superelastic shape memory alloy-based self-centering coupling beam

Figure 2. 28 Authorized patent: Image analysis system and apparatus for track detection

Figure 2. 29 Authorized patent: Self-centering energy dissipation support device

Professional Activities

1. Co-Editor-in-Chief of Journal of Infrastructure Intelligence and Resilience (Publisher: Elsevier). (Figure 2. 30)
2. Co-Editor-in-Chief of Intelligent Transportation Infrastructure (Publisher: Oxford University Press).
3. Member of Experts Committee of the 3rd International Workshop on Structural Health Monitoring for Railway System, 22-23 October 2021, Qingdao, China.
4. Member of Conference Editorial Board of the 5th International Conference on Railway Technology: Research, Development and Maintenance, 30 August - 2 September 2021, Palma de Mallorca, Spain.
5. Member of Scientific Committee of the 15th International Workshop on Advanced Smart Materials and Smart Structures Technology, 23-26 July 2021, West Lafayette, Indiana, USA.

6. Member of International Advisory and Scientific Committees of the 10th International Conference on Structural Health Monitoring of Intelligent Infrastructure, 30 June - 2 July 2021, Porto, Portugal.
7. Member of International Scientific Committee of the 2021 International Conference on Infrastructural Diagnosis, Prognosis and Management, 16-18 April 2021, Nanjing, China.
8. Member of Program Committee of the 2021 SPIE Smart Structures/NDE Conference on Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, 7-10 March 2021, Online.
9. Member of Organizing Committee of the 4th International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites, 9-11 January 2021, Hong Kong.

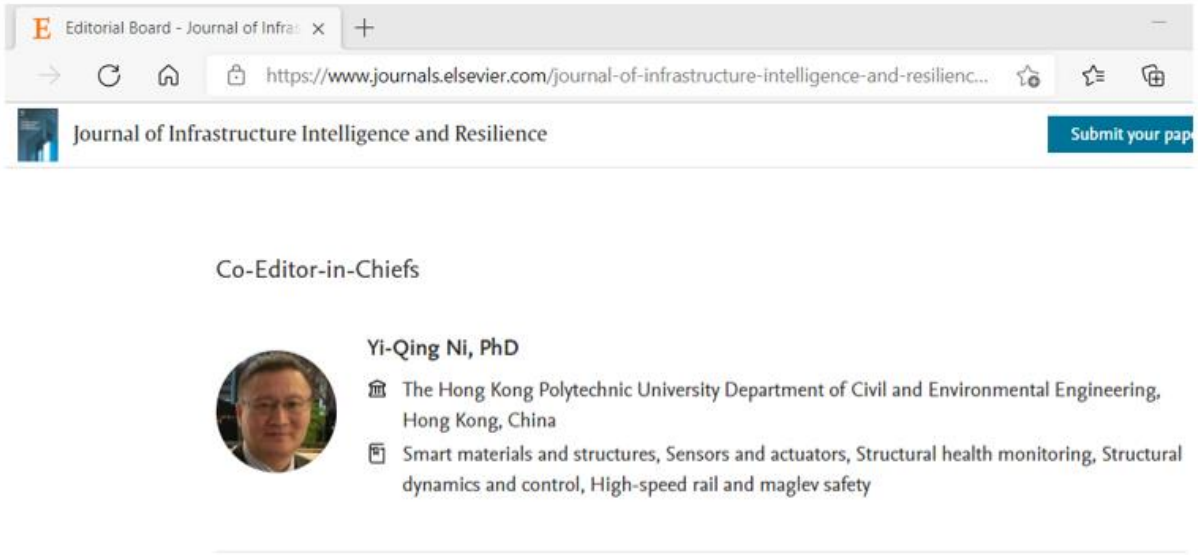


Figure 2. 30 Prof. Yi-Qing Ni, Director of the Center, Appointed as Co-Editor-in-Chief of Journal of Infrastructure Intelligence and Resilience

Collaborations & Communications

Signed Collaboration Agreements

Signed Cooperation Agreement with the Hunan Maglev Technology Research Center Co., Ltd. and Tongji University Maglev Transportation Engineering R&D Center

In December 2021, the CNERC-Rail, Hunan Maglev Technology Research Center Co., Ltd., and Tongji University Maglev Transportation Engineering R&D Center jointly signed the "Cooperation agreement of carrying out cooperative research on investigating the digital twin-based monitoring and control platform of maglev vehicle-suspension-guideway coupling system" (as shown in Figure 3. 1). The three partners are willing to make full use of their respective advantages to cooperate in key technology research such as maglev vehicle-rail coupling interaction, suspension control, smart monitoring, application research, and personnel exchanges. Besides, they agreed to expand the depth and breadth of trilateral cooperation in related fields, thus obtaining good social and economic benefits and jointly promoting technological progress and industrial application in maglev rail transit. The agreement is valid for 5 years, from 31 January 2022 to 31 January 2027.


湖南轨道 HNRT

湖南磁浮技术研究中心有限公司

同济大学磁浮交通工程技术研究中心
Tongji University Maglev Transportation Engineering R&D Center

NMT

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學

关于开展面向磁浮列车-轨道-桥梁
数字孪生监控平台合作研究的合作协议

湖南磁浮技术研究中心有限公司

同济大学磁浮交通工程技术研究中心

香港理工大学国家轨道交通电气化与自动化工程技术研究中心

香港分中心

2021 年 12 月

中国 长沙

Figure 3. 1 Cooperation agreement of carrying out cooperative research on investigating the digital twin-based monitoring and control platform of the maglev vehicle-suspension-guideway coupling system

Signed Cooperation Agreement with the National Innovation Center of Advanced Rail Transit Equipment (Zhuzhou) CRRC Co., Ltd.

On 29 July 2021, the "Hong Kong Investment and Consultation Week" Special Activity in 2021–Science and Technology Innovation Integration Development Matchmaking Meeting between Hunan and Guangdong-Hong Kong-Macao Great Bay Area hosted by the People's Government of Hunan Province and undertaken by the Science and Technology Department of Hunan Provincial, was held in Shenzhen. Mr. Bao-Xiang He, Vice Governor of People's Government of Hunan Province, attended the meeting and delivered a speech.

Six strategic cooperation agreements were signed at the meeting, including a strategic cooperation agreement between the National Innovation Center of Advanced Rail Transit Equipment (Zhuzhou) CRRC Co., Ltd. and the CNERC-Rail of the Hong Kong Polytechnic University on the application research of vibration power generator system for self-powered rail transit. Both partners were willing to make full use of their respective advantages to carry out the technology research, application research, and personnel exchanges in the vibration power generator system for self-powered rail transit. They also agreed to expand the depth and breadth of bilateral cooperation in related fields, obtain social and economic benefits and jointly promote technological progress and industrial application in self-powered rail transit. The agreement is valid for 3 years, from 31 January 2021 to 31 January 2024. Mr. Ying Yang, Chief Engineer of the National Innovation Center of Advanced Rail Transit Equipment (Zhuzhou) CRRC Co., Ltd., Dr. Su-Mei Wang, Research Assistant Professor of the Hong Kong Polytechnic University, and Mr. Qi-Dong Chen, President of the Shenzhen Research Institute of the Hong Kong Polytechnic University, attended the signing ceremony. Mr. Ying Yang and Dr. Su-Mei Wang signed the agreement on behalf of the National Innovation Center of Advanced Rail Transit Equipment (Zhuzhou) CRRC Co., Ltd. and the Hong Kong Polytechnic University respectively (Figure 3. 2). After the ceremony, Dr. Su-Mei Wang, a member of the CNERC-Rail, was interviewed by the press center of the Science and Technology Department of Hunan Province and introduced the cooperative research and the research content of the project (Figure 3. 3).

