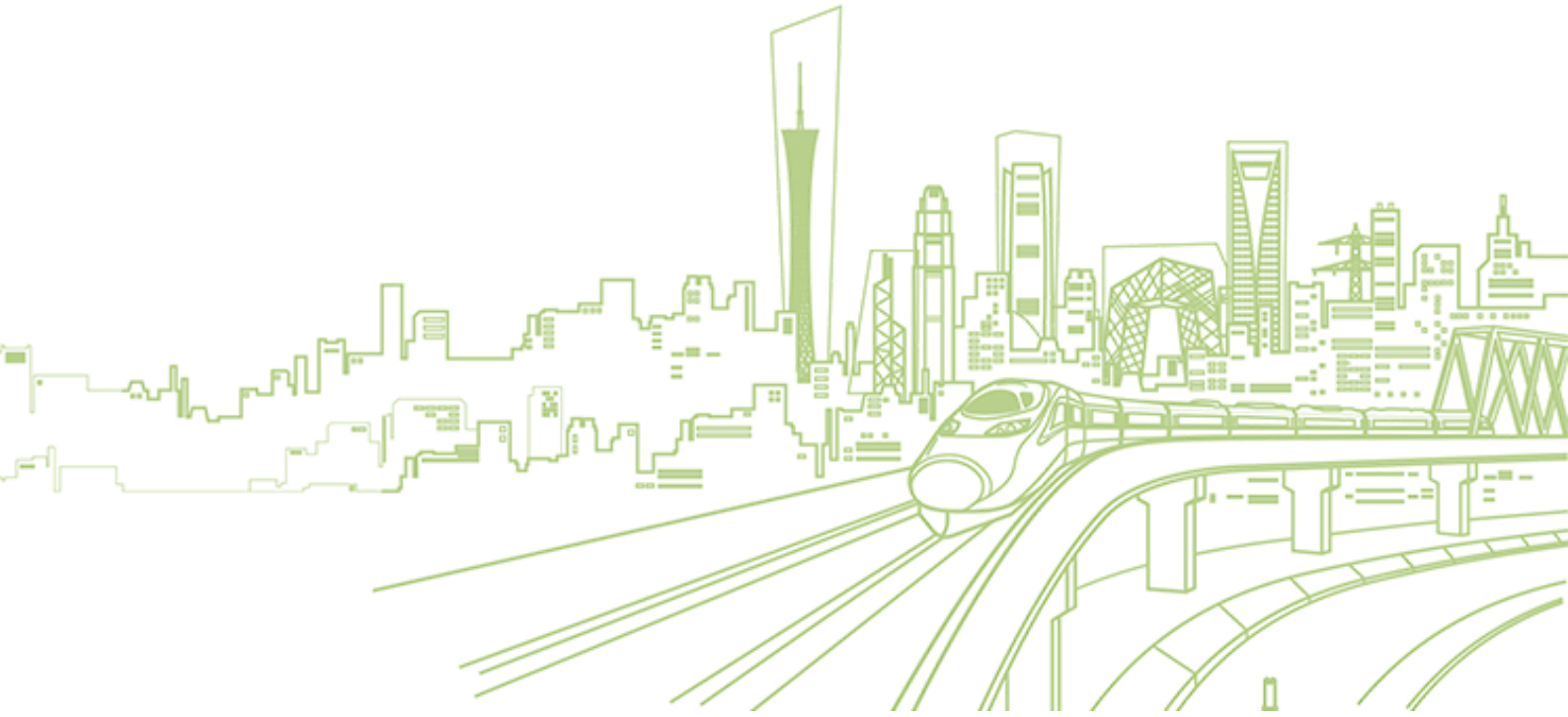
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

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)

2020 Annual Report

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



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Director's Foreword

Over the past year, the abrupt outbreak of the COVID-19 epidemic over the world has significantly influenced all walks of life, including the Hong Kong Branch of the National Rail Transit Electrification and Automation Engineering Technology Research Center (CNERC-Rail), but the pandemic never stopped our pace of research and development.

It can be seen from the stress on accelerating interconnecting infrastructure in the Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area, to the statement of constructing "Greater Bay Area on Tracks" in the Reply to the Intercity Railway Construction Plan for the Guangdong-Hong Kong-Macao Greater Bay Area issued by the National Development and Reform Commission in 2020, that all levels of governments are offering great anticipation and solid support to the development of railway in the Greater Bay Area (GBA), in terms of both macro strategies and specific policies. The CNERC-Rail has been taking the opportunity, actively participating in the development of the GBA, and helping the GBA take off upon railway tracks. Throughout the past year, the CNERC-Rail has participated in the drafting work of the Rail Transit Industry Development Report for the Guangdong-Hong Kong-Macao Greater Bay Area in the role of associating editor unit, applied for research projects including Science and Technology Planning Project of Guangdong Province, Technology Transfer Project of Research Outcomes in Hong Kong and Guangdong, New Engineering Research and Application Project of the Ministry of Education, Hong Kong-Macao-Taiwan Science and Technology Collaborative Project of Shanghai, in collaboration with multiple universities and enterprises in the GBA. Besides, the CNERC-Rail has initiated all kinds of collaborative work with China Railway Guangzhou Group Co., Ltd., Guangzhou Metro Group Co., Ltd., China Railway Guangzhou Engineering Group Co., Ltd. on many engineering and consultancy projects such as Guangzhou-Shanwei high speed rail and noise and vibration control of Guangzhou Metro.

In 2020, Center members overcame all kinds of difficulties and conducted a series of fruitful research activities. A 5-month in-situ testing and monitoring work was carried out on Shanghai Lingang maglev test line using our self-developed onboard and online monitoring system to investigate problems of viaduct stiffness, rail track anomalies, train vibrations and design optimization of rail turnout; four in-situ tests were conducted consecutively on Wenzhou urban rail lines to research into issues of rail noises, noise reduction and vibration mitigation, rail corrugation, etc.; rail corrugation state test was carried out in the curve segment of a Shenzhen metro line; evaluation of train bogie vibration was conducted in Nanning Metro in Guangxi Province. These in-situ testing and monitoring activities provided abundant and valuable data for scientific research.

At last, on behalf of all members in 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 on their great support to the CNERC-Rail. Hopefully we can make more substantial progress in the new year.

Yi-Qing NI

Ir. Chair Professor of Smart Structures and Rail Transit

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 2020

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 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 2020 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 2020 is presented in detail in the following sections.

Research Team

The CNERC-Rail research team consists of 13 key members. 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, and actively recruits talents from worldwide.

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	Songye 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	Hung-Lin Chi, Assistant Professor	Department of Building and Real Estate	Project Leader
2	Xu-Sheng Yang, Assistant Professor	Department of Industrial and Systems Engineering	Project Leader
3	Siu-Kai Lai, Assistant Professor	Department of Civil and Environmental Engineering	Project Leader

Table 1. 3 Recruited staff of CNERC-Rail 2020

No.	Name and Title	Position	Period of Employment	
1	Lu Zhou	Research Assistant Professor	2019/4/1	2023/6/30
2	Jin Guo	Research Fellow	2019/1/25	2020/3/24
3	Cui-Dong Xu	Research Fellow	2019/9/16	2020/6/30
4	Xiang-Yang Xu	Research Fellow	2019/10/30	2020/10/29
5	You-Wu Wang	Research Fellow	2019/6/7	2021/1/3
6	Seyed Masoud Sajjadi Alehashem	Research Associate, Research Fellow	2019/2/27	2021/9/9
7	Xiao-Zhou Liu	Postdoctoral Fellow	2018/7/26	2020/1/25
8	Su-Mei Wang	Postdoctoral Fellow	2019/4/1	2021/9/3
9	Xiang-Yun Deng	Postdoctoral Fellow	2019/9/25	2022/2/28
10	Chih-Shiuan Lin	Postdoctoral Fellow	2020/2/29	2022/2/26
12	Cai-Ling Fu	Postdoctoral Fellow	2019/10/03	2020/10/2
13	Chuan-Rui Guo	Postdoctoral Fellow	2020/8/28	2021/1/3
14	Xi-Zhen Xu	Postdoctoral Fellow	2020/10/26	2021/10/15
15	Yan-Peng Wang	Postdoctoral Fellow	2019/6/11	2020/6/10
16	Chao Zhang	Research Associate	2020/2/17	2022/2/16
17	Qiu-Hu Zhang	Research Assistant, Research Associate, Postdoctoral Fellow	2019/9/5	2022/10/4
18	Si-Qi Ding	Research Assistant, Research Associate, Postdoctoral Fellow	2019/9/6	2022/3/5
19	Chi Xu	Research Assistant, Research Associate	2017/1/10	2020/12/25
20	Yee-Yan Chan	Research Associate	2019/9/9	2020/9/8
21	Yang Lu	Research Assistant	2018/10/2	20223/31
22	Gao-Qiang Kang	Research Assistant	2019/7/16	2020/1/15
24	Tai-Tung Wai	Research Technical Assistant	2017/1/23	2024/1/22
25	Wing-Hong Kwan	Research Technical Assistant	2017/10/4	2021/3/31
26	Zi-Xin Su	Research Technical Assistant	2019/8/20	2020/2/19
27	Yuk-Yee Chow	Research Technical Assistant	2020/6/3	2021/6/2
28	Chen-Xing Zhang	Research Assistant, Research Associate	2020/2/14	2022/2/16
29	Xiang-Tao Sun	Research Assistant	2020/9/25	2021/9/11
30	Gao-Feng Jiang	Research Assistant	2020/10/22	2021/10/21
31	Yu-Ling Wang	Research Assistant	2020/10/14	2021/4/13
32	En-Ze Rui	Research Assistant	2020/10/14	2021/8/31
33	Lei Yuan	Research Assistant	2020/8/24	2020/12/31
34	Kai-Zhen Liu	Research Assistant	2019/9/2	2020/2/28
35	Qian-Cheng Wang	Research Assistant	2019/10/2	2020/1/31
36	Wan-Ting Sun	Research Associate	2019/9/2	2020/8/30
37	Lo-Long Yin	Research Assistant	2019/6/20	2020/6/19

38	Shen-Bo Shan	Research Associate	2019/7/8	2020/7/7
39	Yang Liu	Research Assistant	2019/7/21	2020/7/20
40	Wen-Zheng Xu	Research Assistant	2019/7/22	2020/3/31
41	Chi-Ho Chan	Research Assistant	2019/12/2	2020/1/31
42	Wai-Kin Lau	Research Assistant	2019/12/2	2020/12/1
43	Ru-Qi Sun	Research Assistant	2020/9/1	2020/11/30

Financial Report

In 2020, 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 $2,900,000
- Human Resource $4,050,000
- Equipment Purchase $7,600,000
- General Expenses $450,000

R&D Activities of CNERC-Rail 2020

Research Projects

Applied Research Grants

In 2020, the CNERC-Rail has applied/jointly applied 10 research grants, among which 7 projects have successfully been approved for funding with the total funding amount of more than 4 million RMB, and the rest 3 projects are pending for approval or waiting for oral defense. The funding schemes include theme-based research scheme from Research Grants Council (RGC) of the Hong Kong SAR Government, key program from National Natural Science Foundation of China (NSFC) and various international/Hong Kong-Macau-Taiwan collaborative projects in different levels of government. Detailed project information is shown in Table 2.1.

Table 2. 1 Applied Research Grants in 2020

No.	Title	Funding Source	Amount	Status
1	Trackside acoustic detection method for train axle bearing faults	Sichuan International/Hong Kong-Macau-Taiwan Science and Technology Collaborative Project	RMB 500,000	Approved
2	Development and application of new structure damping device based on inerter	Guangdong International Science and Technology Collaborative Project, Department of Science and Technology of Guangdong Province	RMB 990,000	Approved
3	Talent Fostering and Application of Transportation Engineering under New Engineering Plan in the Hong Kong-Macau-Guangdong Greater Bay Area	New Engineering Research and Application Project, National Ministry of Education	RMB 500,000	Approved