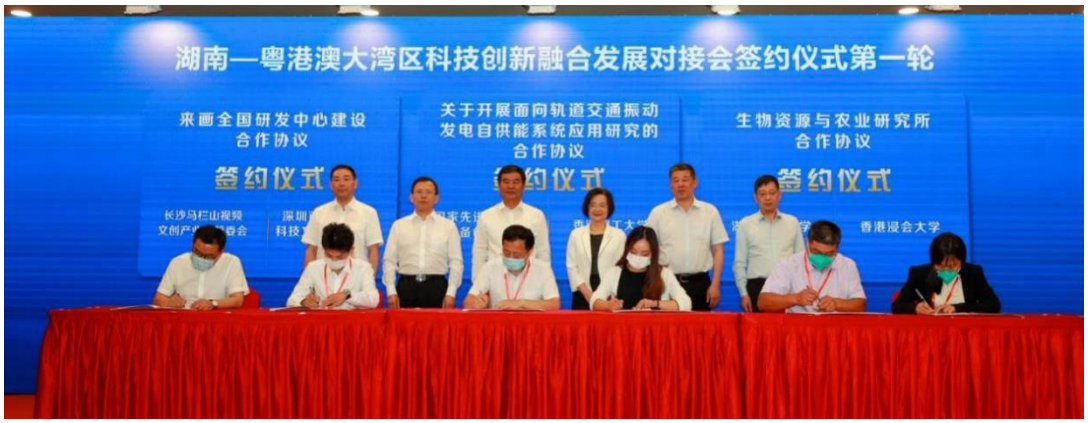


Figure 3. 2 Dr. Su-Mei Wang, a member of the CNERC-Rail, attended the Science and Technology Innovation Integration Development Matchmaking Meeting between Hunan and Guangdong-Hong Kong-Macao Great Bay Area

Figure 3. 3 Signed agreement on the vibration power generator system for self-powered rail transit

Attended Conferences

The 4th International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites

To combat the deterioration of concrete structures in coastal/marine environments due to the corrosion of steel, the use of fibre-reinforced polymer (FRP) to replace steel reinforcement in concrete structures has attracted significant attention and is gaining increasing acceptance. As FRP is expected to be little affected by chloride ions, its application in concrete structures opens a new avenue for concrete production with the direct use of locally available seawater and sea-sand. The resulting structures, referred to as FRP-reinforced seawater sea-sand concrete (FRP-SSC) structures, offer compelling economic and environmental advantages through savings in freshwater and material transportation costs as well as reduced river-sand mining. The bright prospects of FRP-SSC structures in the development of sustainable civil infrastructure have kindled growing research interests on relevant topics among researchers worldwide. The FRP-SSC Structures Workshop series was initiated against this background and has now become an annual event.

From 9 January to 10 January in 2021, Prof. Yi-Qing Ni from the CNERC-Rail attended the "4th International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites" organized by the Department of Civil and Environmental Engineering & Research Institute for Sustainable Urban Development of the PolyU. Dr. Chuan-Rui Guo, a member of the CNERC-Rail, gave an online presentation on the "Graphene/silver nanowire coated LPFG sensor with electroplated FE-C layer for ultrasensitive corrosion monitoring". (Figure 3. 4)

Figure 3. 4 The 4th international workshop on seawater sea-sand concrete (SSC) structures reinforced with FRP composites

The 9th China Maglev Technology Academic Symposium

The China Maglev Technology Academic Symposium was initiated and held by the Maglev Professional Group of the Fluid Engineering Branch of the Chinese Mechanical Engineering Society. It has been 16 years since the first meeting was held in 2005. This symposium is the longest and largest academic symposium in the field of maglev technology in China. The symposium aims to provide a comprehensive platform for experts and scholars in the maglev field to discuss the key scientific issues and technical problems related to maglev technology, and exchange new ideas and methods, thus promoting the rapid and development of maglev technology in China. The 9th China Maglev Technology Academic Symposium was held by Southwest Jiaotong University in Chengdu, Sichuan Province from 20 July to 23 July 2021, and the theme of the symposium is "Collaborative Innovation, Open up a New Chapter of Maglev Application". The symposium focused on multiple research areas under three themes, maglev bearing, maglev traffic, and interdisciplinary areas. Dr. Su-Mei Wang, a member of the CNERC-Rail, attended the symposium and gave a presentation on the dynamic analysis of maglev vehicles (Figure 3. 5). The report title is "Modelling dynamic interaction of maglev train-controller-rail-bridge system by vector mechanics".

Figure 3. 5 Dr. Su-Mei Wang gave a presentation

Figure 3. 6 Group photo of the 9th China maglev technology academic symposium

The 50th International Conference and Exhibition of Noise Control Engineering

The International Conference on Noise Control Engineering (ICCE) is a series of international academic and technical exchanges hosted by the International Society for Noise Control Engineering (I-INCE). It is the oldest international academic conference on physical acoustics. Founded in 1974, I-INCE is composed of international professional associations and institutions representing the noise control profession. Its members consist of more than 50 organizations from more than 40 countries.

The 50th International Conference on Noise Control Engineering (INTER-NOISE 2021) was held in Washington DC, USA, from August 1 to 4, 2021. The conference was sponsored by I-INCE, and co-hosted by the Noise Control Engineering Society of America (ICE-USA) and Pro Acustica of Brazil, with the participation of the Acoustical Society of America, SAE International, The Acoustical Society of Spain, and the Korean Society of Noise and Vibration Engineering. Though the event was held online due to the epidemic, the conference was carried on the careful planning and preparation. Particularly, the ceremony was held at the venue of the 1st conference in memory of 50 years' progress in noise control since the first international

conference held in 1972, and to look ahead and speculate what might be achieved in the next 50 years by focusing on the issues. The theme of the conference was determined as "The next 50 years of noise control". Dr. Siu-Kai Lai, Associate Professor of the CNERC-Rail, attended the conference and gave an online report entitled "Realizing the real-time monitoring system of self-powered high-speed trains" (Figure 3. 7).

Figure 3. 7 The 50th international conference and exhibition of noise control engineering

Publicity Seminar of Supporting Policies to Hong Kong's Science and Technology by Central Government

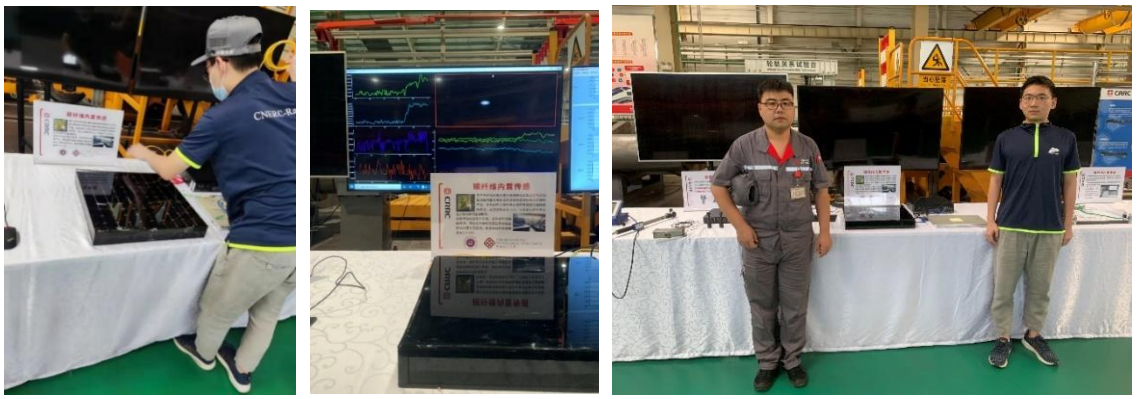
On 7 September 2021, the Publicity Seminar of Supporting Policies to Hong Kong's Science and Technology by Central Government was co-hosted by the Innovation and Technology Bureau of the HKSAR Government, Guangdong-Hong Kong-Macao Greater Bay Area Academicians Alliance, and The Beijing-Hong Kong Academic Exchange Centre (Figure 3. 8). Prof. Tie-Niu Tan, Deputy Director of the Liaison Office of the Central Committee of the Communist Party of China, was invited to elaborate on the Central Government's policies to support Hong Kong's efforts to become an international innovation center and the supporting policies to accelerate the development of the Greater Bay Area. Furthermore, supporting policies to Hong Kong's science and technology as well as the opportunities for Hong Kong were introduced. Three online panelists from the Ministry of Science and Technology, China Association for Science and Technology, and the National Natural Science Foundation of China

introduced the new policy arrangements for Hong Kong's universities and technological innovation community, hoping that Hong Kong's industry practitioners could seize the opportunity. Dr. Su-Mei Wang, Research Assistant Professor of the CNERC-Rail, was invited to attend the conference.

Figure 3. 8 Publicity seminar of supporting policies to Hong Kong's science and technology by central government

The 140th Anniversary of the China Rail Transit Industry

The 140th Anniversary of the China Rail Transit Industry was held in Tangshan, Hebei on 27 September 2021. This summit was organized by the CRRC Tangshan Co., Ltd., presenting the honorable history of China's rail transit industry and the latest research progress. Mr. Gao-Feng Jiang, a member of the CNERC-Rail, was invited to show the load location identification system of CFC laminate based on the FBG sensing network (Figure 3.7). The main works included: the in-site arrangement of FBG sensors, data acquisition system, CFC laminate, and the algorithm optimization of signal processing software according to the in-site temperature change. Eventually, this system can identify the load location accurately in real-time in both testing and presenting stages.



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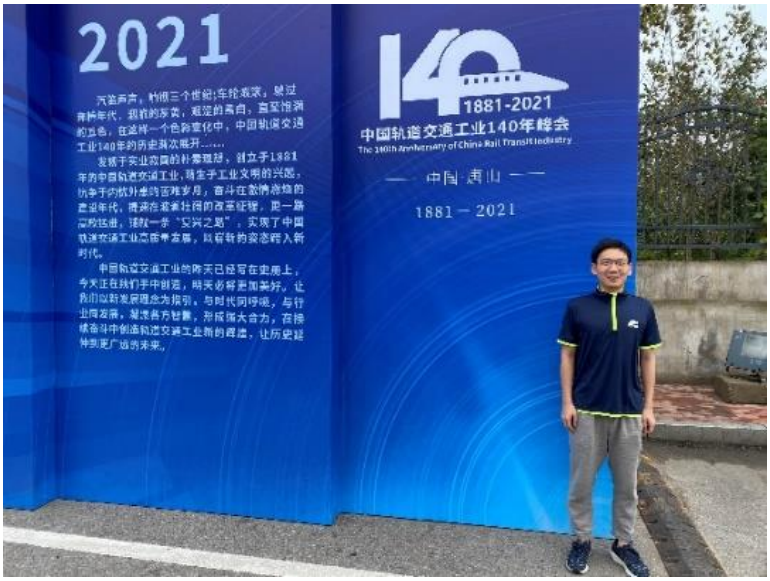
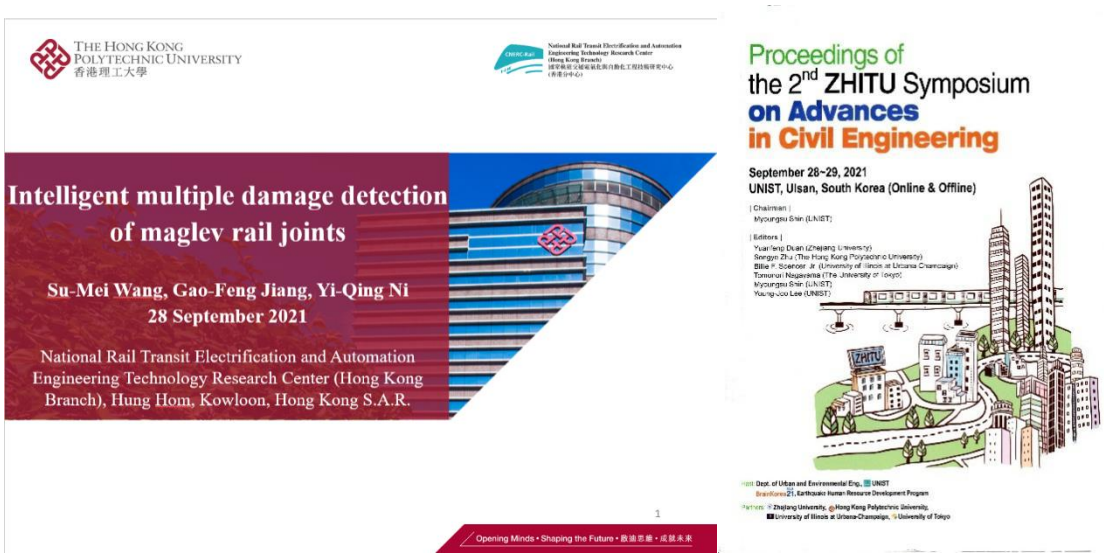


(b)

Figure 3.9 The 140th anniversary of the China rail transit industry (a) in-situ display, (b) in-situ photo

Proceedings of the 2nd ZHITU Symposium on Advances in Civil Engineering

The ZHITU is an international consortium on civil engineering among the five prestigious colleges, including Zhejiang University, Hong Kong Polytechnic University, the University of Illinois at Urbana-Champaign, the University of Tokyo, and the Ulsan National Institute of Science and Technology (UNIST). The goal of the conference is to promote collaborations on research and education. The ZHITU was conceived in 2018 under the lead of Prof. Chung-Bang Yun and his colleagues at Zhejiang University. The 2nd ZHITU symposium was held by UNIST (South Korea) from 28 September to 29 September 2021. The symposium focused on multiple research areas including structural health monitoring, urban planning and disaster management, sustainable construction materials, earthquake and geotechnical engineering, and resilient structural systems. Several members of the CNERC-Rail, Prof. Yi-Qing Ni, Prof. Song-Ye Zhu, Dr. Su-Mei Wang, Dr. Zheng-Wei Chen, Mr. Gao-Feng Jiang, Mr. Bei-Yang Zhang, Mr. Xin Ye attended the symposium and gave presentations (Figure 3. 10).



(a) (b)

Figure 3. 10 Proceedings of the 2nd ZHITU symposium on advances in civil engineering (a) conference presentation, (b) proceedings

Forum for Young Scholars on Future Transport Infrastructure Development of NSFC-RGC

As an important carrier of economic and social development, the sustainability of infrastructure construction has been widely concerned by the international community. Quickly realization of sustainable, green and intelligent development of infrastructure construction has become an inevitable trend for modern infrastructure exhibition. At the same time, with the implementation of the strategy of building a strong transport country and the "Hundred-year Safe Quality Project", "more durable", "safer", "smarter" and "greener" have become the consensus and trend in the field of transport infrastructure. On the basis of the existing achievements in China's transportation construction, it has become an essential problem for traffic construction and management departments, scientific research institutes and government departments to be solved in the "fourteenth five-year" and even longer time that how to fully implement the strategy of building a strong transport country, further implement the concept of green development in the whole life cycle, promote the recycling system of engineering materials, strengthen the technical support for green construction, improve the intelligent level of engineering construction and maintenance, and promote the development and technological progress of related industries.

On 11 December 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail was invited to attend the "Forum for Young Scholars on Future Transport Infrastructure Development of NSFC-RGC" and gave an online presentation. The presentation title was "Online monitoring of railway system: metro, municipal tracks, high-speed rail, and maglev trains". (Figure 3. 11)

Figure 3. 11 The NSFC-RGC forum for young scholars on future transport infrastructure development

2021 Annual Meeting of the Transportation Teaching Steering Committee of Guangdong Undergraduate Universities

On 18 December 2021, the 2021 Annual Meeting of the Transportation Teaching Steering Committee of Guangdong Undergraduate Universities was held in the School of Intelligent Engineering, Sun Yat-Sen University.

At the meeting, Sheng-Ping Chen and Xing-Chen Zhang made a speech, respectively. Sheng-Ping Chen introduced the situation of undergraduate teaching and the construction of "five integration" first-class talent training system and the development of traffic engineering major of Sun Yat-Sen University. He hoped that the conference could further strengthen the mutual exchange and cooperation between colleges and universities of the Guangdong province, as well as majors, and make joint efforts to improve the level of talent training. Xing-Chen Zhang said that the Education Steering Committee is responsible for training new engineering talents, and the meeting should carry out an in-depth discussion on the practice and innovation of the development of transportation major and talent training and the improvement of the teaching theory level of transportation major.

Prof. Yi-Qing Ni, Director of the CNERC-Rail, was invited to attend the "2021 Annual Meeting of Transportation Teaching Steering Committee of Guangdong Undergraduate Universities" and gave an online lecture. The report title is "Intelligent online monitoring and vibration/noise control for rail transit: from metro to Maglev train" (Figure 3. 12).

Figure 3. 12 2021 annual meeting of the transportation teaching steering committee of Guangdong undergraduate universities

Technical Activities with the Urban Construction Research Center of Wushan Campus of South China University of Technology

On 26 May 2021, Dr. Su-Mei Wang, a member of the CNERC-Rail was invited to visit the Urban Construction Research Center of Wushan Campus of South China University of Technology (Figure 3. 13). During the visit, Dr. Su-Mei Wang introduced the relevant research on the maglev electromagnet-rail coupling conducted by the CNERC-Rail to Prof. Cheng Su's team. Dr. Ran Chen from Prof. Su's team introduced their research on the vehicle-rail coupling random vibration. Dr. Su-Mei Wang and Prof. Cheng Su's team then discussed the research and cooperation on maglev vehicle-bridge coupling vibration and vehicle-rail random vibration analysis.

Figure 3. 13 Dr. Su-Mei Wang, a member of the CNERC-Rail visited the Urban Construction Research Center of Wushan Campus of South China University of Technology

Technical Activities with the Shenzhen Metro Group Co., Ltd.

(1) A member of the CNERC-Rail visits the Shenzhen Metro Operation and Maintenance Center

On August 25, 2021, a member of the She, Mr. Chao Zhang, visited the Shenzhen Metro Operation and Maintenance Center and introduced modular rail particle dampers and technologies for vibration and noise control to Mr. Mian-Wu Li, General Manager of the Operation and Maintenance Center, and his team members (Figure 3. 14). The two parties conducted in-depth discussions on the application of the modular rail particle dampers for

vibration and noise control in Shenzhen Metro operation lines. Finally, the two parties reached a cooperation intention on the field test of vibration and noise control in the Shenzhen Metro Line 6, 9 and 11.

Figure 3. 14 Technical seminar about vibration and noise control by the Shenzhen Metro Operation and Maintenance Center

(2) Leaders of the Shenzhen Metro Group Co., Ltd. visit the Shenzhen Research Institute of Hong Kong Polytechnic University

On 7 September 2021, Mr. Bo Sun, Vice President and Chief Engineer of the Shenzhen Metro Group Co., Ltd., and his team members visited the Shenzhen Research Institute of Hong Kong Polytechnic University. Dr. Qi-Dong Chen, President of the Shenzhen Research Institute of the Hong Kong Polytechnic University, Dr. Xiang-Yun Deng, and Mr. Chao Zhang, members of the CNERC-Rail, discussed the scope of technical cooperation between the CNERC-Rail and Shenzhen Metro Group Co., Ltd. with the guests, and show them the test platform and samples of "modular rail particle dampers" (Figure 3. 15).