4	Track geometric condition monitoring system based on machine vision	Hong Kong-Macau Collaborative Research Fund, Wuyi University	RMB 400,000	Approved
5	Research on the key aerodynamic detection technologies in multi-field coupled for ultra-high-speed maglev vehicles	Hong Kong-Macau Collaborative Research Fund, Wuyi University	RMB 400,000	Approved
6	High-speed rail inspection robot based on image processing	Quanzhou Science and Technology Bureau	RMB 500,000	Approved
7	Investigation of influencing mechanism of high-frequency dynamic stiffness and damping characteristics on wheel-rail contact behaviors and vibrations	Research Project of China Academy of Railway Sciences	RMB 1,000,000	Approved
8	Development and application of smart monitoring platform for urban rail short-pitch irregularities	Department of Science and Technology of Guangdong Province	RMB 1,000,000	Pending
9	Smart safety assessment and pre-alarming technique for wind turbine tower based on machine learning	Hong Kong-Macau-Taiwan Science and Technology Collaborative Project, Science and Technology Innovation Plan of Shanghai	RMB 600,000	Pending
10	INTACT: Intelligent anti-tropical-storm system for coastal cities	Hong Kong Research Grants Council Theme-based Research Scheme 2021/22 (Eleventh Round)	HKD 45,050,000	Pending

Established Research Projects

The CNERC-Rail has established research projects with project information listed in Table 2.2.

Table 2. 2 CNERC-Rail Established Research Projects in 2020

No.	Title	Principal Investigator	Department	Start-End Date
1	Development and Design of Energy Harvesting System for Applications in High-speed Railway	Prof. Eric Cheng	Electrical Engineering	2020.12.1 – 2021.9.30

2	Development of a New Energy Harvesting Technique and Its Application in Railway Engineering	Dr. Siu-Kai Lai	Civil and Environmental Engineering	2020.12.1 – 2021.10.30

Research Progress

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

Under the Research Grants Council's Research Impact Fund (RIF) Research Scheme, 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.

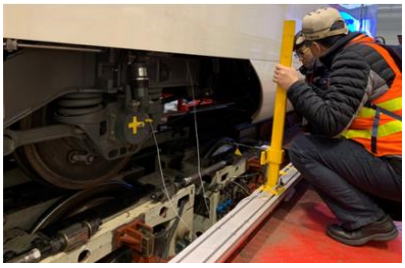
This project is aimed to use new technologies including advanced sensing techniques, big data analysis and artificial intelligence methods to enhance railway safety, punctuality and ride comfort. It consists of six main tasks focusing on wheel/rail wear prediction, advanced train suspension system development,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

In the first year (from 1 June 2019 to 30 June 2020), the research team has conducted extensive theoretical and experimental research on wheel-rail contact, machine learning algorithms for health monitoring of railway systems, new technologies for railway electrification systems, advanced railway suspension system and railway damage identification. To connect the research output with practice, the project team has established collaborations with different railway industries and universities all over China, such as the China Academy of Railway Sciences, Guangzhou Metro Co., Ltd. and Tongji University. By the reporting date

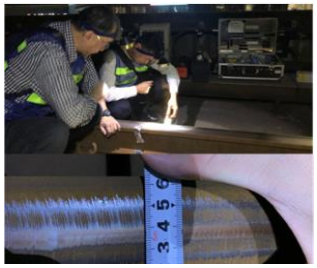
(30 June 2020), the team has conducted a number of in-situ tests, including monitoring of Shanghai Lingang Maglev system, noise control of Wenzhou Metro and Hong Kong MTR, rail condition in Guangzhou Metro and vehicle vibration in CRRC Zhuzhou Electric Locomotive Co., Ltd. (Fig.1). As the research output, during the first year of the project, the research team has published 15 papers directly arisen from this project, another 8 papers are under review. Furthermore, the team has submitted 4 patent applications. Among them, 2 have been approved.

On 17 June 2020, the project team held the first annual progress meeting in PolyU. The PC, Prof. Yi-Qing Ni, and all Co-PIs, Prof. Songye Zhu, Dr. Siu-Kai Lai, Prof. Siu-Wing Or, Prof. Kwok-Leung Tsui and Dr. Heung-Fai Lam, attended the meeting via either online video or face-to-face way at PolyU. Dr. Lu Zhou, Dr. Xiang-Yun Deng, Dr. Su-Mei Wang, Dr. You-Wu Wang, Dr. Ying-Yu Hua also attended the meeting. During the meeting, the PC, all Co-PIs and two researchers from PolyU gave presentations to report their research progress on the project (Fig. 2). After the meeting, the first annual progress report was submitted to the Research Grants Council on 31 August 2020.

Monitoring test, Lingang maglev test line, Shanghai



In-House laboratory test, Zhuzhou National Innovation Railway Technology Co. Ltd.



Rail inspection, Guangzhou Metro Co. Ltd.

Noise test, Wenzhou S1 railway

Noise test, MTR of Hong Kong

Figure 2. 1 In-situ tests of the RIF project in 2020

Figure 2. 2 First RIF progress meeting in PolyU (17 June 2020)

Smart Health Monitoring of Maglev Train Suspension System

Shanghai Lingang medium-low speed maglev test line, as the first maglev test line in China, provides a great test stage for the development of the Chinese maglev trains. Team members from the National Rail Transit Electrification and Automation Engineering Technology Research Center (Hong Kong Branch) of the Hong Kong Polytechnic University have carried out a series of research with the application of the independent developed vehicle-mounted and rail-mounted monitoring system in the test line for five months since August 2020, the detailed researches are listed as follows:

Investigation for girder stiffness limitation

Girder stiffness is a principal parameter for the design of a maglev-passing bridge, which may have a great impact on the vibration of the maglev vehicle. To investigate the stiffness limit value, a two-span simply-supported bridge with adjustable girder height was designed and installed. The vibrations of the F-rail and the steel girder were monitored with different girder stiffness (adjusted through controlling the girder height) under the moving loads of the maglev vehicle.

Influence of track abnormality (Geometric irregularity and Loose bolts) on the vibration of the maglev vehicle

A series of abnormalities of F-track are artificially installed at the test line. The vibration

of the maglev vehicle when passing through the abnormalities were recorded. The recorded data was applied to investigate the influence of track abnormalities on vehicle dynamics.

Optimization on the design of track turnout

According to the measurement data collected during the maglev passing the turnout section, resonance phenomena were observed on some turnout critical components. To overcome resonances, vibration data of turnout was collected. The numerical analysis was finally conducted along with the collected vibration data to offer an optimization design guidance.

Figure 2. 3 Steel box-girder with adjustable height

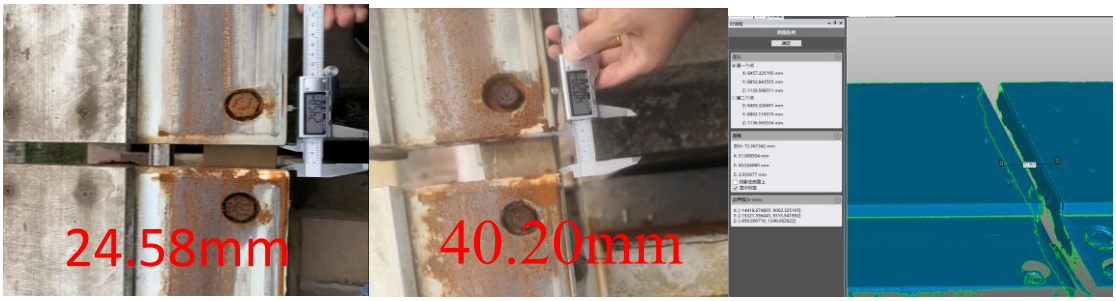


Figure 2. 4 Connectors of F-rails

Figure 2. 5 Turnout of mid-to-low speed maglev rail line

Inspection of Bogie Vibration for a Metro Line in Nanning, Guangxi

From 17 Sep 2020 to 18 Sep 2020, members from CNERC-Rail (Hong Kong Branch) conducted a bogie vibration test on Nanning Metro Line 4, Guangxi, to grasp the characteristics of bogies` vibration amplitude variations with varying speed and the corresponding frequency features during the train operation. The dynamic characteristics of the bogie of the Guangxi Nanning metro were collected through the on-board vehicle dynamic monitoring system. Specifically, the vibration data of bogies and vehicle grounds from both towing vehicles and non-towing vehicles with speeds ranging from 40 km/h to 90 km/h was collected.

Fig 2. 6 Bogie vibration measurement for the Nanning metro line, Guangxi

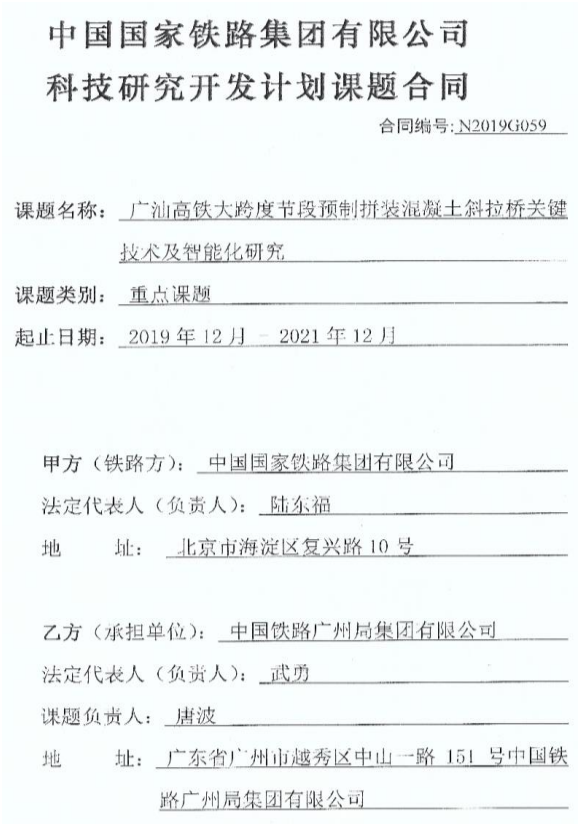
Key Technology Research on Long-Span Segment of Precast Concrete Cable-Stayed Bridge in Guangshan HSR

Key Project of Science and Technology Research and Development Project of the China State Railway Group Company

The Guangzhou-Shanwei High-speed Railway is designed with a total mileage of 206.2 km, a high-speed railway operation speed of 350 km/h, and 7 new stations. Its accomplishment will shorten the traveling time cost from 2 hours to 40 minutes, which ensures people`s traveling convenience and prompt the development of the eastern area of Guangdong Province. Zengjiang long-span Bridge is one of the key projects for the Guangzhou-Shanwei High-speed

Railway, and it is also the first concrete cable-stayed railway bridge by using precast segmental construction method in the world.

In July 2020, the contract of "Key technology research on long-span segment of precast concrete cable-stayed bridge in Guangshan HSR" was formally signed, where CNERC-Rail is responsible for the research sub-project titled “Research on development an intelligent monitoring method of alignment control of long-span segment of precast concrete cable-stayed bridge”. The laser scanner and industrial-grade unmanned aerial vehicle will be applied to scan the shape features of the precast construction parts. With the scanned results, structural health monitoring will be conducted on the main-girder precast construction and bridge tower alignment inspection. Meanwhile, the scanning results will be compared with traditional total stations to raise an updated high-efficient monitoring strategy. Besides, the measurement accuracy, stability and battery life of the full-version swift precast construction monitoring techniques by unmanned aerial vehicle will also be investigated.



中国国家铁路集团有限公司
科技研究开发计划课题合同

合同编号：N2019G059

课题名称：广汕高铁大跨度节段预制拼装混凝土斜拉桥关键技术及智能化研究

课题类别：重点课题

起止日期：2019 年 12 月 – 2021 年 12 月

甲方（铁路方）：中国国家铁路集团有限公司

法定代表人（负责人）：陆东福

地　　址：北京市海淀区复兴路 10 号

乙方（承担单位）：中国铁路广州局集团有限公司

法定代表人（负责人）：武勇

课题负责人：唐波

地　　址：广东省广州市越秀区中山一路 151 号中国铁路广州局集团有限公司

Figure 2. 7 Signed contract of the sub-project

On 4 August 2020, Dr. Ruolin Wang and Mr. Youliang Zheng, members of CNERC-Rail, went to China Railway Guangzhou Engineering Group Co. Ltd. to attend the kick-off meeting of the Research Project and introduced the research plan.