Figure 3. 15 Mr. Bo Sun, Vice President and Chief Engineer of the Shenzhen Metro Group Co., Ltd. and his team members visit the Shenzhen Research Institute of Hong Kong Polytechnic University

(3) Visit the Shenzhen Metro Operation and Maintenance Center

On 8 September 2021, Mr. Chao Zhang, a member of the CNERC-Rail, visited the Shenzhen Metro Operation and Maintenance Center to introduce the application of "rail transit intelligent operation and maintenance monitoring system" in Singapore Metro lines to Mr. Mian-Wu Li, General Manager of the Operation and Maintenance Center, and his team members. Prof. Kang-Kuen Lee, Deputy Director of the CNERC-Rail, Prof. Hwa-Yaw Tam, and Dr. Shun-Yee Liu, key members of the CNERC-Rail were also invited to attend the meeting through remote connection. Both sides discussed the technical details of the rail transit intelligent operation and maintenance monitoring system installed in Singapore Metro and the feasibility of the system installed in the Shenzhen Metro in the future (Figure 3. 16).

Figure 3. 16 Remote technical seminar between the Shenzhen Metro Operation and Maintenance Center and CNERC-Rail

(4) Leaders of the Shenzhen Metro Group Co., Ltd. visit the Shenzhen Research Institute of Hong Kong Polytechnic University

On 17 September, 2021, Mr. Bin He, Director of the Shenzhen Metro Group Co., Ltd. Engineering Technology Centre, and his team members visited the Shenzhen Research Institute of Hong Kong Polytechnic University. Dr. Qi-Dong Chen, President of the Shenzhen Research Institute of Hong Kong Polytechnic University, Prof. Yi-Qing Ni, Director of the CNERC-Rail, together with Dr. Xiang-Yun Deng and Mr. Chao Zhang, members of the CNERC-Rail, had a meeting with Mr. Bin He. Prof. Yi-Qing Ni had an in-depth discussion with Mr. Bin He on the application of modular rail particle dampers for railway vibration and noise control (Figure 3. 17). The two sides reached a cooperation intention on the future application of modular rail particle dampers in Shenzhen Metro Line 5.

Figure 3. 17 Mr. Bin He, Director of the Shenzhen Metro Group Co., Ltd. Engineering Technology Centre along with his team members visit the Shenzhen Research Institute of Hong Kong Polytechnic University

(5) Collaboration meeting with the Shenzhen Metro Group and CRRC Zhuzhou Locomotive Corporation on 3 November 2021

Initiated by the Engineering Technology Center of the Shenzhen Metro Group, Professor Ni Yiqing, Director of the CNERC-Rail, and other center members had a online meeting with the representatives of the Shenzhen Metro Group and CRRC Zhuzhou Locomotive Corporation. The three parties had detailed technical exchanges on the research collaborations of noise and vibration mitigation in urban rail transit (Figure 3. 18), and reached cooperation intention on development of a vehicle on-line monitoring system for track irregularity detection in Shenzhen Metro lines.

Figure 3. 18 Collaboration meeting with the Shenzhen Metro Group and CRRC Zhuzhou Locomotive Corporation

(1) Visit by Dr. Tony Lee, Operations Director of the MTR and the delegation team

On 12 November 2021, Dr. Tony Lee, Operations Director of the MTR Co., Ltd. led a team to visit CNERC-Rail. The guests were warmly welcomed by Prof. Yi-Qing Ni, Director of the CNERC-Rail, Prof. William Lam, Chair Professor of Civil and Transportation Engineering, and Dr. Hon-Wah Wai, Director of Industrial Centre. Dr. Lee Tony firstly visited CNERC-Rail and the Industrial Center in the Hong Kong Polytechnic University. Prof. Yi-Qin Ni and Dr. Hon-Wah Wai introduced the latest technological research progress and scientific projects. Both sides exchanged views on their respective research progress and R&D needs at the meeting (Figure 3. 19), where they achieved an intention of cooperation. The two sides will sign a cooperation agreement in the future.

Figure 3. 19 Technical meeting between the CNERC-Rail members and the delegation of the MTR

(2) Prof. Yi-Qing Ni, Director of the CNERC-Rail, led a research team to the Hung Hom Station of the MTR for an in-situ survey

On 19 November 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail, led a research team to conduct an in-situ survey for exiting railway problems discussed with the delegation team of the MTR on 12 November (Figure 3. 20). The research team members include Dr. Siu-Kai Lai, Associate Professor of Department of Civil and Environmental Engineering (CEE), Dr. Kenneth Lai, Scientific Officer of CEE, Dr. You-Wu Wang, Research Assistant Professor of CEE, Mr. Tai-Tung Wai, Research Technical Assistant of the CNERC-Rail, Mr. Wing-Hong Kwan, Research Technical Assistant of the CNERC-Rail, Mr. Yun-Ke Luo, Ph.D. Student, and Mr. You-Liang Zheng, Ph.D. Student.

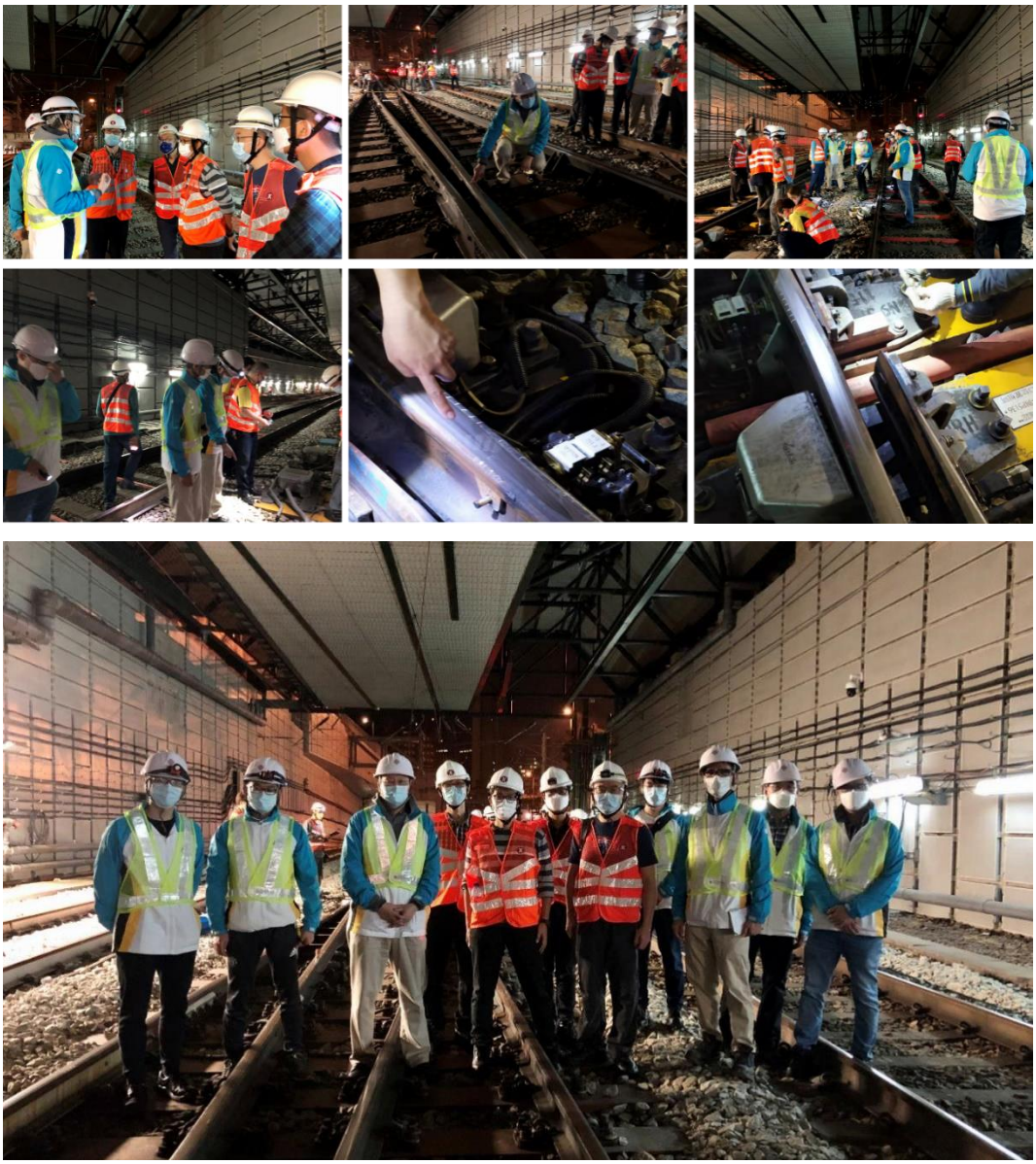


Figure 3. 20 In-situ survey of Hung Hom Station of the MTR

(3) Prof. Yi-Qing Ni, Director of the CNERC-Rail, had an online meeting with Mr. Hing-Keung Chan, General Manager of the MTR Engineering & Innovation Centre

On 25 November 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail, and research team members had an online meeting with Mr. Hing-Keung Chan, General Manager of the MTR Engineering and Science and Innovation Centre, and his team members (Figure 3. 21). During the meeting, the two sides had an in-depth discussion on the cooperation agreement and confirmed the cooperation areas to be carried out. Finally, members of the CNERC-Rail exchanged views on whether the rail section (not in operation at the moment) close to Block Z of the Hong Kong Polytechnic University can be used as a test base for cooperation research.