Figure 2. 8 Meeting on 4 August 2020

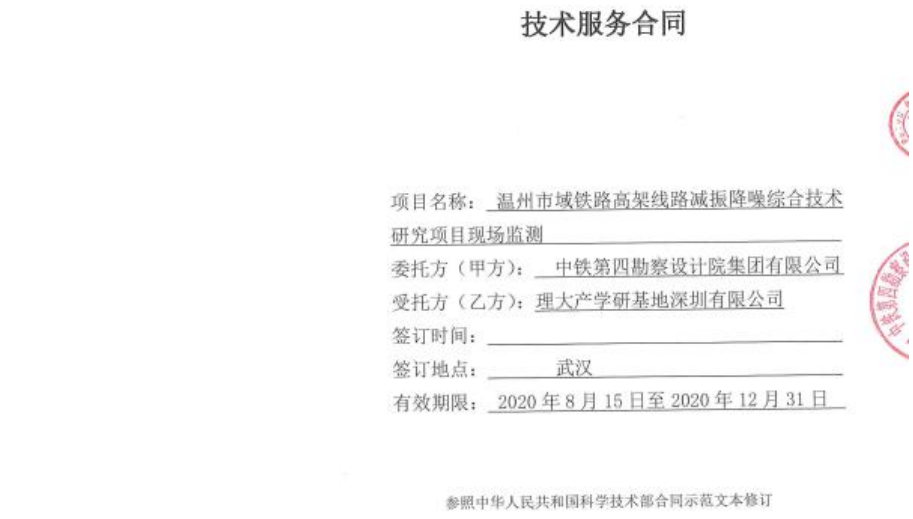
On 4 December 2020, Mr. Chao Zhang, member of CNERC-Rail, went to China Railway Guangzhou Engineering Group Co. Ltd. to attend the progress meeting and introduced the current execution plan. After the meeting, Mr. Chao Zhang visited the construction site of Zengjiang Large-span Bridge for the preparation of the following in-situ field test.

Figure 2. 9 Progress meeting and site inspection on 4 December 2020

Research on Integrated Technologies of Vibration and Noise Control for Viaduct Section of Wenzhou Urban Rail Rapid Transit System

This project is the scientific research subject of Wenzhou Railway and Rail Transit Investment Group Co., Ltd.

In 2020, the contract of "Research on integrated technologies of vibration and noise control for viaduct section of Wenzhou urban rail rapid transit system" was formally signed with China Railway Siyuan Survey and Design Group Co., Ltd.



技术服务合同

项目名称：温州市域铁路高架线路减振降噪综合技术研究项目现场监测

委托方（甲方）：中铁第四勘察设计院集团有限公司

受托方（乙方）：理大产学研基地深圳有限公司

签订时间：

签订地点：武汉

有效期限：2020 年 8 月 15 日至 2020 年 12 月 31 日

参照中华人民共和国科学技术部合同示范文本修订

Figure 2. 10 Project technical service contract

Through numerical simulation, theoretical analysis for the noise and vibration of Wenzhou S1 line, the aim of this research project is to development a comprehensive vibration and noise reduction scheme for viaduct section of Wenzhou urban rail rapid transit system to apply on the planning line in the future.

During 2020, Dr. Xiang-Yun Deng, Mr. Yun-Ke Luo, Mr. Chao Zhang and Mr. Xin Ye have conducted a series of monitoring tests on structural vibrations and noise of elevated rail tracks, as well as environmental noises.

Figure 2. 11 Noise and vibration test of Wenzhou S1 line in January 2020

Figure 2. 12 Noise and vibration test of Wenzhou S1 line in September 2020

Figure 2. 13 Source/frequency resolving analysis of Wenzhou S1 line in October 2020

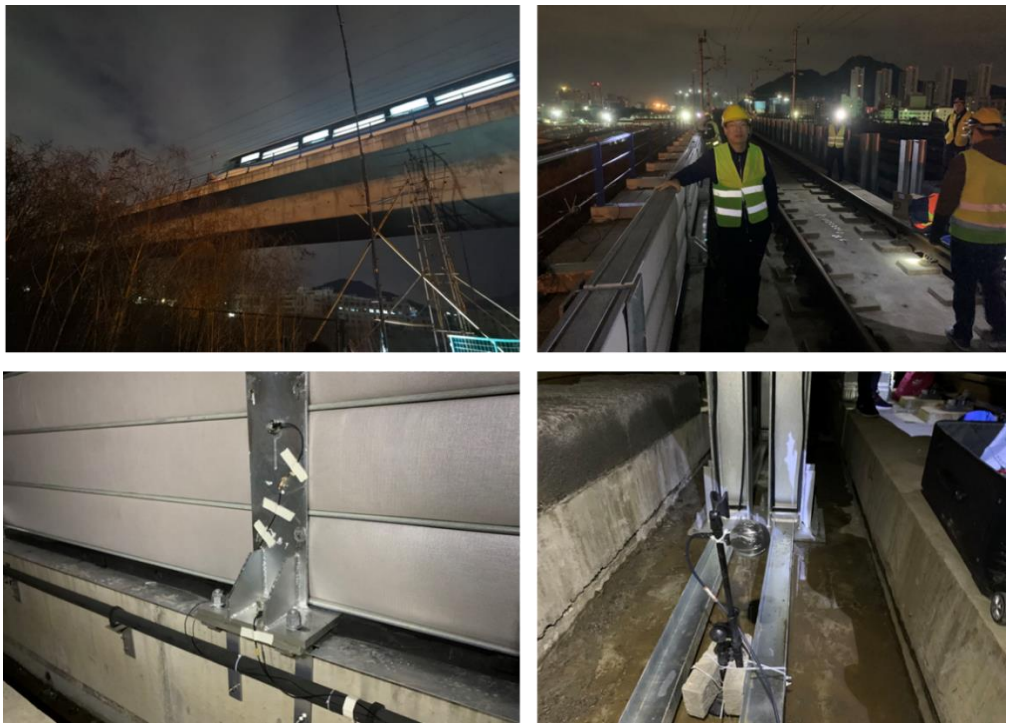


Figure 2. 14 Assessment of vibration reduction measures of Wenzhou S1 line in November 2020

Developing A New Rail Particle Damper

Rolling noise caused by intense wheel/rail interactions has long been a global concern, and great efforts have been spent reducing rolling noise. When the vibration propagates in the wheel and rail, the structure radiates noise. Noise reduction and vibration mitigation of railway systems in operation are imperative for ensuring their safety, serviceability, and protecting human health. It is, therefore, necessary to develop a proper noise and vibration control device for railway systems. To that end, a novel rail particle damper (Rail-PD) was designed and prototyped, and its performance was evaluated through comprehensive experiments and numerical simulations. A particle damper (Figure 2. 15) is an auxiliary-mass type vibration damper wherein various types of particles (e.g., ball-shaped particle, sand, powder, liquid, etc.) are placed within the cavities of the vibrating structure or the enclosures attached to the vibrating structure to mitigate the response of the structure. When the structure vibrates, the particles collide with each other and with the enclosure walls, causing damping through inelastic or nearly inelastic collisions and friction between particles. The proposed rail particle damper can mitigate the broadband noise and vibration (500-1500Hz) generated in the variant rail operating environments.

To further evaluate the performance of the developed rail damper in a real operating condition, a unique configurable Rail Dynamic Testbed is designed and installed at PolyU Shenzhen Base Lab (Figure 2. 16). The designed testbed is a platform to simulate the wheel/rail interactions by using dynamic shakers. It enables the study of various phenomena in the railway field to explore and evaluate each phenomenon's cause in a laboratory environment and eventually find a proper solution for the problems. The testbed is a 6-meter full-scale rail track, including ten synthetic sleepers and two CHN60 rails, installed in the standard-gauge distance (1435 mm) and fixed to the concrete floor by using bolts. In total, three types of fastening system which are commonly used in China railways are chosen and installed on the testbed. A controllable dynamic force will apply to one end of the rail system through two dynamic shakers. The dynamic force can be applied in both directions, i.e., lateral and vertical, individually. By employing the dynamic rail testbed, several research projects related to

broadband vibration and noise phenomena with different track forms can be initiated in the future.

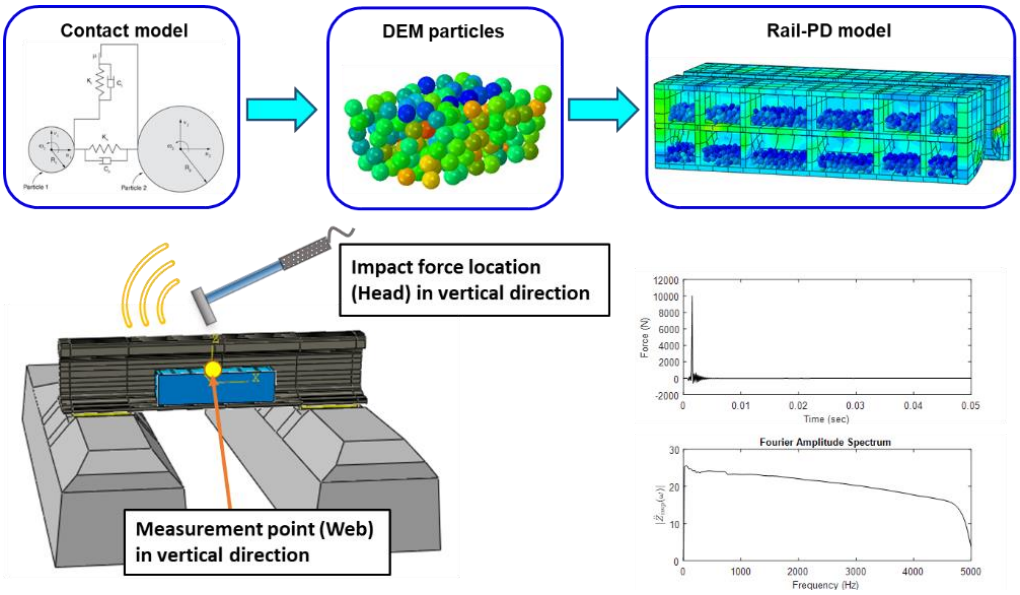


Figure 2. 15 Rail particle damper model based on DEM method

Figure 2. 16 Rail dynamic testbed

In-situ Test of Rail Corrugation and Wheel Wear on Wenzhou Suburban Railway S1 Line

To investigate the formation mechanism and evolution of rail corrugation on suburban railway, on 6 September 2020, four members of CNERC-Rail, Mr. Yun-Ke Luo, Mr. Chao Zhang, Mr. Youliang Zheng and Mr. Xin Ye, conducted a visit to Wenzhou Suburban Railway Line S1. The railway section between Panqiao Station and Wenzhou South Station was inspected. In the inspection, the corrugation condition was recorded by photographing, and the 3D geometry data of corrugation was collected by a 3D laser scanner. To monitor the wear evolution of wheel, on the following days, the team also visited a Metro Vehicle Depot and collected the 3D geometry data of wheels of vehicles in operation. The collected data will be used for the evaluation of rail corrugation and for the study of the corrugation evolution.

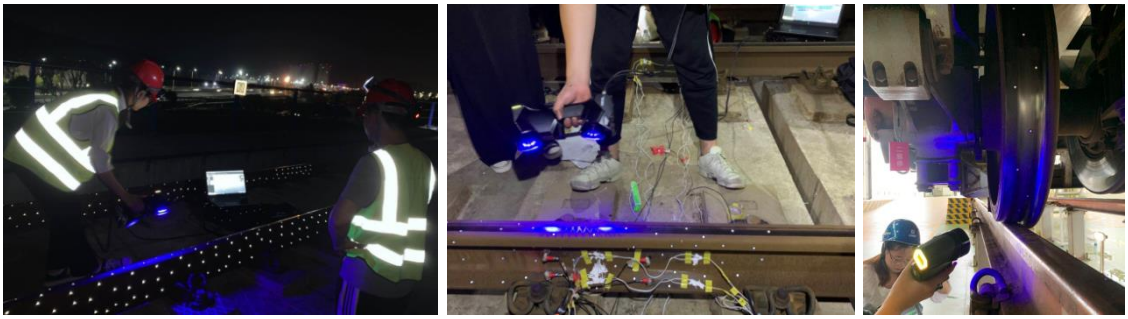


Figure 2. 17 Measurement of rail corrugation and wheel wear on Wenzhou S1 line (first test)

To monitor the evolution of rail corrugation on the track section between Panqiao Station and Wenzhou South Station, Dr. Xiang-Yun Deng and Mr. Yun-Ke Luo paid a visit again on 28 November 2020. The 3D geometry data of rail corrugation was collected through the 3D laser scanner of the CNERC-rail. Also, the pattern of corrugation was recorded by taking photos. Additionally, the running band and rail surface conditions were also checked in the visit.