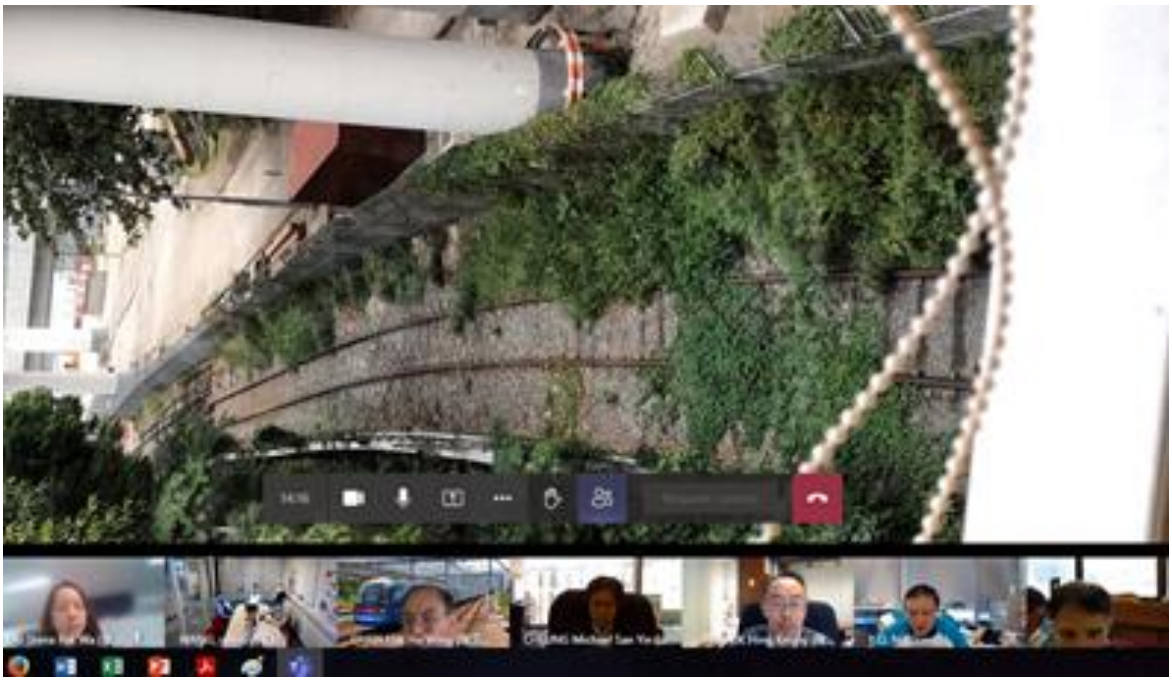


Figure 3. 21 The online meeting with Mr. Hing-Keung Chan, General Manager of the MTR Engineering and Science and Innovation Centre

(4) An engineer delegation team from the MTR visited the Optical Structure Laboratory and Industrial Center of the Hong Kong Polytechnic University

On 16 December 2021, an engineer delegation team from the MTR visited the Optical Structure Laboratory and Industrial Centre of Hong Kong Polytechnic University. Dr. Kenneth Lai, Scientific Officer, and Dr. Lu Zhou, Research Assistant Professor, from Civil and Environmental Engineering, introduced the latest research progress and in-situ investigation about the fiber optic sensors to the delegation. Two sides had an in-depth discussion on the application of relevant technology in the railway field (Figure 3. 22).

Figure 3. 22 Visit by an engineer delegation team from the MTR

Organized Seminars

(1) CEE Chair Professor lecture series

On 7 May 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail, was invited to share online research at the "78th Research Salon–Railway Technology" held by the Hong Kong Polytechnic University, and the report title was "Online Monitoring of Rail Systems: Sensing Network and Algorithm Implementation" (Figure 3. 23).

Figure 3. 23 The online lecture of "78th Research Salon–Railway Technology"

(2) Online lecture at Lanzhou University of Technology

On 11 October 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail, gave an online seminar on "Structural Health Monitoring in Civil Engineering and System Identification Based on Scientific Machine Learning" in a lecture at Lanzhou University of Technology" (Figure 3. 24). The total number of participants (online and offline) is more than 350.

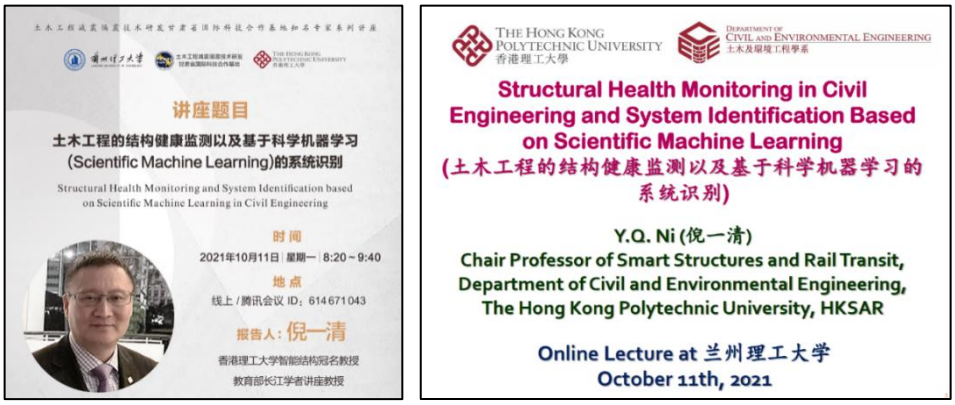


Figure 3. 24 The online lecture at Lanzhou University of Technology by Center Director Prof. Yi-Qing Ni

(3) The 5th “Yang Hua” forum of Southwest Jiaotong University

On 13 October 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail, gave an online seminar on “On-line Monitoring, Vibration and Noise Control of Railway Systems: Subways, Municipal Tracks, High-speed Railways, Maglev trains” in a lecture at the “Yang Hua” forum of Southwest Jiaotong University (Figure 3. 25). More than 400 people participated in the online and offline lectures.

Figure 3. 25 The online lecture at Southwest Jiaotong University by Center Director Prof. Yi-Qing Ni

(4) Online lecture series at Southwest Jiaotong University

On 16 and 23 November 2021, Prof. Yi-Qing Ni gave an online seminar on “Bayesian Inference and its Applications to Structure Health Monitoring (SHM)” in a lecture series for graduate students of Southwest Jiaotong University (Figure 3. 26).

Figure 3. 26 The online lecture at Southwest Jiaotong University by Center Director Prof. Yi-Qing Ni

(5) Lecture series on "Hong Kong, Macao, and Mainland High Education Exchange Program": The Hong Kong Polytechnic University–China University of Petroleum (East China)

On 26 November 2021, the Hong Kong Polytechnic University, the CNERC-Rail, and China University of Petroleum (East China) jointly hosted the lecture series on "Hong Kong, Macao, and Mainland High Education Exchange Program". Many well-known scholars at home and abroad attended and shared their reports at the lecture (Figure 3. 27).

Figure 3. 27 Lecture series on "Hong Kong, Macao, and Mainland High Education Exchange Program"

Visiting Scholars & Delegations

Visit by Mr. Alfred Sit, Secretary of Innovation and Technology, the Government of Hong Kong SAR, and the Delegation Team

On 20 May 2021, Mr. Alfred Sit, Secretary of Innovation and Technology, the Government of Hong Kong SAR, led a delegation team to visit CNERC-Rail and Railway Corner in Industrial Centre (Figure 3. 28). The Delegation Team was warmly welcomed by Prof. Jin-Guang Teng, President of the Hong Kong Polytechnic University, Dr. Miranda Lou, Executive Vice President of the Hong Kong Polytechnic University, Prof. Yi-Qing Ni, Director of the CNERC-Rail, together with center members. The delegation team members also include Dr. David Chung, Under-Secretary of Innovation and Technology, Ms. Rebecca Pun, Commissioner of Innovation and Technology, Mr. Arthur Au, Deputy Commissioner of Innovation and Technology, Ms. Fiona Au, Assistant Commissioner of Innovation and Technology, Mr. Jeffrey Chim, Administrative Assistant to Secretary of Innovation and Technology, Ms. Jessie Wong, Press Secretary to Secretary of Innovation and Technology, Ms. Lillian Cheong, Political Assistant to Secretary of Innovation and Technology, and Mr. John Kwong, Head of Project Strategy and Governance Office, Development Bureau.