Figure 2.18 Measurement of rail corrugation and wheel wear on Wenzhou S1 line (second test)

Track Inspection and in-Situ Measurement of Rail Corrugation on Shenzhen Metro

To investigate the formation mechanism and evolution of rail corrugation on Metro curved tracks, collaboration with Southwest Jiaotong University and China SWJTU Railway Development Co., Ltd (CSRD), a project on rail corrugation monitoring is being conducted. The project lasts nine months, from December 2020 to August, 2021. The monitoring is focused on the curved track section of Shenzhen Metro Line 1 between Zhuzilin Metro Station and Qiaochengdong Metro Station. To monitor the evolution of corrugation, a number of regular inspections were planned. The first inspection was conducted on 3 December 2020. Three members from CNERC-Rail, Dr. Xiang-Yun Deng, Mr. Chao Zhang and Mr. Youliang Zheng, together with Mr. Xun Song from CSRD attended the rail inspection. During the inspection, the 3D geometry data of rail was measured by using the 3D laser scanner of CNERC-rail. Also, the longitudinal rail profile of the whole curved track section was measured by using a mobile corrugation measuring system. In the end, the rail surface condition was recorded by taking photos.

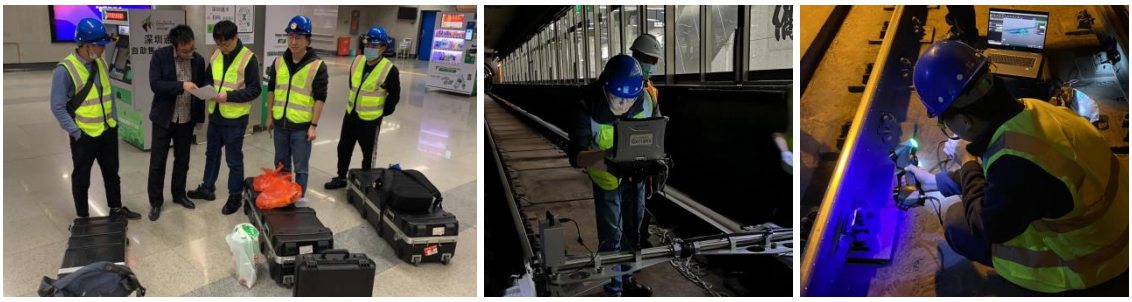


Figure 2. 19 Measurement of rail corrugation on Shenzhen Metro curve line

CO_2 Laser Aided Fiber Grating System Laboratory

Long period fiber gratings (LPFG) is a light loss element with the refractive index of the fiber core periodically modulated. The resonant wavelength of a cladding mode is proportional to the grating period and the difference in effective index between the core and the cladding. The effective index of the cladding largely depends on the indices of the core, the cladding and the surrounding medium of an optical fiber. This responsive nature makes the LPFG an ideal sensing platform for structural, chemical and biological applications. The CO_2 laser aided fiber grating system (Figure 2.20) is built for LPFG fabrication. The system consists of a CO_2 laser source, beam delivery optics, a 3-axis manual linear stage, a single-axis motorized linear stage, controllers, a broadband light source, an optical spectral analyzer (OSA) and a computer. A laser source of 40 W is used for grating inscription with the output power tuned at 9 W and 100 ms pulse duration. The fabricated LPFG sensor can be utilized for liquid level, pH and chemical sensing based on the refractive index change of the surrounding medium.

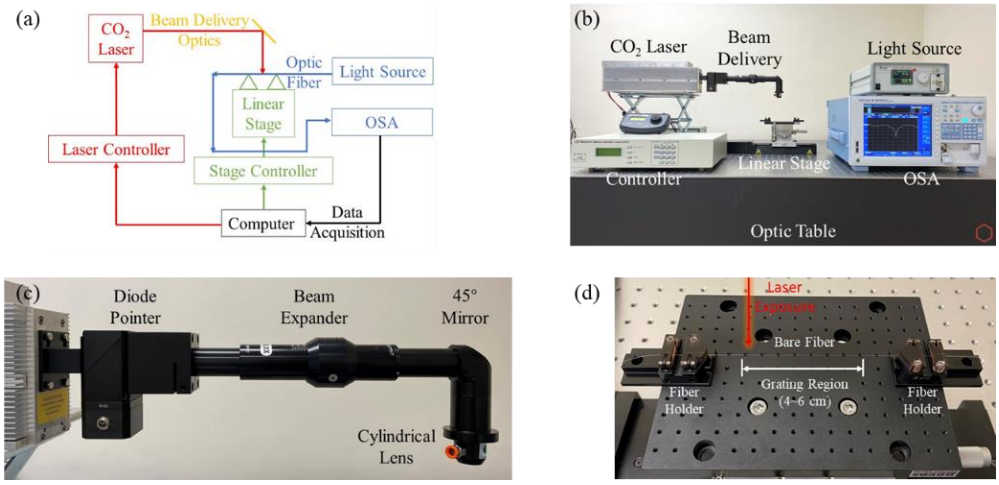


Figure 2. 20 The CO_2 laser aided fiber grating system (a) schematic diagram, (b) laboratory layout, (c) optical element and (d) optical fiber fixing platform

Research Outcomes

In 2020, the CNERC-Rail participated in the preparation of 1 monograph, published/submitted 28 SCI journal papers, won 5 awards, granted 2 patents, and applied for 3 patents. Key members were invited to give keynote speech at 6 international conferences.

Monograph

In 2020, CNERC-Rail participated in the writing of the "Rail Transit Industry Development Report for the Guangdong-Hong Kong-Macao Greater Bay Area" as the associate editor unit. The report, led by the Guangdong-Hong Kong-Macao Greater Bay Area Collaborative Innovation Center for Modern Rail Transit and jointly compiled by each member unit of the Center, is an industry report covering the development overview, frontier tracking and development suggestions of rail transit in the Bay Area. It has a total of more than 100 pages and will be officially published by China Railway Publishing House in the first half of 2021.