Figure 3. 28 Visit by Mr. Alfred Sit, Secretary of Innovation and Technology, the Government of Hong Kong SAR, and the delegation team

Visit by Mr. Hai-Shan Xu, President of the Hong Kong Academic Exchange Centre

On 10 August 2021, Mr. Hai-Shan Xu, President of the Hong Kong Academic Exchange Centre visited CNERC-Rail and was warmly welcomed by Prof. Yi-Qing Ni, Director of the CNERC-Rail. Prof. Yi-Qing Ni communicated with Mr. Hai-Shan Xu about the latest research technology and the progress of scientific research projects in the CNERC-Rail (Figure 3. 29). Dr. Su-Mei Wang, Research Assistant Professor of the CNERC-Rail, also joined the visit.

Figure 3. 29 Visit by Mr. Hai-Shan Xu, President of the Hong Kong Academic Exchange Centre

Visit by Prof. Qing-Yan Chen, Director of the Hong Kong Polytechnic University (PolyU) Academy for Interdisciplinary Research (PAIR)

On 26 October 2021, Prof. Qing-Yan Chen, Director of the Hong Kong Polytechnic University Academy for Interdisciplinary Research (PAIR) and Chair Professor of Building Thermal Science of the Hong Kong Polytechnic University, visited CNERC-Rail and its research facilities in Industrial Centre (Figure 3. 30). Ms. Florence Chan, Senior Executive Officer of the PAIR, joined the visit. Prof. Qing-Yan Chen and Ms. Florence Chan were warmly welcomed by Prof. Yi-Qing Ni, Director of the CNERC-Rail, together with key members of the CNERC-Rail: Prof. Hwa-Yaw Tam, Head of Electrical Engineering (EE), Prof. Li Cheng (Mechanical Engineering), Prof. Siu-Wing Or (EE), and Prof. Song-Ye Zhu (CEE).

Figure 3. 30 Visit by Prof. Qing-Yan Chen, Director of the PAIR

Visit by Prof. Christopher Chao, Vice President of the Hong Kong Polytechnic University

On 5 November 2021, Prof. Christopher Chao, Vice President (Research and Innovation) and Chair Professor of Thermal and Environmental Engineering of the Hong Kong Polytechnic University, visited CNERC-Rail and its research facilities in the Industrial Centre (Figure 3. 31). Ms. Aileen Chau, Administrative Officer of VPRI's office, joined the visit. Prof. Christopher Chao and Ms. Aileen Chau were warmly welcomed by Prof. Yi-Qing Ni, Director of the CNERC-Rail, together with center members: Dr. Siu-Kai Lai, Associate Professor of Civil and Environmental Engineering (CEE), Dr. Lu Zhou, Research Assistant Professor of CEE, Dr. You-Wu Wang, Research Assistant Professor of CEE, and Dr. Su-Mei Wang, Research Assistant Professor of CEE.

Figure 3. 31 Visit by Prof. Christopher Chao, Vice President of the Hong Kong Polytechnic University

Visit by Dr. Tony Lee, Operations Director of the MTR Co., Ltd., and the Delegation Team

On 12 November 2021, Dr. Tony Lee, Operations Director of the MTR Co., Ltd. led a team to visit CNERC-Rail and research facilities in Industrial Centre (Figure 3. 32). The MTR visitors include Mr. Nelson Ng, Chief of Operations Engineering, Mr. Ho-Wing Chan, Head of Operations Innovation Hub, Mr. Hing-Koeng Chan, General Manager of Engineering & Innovation Centre, Mr. Kim-Hung Lee, General Manager of Rolling Stock Workshop. The guests were warmly welcomed by Prof. Yi-Qing Ni, Director of the CNERC-Rail, Prof. Hing-Keung Lam, Chair Professor of Civil and Transportation Engineering, and Dr. Hon-Wah Wai, Director of Industrial Centre. The academic staffs from the Hong Kong Polytechnic University (PolyU), including Prof. Zhi-Zhao Liu, Professor of Land Surveying and Geo-Informatics (LSGI), Dr. Siu-Kai Lai, Associate Professor of Civil and Environmental Engineering (CEE), Dr. Xin-Tao Liu, Assistant Professor of LSGI, Dr. Ma Wei, Assistant Professor of CEE, Dr. Lu Zhou, Research Assistant Professor of CEE, and Dr. You-Wu Wang, Research Assistant Professor of CEE, also joined the visit.

Figure 3. 32 Visit by Dr. Tony Lee, Operations Director of the MTR Co., Ltd., and the delegation team

Visit by Mr. Patrick Siu, Chief Executive Officer of the Hong Kong-Shenzhen Innovation and Technology Park Limited (HKSTP), and the Delegation Team

On 20 December 2021, Mr. Patrick Siu, Chief Executive Officer of the Hong Kong-Shenzhen Innovation and Technology Park Limited (HKSTP) visited the Hong Kong Polytechnic University and research facilities of the CNERC-Rail in Industrial Centre (Figure 3. 33). Ms. Michelle Kam, Director of Operations of HKSTP, and Ms. Dora Chin, Associate Director of Business Development of HKSTP, joined the visit. Mr. Patrick Siu, Ms. Michelle Kam, and Ms. Dora Chin were warmly welcomed by Prof. Yi-Qing Ni, Director of the CNERC-Rail. Prof. Yi-Qing Ni introduced the latest research technology achievements and scientific research projects for the guests. The key center members including Dr. Siu-Kai Lai, Associate Professor of Civil and Environmental Engineering (CEE), Dr. Lu Zhou, Research Assistant Professor of CEE, and Mr. Chao Zhang, Associate Research Fellow, joined the visit.

Figure 3. 33 Visit by Mr. Patrick Siu, Chief Executive Officer of the HKSTP, and the delegation team

News Interview

Interview with the Radio Television Hong Kong (RTHK)

In September 2021, the CNERC-Rail was invited by the Radio Television Hong Kong (RTHK) and participated in the shooting of the program “I&T New Era”. The program consists of 22 three-minute episodes and introduces the research projects and achievements of 16 scientists from six Hong Kong branches of the State Key Laboratories (SKLs) and the China National Engineering Research Center (CNERCs). The videos outline how these research projects improve people’s daily lives and aim to improve public understanding of scientific research. Prof. Yi-Qing Ni, Director of the CNERC-Rail, participated in the interview and recording on behalf of the center (Figure 3. 34). The chapter of the CNERC-Rail will be broadcast on the RTHK 31 at 20:25 in March/April 2022. After the premiere date, each chapter will be repeated on the RTHK 31 and 32. The video will be uploaded to the RTHK’s Facebook page and YouTube channel.

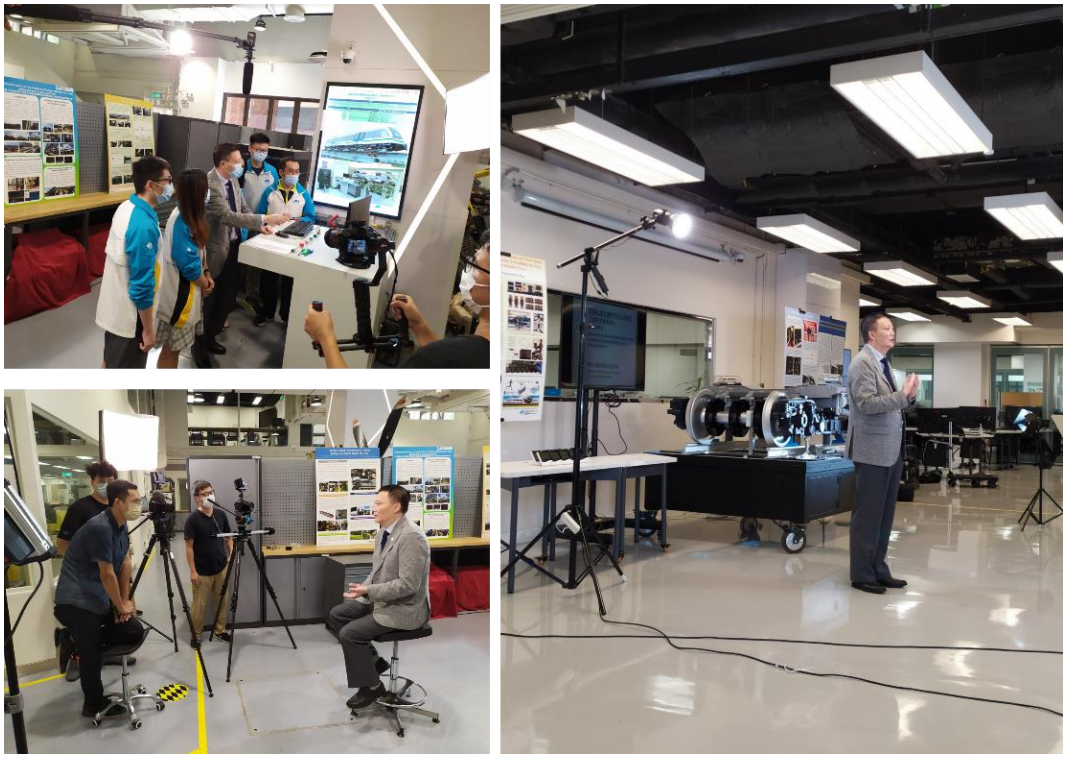


Figure 3. 34 Prof. Yi-Qing Ni, Director of the CNERC-Rail, participated in the interview and recording by RTHK

Interview with the Hong Kong Polytechnic University

In November 2021, Prof. Yi-Qing Ni, Director of the CNERC-Rail was interviewed by the Hong Kong Polytechnic University for winning the "Yim, Mak, Kwok & Chung Endowed Professorship in Smart Structures" (Figure 3. 35). The "Yim, Mak, Kwok & Chung Endowed Professorship in Smart Structures" is a professorial chair set up by Mr. Kwok-Fai You, Executive Director of the Able Engineering Holdings Limited, in his name to support the Hong Kong Polytechnic University's research in the field of structural engineering. It is named after his four former teachers at Kwun Tong Government Technical Secondary School (now known as Kwun Tong Kung Lok Government Secondary School): Mr. Kwong-Rong Yim, Ms. Suk-Hing Mak, Mr. Hee-Leung Kwok, and Ms. Wai-Fan Chung. With the professorship, Mr. Kwok-Fai You hopes to celebrate the selfless dedication of exemplary teachers to students and their contributions to society.

Figure 3. 35 Prof. Yi-Qing Ni, Director of the CNERC-Rail, participated in the interview and recording by the Hong Kong Polytechnic University

Appendix

A.1 Purchased Equipment

No.	Device/Sensor	Quantity
1	Simulation software package for calculating the elastic/viscoelastic rolling contact, for the railway wheel-rail contact simulation	1
2	Rail Particle Damper and Fixture	34
3	Enhancement of the Test Platform for Electromagnet-Rail Coupling Vibration of Medium-Speed Maglev	1
4	Uni-axial accelerometer	4
5	High-speed Camera system	1
6	200TB data storage unit	1
7	8 channels multi input DAQ	1
8	High Power Gated RF Pulse Amplifier	1
9	Industry-level Drone : Matrice300RTK	1
10	YZKD KD1500LS-Triiaxial accelerometer	2
11	3 sets of AOMS temperature and humidity sensors	3
12	Expansion units for existing Huawei server	1
13	High cores CPU with GPU computing servers	1
14	DEWESOFT Ethercat Solution with FOC Cable	1
15	Thin line pressure transducer signal conditioner	2
16	Heating equipment, "Sun Run" jack	1
17	Digital Storage Oscilloscope	1
18	B&K duel channel waveform generators	1
19	Shaker excition force sensor	1
20	DSI-ACC adapters for 8 channels STG Dewesoft DAQ	8
21	Laser displacement transducer	2
22	B & K 4231 Sound Level Calibrator	2
23	FBG temperature and strain sensors	15
24	Dytran accelerometers	5

25	Dewesoft 16 ch DAQ, software and accelerometers	1
26	Modules for Simulation of Railway Vehicle Dynamics	1
27	Keyence Laser displacement sensor	1
28	enDAQ accelerometer	1
29	Levitation System Commissioning software	1
30	Stainless-Steel Balls for particle damper	1
31	Remote Sensing system	1
32	100g Accelerometer	4
33	Triaxial accelerometer	2
34	Workstation Computer	1
35	Load cell LCX	1
36	Load cell LUR	1
37	LVDT 50mm	1

A.2 News Report

香港新聞 Hong Kong Commercial Daily http://www.hkcd.com

監察路軌安全 守護鐵路乘客

倪一清研傳感器屢獲國家大獎

港創科 創科港

【香港商報訊】特約記者呂少群、記者文毅報道：香港理工大學的「國家軌道交通電氣化與自動化工程技術研究中心香港分中心」，是國家科技部批准在港設立的六個工程分中心之一，成立5年多以來，該中心在土木及環境工程學系講座教授倪一清帶領下，開注面從地鐵、高鐵擴展到磁懸浮列車，開發了控制高鐵列車振動的技術以提升鐵路安全水平。有關技術除應用於國家高鐵項目，包括京滬高鐵，也應用於新加坡和巴西地鐵系統。實踐着「科學報國、科研為民」的初心。

倪一清與本港及內地人員測試列車高鐵振動系。

研究人員在列車軌道安裝傳感器(圖後)。

倪一清致力研究各種傳感器，讓高鐵成為智慧高鐵。

光纖傳感器監控軌道風險

人們搭列車，有時會覺得振動很大，原因是車輪出現扁疤。傳感器的作用就是發現哪列車輪出現了扁疤，2013年，倪一清團隊研發的光纖光柵傳感器安裝於路軌上，協助鐵路人員追蹤列車不同軌的情況，適時維修，保障乘客安全。

2014年，其團隊曾與智慧鄰尼技術，通過電力系統低不同車速產生的振動，在京滬高鐵上，非型鄰尼器可連付逾300公里最高時速，亦可在一般時速運用自如，既令整車舒適，又可延長列車壽命。

加入雙大第20期年級的倪一清，致力協助鐵路建監網，協助振動與控制，智慧材料與結構，以及傳感器技術等領域的研究。

期待傳感器成列車一部分

近年地鐵網擴展，產一步採取三維射頻識別技術，超智波等手段，監測軌道狀況及軌道幾何，並用以監測地鐵、城軌和高鐵軌道運作。他表示，未來將運用大數據建立數據庫，高效快速地診斷出各類缺陷，更是期待的研究。

登起灣區軌道交通協同中心

除了鐵路工作發展，倪一清的研究成果亦應用於保障飛機和航運安全方面。他參與香港青馬大橋及昂船洲大橋的結構健康監測系統設計，在橋塔將大橋設計溫度傳感器以監測溫度在長55公里、8車道的全球最長斜纜鋼結合跨海通道的安全。

多年來，倪一清應邀為廣州港、深圳鹽田安易有限公司等大型港口非等物，進行全面命脈的健康監測。「廣州港工程關鍵技術」項目獲得最高2000年國家科學技術進步第二等獎。近年亦獲得中國鐵路工程學會科學技術獎。

在倪一清指導下，由雙大與深圳大學及超、騰訊中山大學、廣州大學、澳門大學以及英國倫敦帝國學院、伯明翰大學等12間大學和企業，成立「粵港澳大灣區軌道交通協同創新中心」，希望透過共同合作，充分發揮技術優勢，實現資源共享、聯合共贏。

身為雙大與道工程跨學科研究召集人，倪一清特別強調跨學科合作，五年來帶領團隊與校內工學及系統工程學系和航空及民航工程學系等八個學系開展合作，透過科研協作，為港提更安全社會一貫努力。

（《香港科 創科港》由本報和香港專業交流中心合作推出）

5男涉販毒落網包括2青少年

【香港商報訊】記者盧沐海報道：警方上周展開反毒品行動，分別在紅磡、荃灣和東大嶼圍共拘捕5名男子，其中兩人仍未成年，檢獲海洛英、可卡因、咭達可卡因及氯胺酮等毒品，總值1780萬元，警方呼籲家長注意拘捕學生證號子女是否拘捕干涉分子和外圍毒品網。

毒品調查科高級督察何福樂表示，拘捕組報及深入調查後，在上周五(15)第開展反毒品行動，當日下午3時許，警員於油麗道全合安警徵金紀錄一個該場所，當時房內有一名17歲男子，搜出17歲共重8.8公斤咭達英，以及13包以英業貨包裝共重13公斤的氯胺酮，市值約1430萬元。警員拘該名男子拘捕，涉嫌「販運危險藥物」。其後警員在同日晚至深圳一工廠大廈單位搜查，再拘捕1名20至30歲男子，涉嫌「串謀販毒」。

警方檢值1780萬毒品

除檢舉組，在拘該中被捕的17歲男子報稱無業，已被暫控一項「販運危險藥物」罪，將於今日在九龍城裁判法院提堂。其餘被捕3人，16歲男子與一名學生，另外兩人報稱無業和從職合資員，他們已獲准保釋候查，若於下月中旬再警下報到。

在同日下午4時，另一隊警員與東大嶼區展開一連串外截查一名日籍男子，在其手持的一個單保袋內，搜出約重940克可卡因及約7克咭達可卡因，警員將他與獲悉其相住的單位內，再搜出疑重約1.3公斤可卡因、12包約260克咭達可卡因、少量冰毒、約2萬元以及一批製毒工具，毒品市值約350萬元，被捕39歲男子報稱無業，涉嫌「販毒」及「製毒」今日在九龍城裁判法院提堂。

案中檢獲大批毒品及毒品包裝工具。

陳檢舉表示，留意到該個人士中兩人未成年，相信是透過社交媒體認識例不法分子，或聽聽暴徒開開青少年心念「攬炒班」，以金錢引誘，令年輕人誤入法網。他呼籲父母與子女應多作溝通，如有需要應尋求有關部門的協助。

灣仔警區掃黃拘68人

【香港商報訊】記者盧沐海報道：灣仔警區在上周五(19日)展開代號「驅逐」大型掃黃行動，動員逾百警力，揭破16個設於灣仔的娛樂場所的控制場所，大部分有提供性服務，行動中共捕68名男女，包括涉嫌主腦和骨幹成員，檢獲30萬元現金；警方指相關已遣散員內提控場所。

無廣告牌裝玻璃圍避警

灣仔警區總督察(刑事)馬雪梅行動主任何淑幸表示，在本年初進行情報搜集，留意到不法分子趁疫情期間，利用網絡平台招攬客人，以提供色情服務為幌子，在樓上單位開設無牌娛樂場所，並提供性服務。為逃避警方執法，單位內無廣告牌，且在大堂外圍和走廊等公眾地方安裝閉路電視錄影監控，經過多月偵查，相信絕大部分控制場所都有實際活動進行，在上周五(19日)展開代號「驅逐」行動，鎖定區內16間樓上單位處所，拘捕3男65女(19至66歲)，當中4人是屬於3個管理架構的主腦，6人是架構骨幹成員，另外50人屬性工作者(19至46歲)，涉違「控制他人為目的而安排他人進行非法性交」、「藉用不可合法受僱人士」、「協助經營娛樂場所」及「違反逗留條件」等罪。行動中檢獲超過30萬元港幣和內地幣，相信是首批收益，大量按摩椅、避孕套、數碼相機設備等證物。

弘揚中華傳統文化

善爲至寶，一生用之不盡

衆人常懷善良之心，會讓行善成爲一種習慣，從而改變人生的軌迹，命運。

善良的內心就像一座巨大的寶藏，待之以世，堅持不懈的行善積德，能量和福報自會源源不絕，福氣滿滿。古語云：「善爲至寶，一生用之不盡；心作良田，百世耗之有餘。」善良是一切福報的種子，埋心通着，自會生根發芽，欣欣向榮，結出善果，福澤深厚。

宋朝時江蘇崇州人許叔微，自幼家貧，好苦讀書，屢早赴考上了秀才，卻在參加會試時屢屢落第，一次下他落地返鄉途中，乘船經過平望小鎮，夢見關王指點他說：「你沒有積下陰德，所以福緣淺薄，屢考不中。」許叔微說：「我家境貧寒，沒有錢財施給別人，怎麼積陰德呢？」關王說：「你有善心，可以學醫濟世救人，我可以幫你。」

許叔微回到家後，認眞研讀醫書，悟得了扁鵲、張仲景的精粹醫理，醫術大進，凡上門求醫之人，許叔微都是有求必應，細心診治，遇到家境貧困者，許叔微還贈送藥物，不收分文，被他治好的人，不計其數。

南宋建炎元年，貴州發生瘟疫，許叔微上門爲百姓診治，十治八九，五年後，許叔微到禮部參加會試，又經過平望，再次夢見關王，謝許叔微：「冥有陰功，陳榜開處：堂上呼慶，喝六作五。」

許叔微醒來，苦思冥想，不解其意。當年會試，許叔微以進士第六名及第，不久，因上方有一名平台格，所以升爲第五名。他的上一名叫陳祖言，下一名叫樓材，他的名次正是處於陳、樓二人之間，許叔微方才有悟夢中許句的意思，冥冥中一切都有安排。

許叔微與抗金名將韓世忠過從甚密，不滿高宗句安江南及秦檜陷害忠良，退隱鄉裏，行醫濟人，百姓奉爲神醫，尊稱他爲「名醫進士」。

許叔微心慕宜興，結廬忘歸，遇事教言，與人爲善，人們讚其「唐世活人，矢誼如一」。許宏存醫，不爲利回，他的兒子許必勝、孫子許時都考中了進士，家道昌盛，許氏一族成爲名門望族。

善良是一個人高貴的品格，心存善念，善待別人，上天自會眷顧，福報自來，是當大福說：「潛行善舉，是永不失敗的投資；慈悲大愛，是永不戰敗的信牌。」

北宋宰相司馬光持行善積德教爲家族的傳家寶，司馬光在《家訓》說：「積金以遺子孫，子孫未必能守；積書以遺子孫，子孫未必能看；不如積陰德於冥冥之中，以爲子孫長久之計。」

中國歷史上聲名顯赫的名門望族，百世其昌，繁衍興旺，都是自祖上到後代子孫，一代人一代人行善積德而來。

善良是一切福氣和福報的根源，一個人，一個家族只有行善積德，才能興旺昌盛，富貴，康寧和善舒，五福臨門，福運綿延。

唐代時，唐東陽禮龍山縣人盧庇道，乾隆四十九年考取進士，有位相士給他相面，說他這一生只能做到縣令官，乾隆五十九年，唐東的堂大哥因案決，盧庇道因爲了要援郎，目睹百姓流離失所的慘狀，毅然拿出全部家產救助鄉親安定成家的善舉。

除此之外，他還捐立義學，講授儒家經典，五常八德，勸導世人積德行善，廣積陰功，後來，他回到京城，郭泰相士看了他的面相，很驚訝地說：「你一定懂了許多福證，不然面相和骨格怎麼會改變這麼多？你可以告上福品官了！」盧庇道把經過告訴相士，相士笑着說：「相由心生，你的前程未來不可限量！」

盧庇道任官期間行走，園子監祭酒，與甘肅學使，某官至都察院副都御史，兵部右侍郎，他的兒子盧承錫，道光六年考取進士，進入翰林院，做了刑部主事官。這也是因爲盧家行善積世，福蔭子孫的緣故。

《格言聯璧》有對聯說：「古今來多少世家，無非積德；天地間第一人品，讀是讀書。」積德能無人見，行善自有天知。一個人心存善念，積德累功，積德的福氣和福報，不僅可以改變自身的前程和命運，還可以惠及子孫後代，福蔭家族。

人行善，福氣來至，禍已遠行；人行惡，禍緊來至，福已遠去。人有善心，行善積德，不止是一種修養，一種慈善，更是一種遠見，一種智慧。善良的人，自帶福星，行善之心不滅，福星之光就會永遠照臨。

弘揚關帝文化 彭允好

新华网 湖南

湖南与粤港澳大湾区开展科技创新专题对接

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7月29日上午，由湖南省人民政府主办，湖南省科技厅承办的2021年“港洽周”专题活动——湖南-粤港澳大湾区科技创新融合发展对接会在深圳举行。

会议重点推介了湖南打造具有核心竞争力的科技创新高地相关部署情况，以及岳麓山国家大学科技城、马栏山视频文创产业园“两山”建设和重点产业发展情况，并发布技术需求200余项。参会代表围绕科技创新对接合作机制共建、产学研协同发展、重点产业领域合作、高端人才引进与培养、科技成果转化等主题内容，进行了深入交流与探讨。

会上，马栏山视频文创园、国家先进轨道交通装备创新中心、湖南大学、湖南农业大学、长沙理工大学、补天健康产业控股集团有限公司等有关单位与深圳市前海手绘科技文化有限公司、深圳方大智创科技有限公司、京兆昌九（中国）股份有限公司等创新主体现场签订6项战略合作协议，将促进湖南与大湾区在轨道交通、生物医药、人工智能、视频文创等产业领域对接合作。

湖南省人民政府副省长何报翔说，粤港澳大湾区是我国开放程度最高、创新活力最强、发展潜力最大的区域之一，近年来，湖南积极对接粤港澳大湾区，不断加强在研发攻关、创新平台建设、知识产权保护、人才培养、科技金融等方面的合作，取得了一批丰硕的合作成果。他表示，湖南正大力实施“三高四新”战略，奋力建设现代化新湖南，希望通过此次对接会，进一步深化双方在科技创新领域的交流合作，湖南将以更加优惠的政策、更加优美的环境、更加优质的服务，为双方在科技创新政策、资源、项目、人才、平台等方面密切交流合作提供有力保障，着力共建协同创新体系，共促产业深度融合，共绘高质量发展新篇章。

会议同时举办了湖南科技创新展，现场展示湖南科技创新政策和成果。湖南各市州科技局、有关高新区和园区、科研院所、高校和企业代表还组成代表团，专程前往深圳前海管理局“取经”，实地考察学习科技创新先进经验，了解前海发展规划以及深港青年创新创业情况。(廖晨昊)

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創科新里程

簡介 GIST

中國近年經濟增長迅速，創科熱潮席捲全國，而在國家規劃未來社會經濟藍圖中，支持香港建設國際創新科技中心，展望香港變成「新矽谷」。目前，全國約有兩百多個經科學技術部批准的「國家重點實驗室」，而香港亦已設有16個「國家重點實驗室」，及6個「國家工程技術研究中心香港分中心」，各有不同的研究重點，他們的科研除了帶來進步，亦帶來啟發，為香港年青一代作為借鏡，讓創新之路在未來走得更快更遠，趕上創科新里程。

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