Figure 2. 21 Rail Transit Industry Development Report for the Guangdong-Hong Kong-Macao Greater Bay Area

International Journal Publications

1. Ni, Y.Q., and Xu, C. (2020), "A Bayesian blind source separation method embedding Gaussian process prior and its application to identification of structural excitations", submitted to *Structural Control and Health Monitoring*. (SCI)
2. Wang, S.M., Wang, Y.W., Ni, Y.Q., and Lu, Y. (2020), "Real-time malfunction detection of maglev suspension controllers", submitted to *IEEE Systems Journal*. (SCI)
3. Ruan, Z.G., Ying, Z.G., and Ni, Y.Q. (2020), "Response characteristics of a periodic sandwich plate with controllable visco-elastomer core and periodically supported masses under random excitation", submitted to *Journal of Sandwich Structures and Materials*. (SCI)
4. Ying, Z.G., Wang, Y.W., Ni, Y.Q., and Xu, C. (2020), "Model-free identification of multiple periodic excitations and detection of structural anomaly using noisy response measurements", submitted to *Smart Structures and Systems*. (SCI)
5. Wang, Y.W., Zhang, C., Ni, Y.Q., and Xu, X.Y. (2020), "A Bayesian approach for occupant comfort assessment of high-rise structures based on full-scale measurements", submitted to *Mechanical Systems and Signal Processing*. (SCI)
6. Wang, C., Lai, S.K., Wang, J.M., Feng, J.J., and Ni, Y.Q. (2020), "An ultra-low-frequency, broadband and multi-stable tri-hybrid energy harvester for enabling the next-generation sustainable power", submitted to *Applied Energy*. (SCI)
7. Zhang, B.Y., and Ni, Y.Q. (2020), "A hybrid sequential sampling strategy for sparse

polynomial chaos expansion based on compressive sampling and Bayesian experimental design", submitted to *Computer Methods in Applied Mechanics and Engineering*. (SCI)

8. Chen, S.X., Zhou, L., Ni, Y.Q., and Liu, X.Z. (2020), "An acoustic-homologous transfer learning approach for acoustic emission-based rail condition evaluation", *Structural Health Monitoring*, DOI: 10.1177/1475921720976941. (SCI)
9. Wang, S.M., Liao, C.L., and Ni, Y.Q. (2020), "A machine vision system based on driving recorder for automatic inspection of rail curvature", *IEEE Sensors Journal*, DOI: 10.1109/JSEN.2020.3020907. (SCI)
10. Ni, Y.Q., and Zhang, Q.H. (2020), "A Bayesian machine learning approach for online wheel fault detection using track-side monitoring", *Structural Health Monitoring*, DOI: 10.1177/1475921720921772. (SCI)
11. 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)
12. Wang, S.M., Yau, J.D., Duan, Y.F., Ni, Y.Q., Wan, H.P., and Wu, S.K. (2020), "Prediction of crosswind-induced derailment of train-rail-bridge system by vector mechanics", *Journal of Engineering Mechanics*, ASCE, Vol. 146, No. 12, Paper No. 04020132. (SCI)
13. Wang, Y.W., and Ni, Y.Q. (2020), "Bayesian dynamic forecasting of structural strain response using structural health monitoring data", *Structural Control and Health Monitoring*, Vol. 27, No. 8, Paper No. e2575. (SCI)
14. Ying, Z.G., and Ni, Y.Q. (2020), "A multimode perturbation method for frequency response analysis of nonlinearly vibrational beams with periodic parameters", *Journal of Vibration and Control*, Vol. 26, No. 13-14, 1260-1272. (SCI)
15. Zhang, Q.H., and Ni, Y.Q. (2020), "Improved most likely heteroscedastic Gaussian process regression via Bayesian residual moment estimator", *IEEE Transactions on Signal Processing*, Vol. 68, 3450-3460. (SCI)
16. Ke, Y.T., Cheng, C.C., Lin, Y.C., Ni, Y.Q., Hsu, K.T., and Wai, T.T. (2020), "Preliminary study on assessing delaminated cracks in cement asphalt mortar layer of high-speed rail track using traditional and normalized impact–echo methods", *Sensors*, Vol. 20, No. 11, Paper No. 3022 (16pp). (SCI)
17. Ding, S.Q., Wang, Y.W., Ni, Y.Q., and Han, B.G. (2020), "Structural modal identification and health monitoring of building structures using self-sensing cementitious composites", *Smart Materials and Structures*, Vol. 29, No. 5, Paper No. 055013 (18pp). (SCI)
18. Ni, Y.Q., Wang, Y.W., and Zhang, C. (2020), "A Bayesian approach for condition assessment and damage alarm of bridge expansion joints using long-term structural health monitoring data", *Engineering Structures*, Vol. 212, Paper No. 110520. (SCI)
19. Wan, H.P., and Ni, Y.Q. (2020), "A new approach for interval dynamic analysis of train-bridge system based on Bayesian optimization", *Journal of Engineering Mechanics*, ASCE, Vol. 146, No. 5, Paper No. 04020029. (SCI)
20. Wang, Y.W., Ni, Y.Q., and Wang, X. (2020), "Real-time defect detection of high-speed train wheels by using Bayesian forecasting and dynamic model", *Mechanical Systems and Signal Processing*, Vol. 139, Paper No. 106654. (SCI)
21. Fong, Y.C., Cheng, K.W.E., and Sekhar, R. (2020), "A Current allocation strategy based balancing technique of voltage source string in switch-ladder inverter and its switched-

capacitor variety", *IEEE Transactions on Energy Conversion*, doi: 10.1109/TEC.2020.3031224. (SCI)

22. Shao, J.W., Xu, C.D., and Cheng, K. W. (2020), "Core stress analysis of amorphous alloy transformer for rail transit under different working conditions", submitted to *Energies*. (SCI)
23. Shao, J.W., Xu, C.D., and Cheng, K.W. (2020), "A distributed rolled core for energy harvesting circuit", accepted by *PESA 2020*. (SCI)
24. Chi, H.L., Thedja, J., Kim, M.K. and Seo, J. (2020), "Framework for automated formwork quality inspection system using laser scanning and augmented reality", submitted to *Advanced Engineering Informatics*. (SCI)
25. Yang, X., Wang, C., and Lai, S.K. (2020), "A magnetic levitation-based tristable hybrid energy harvester for scavenging energy from low-frequency structural vibration", *Engineering Structures*, 221, 110789. (SCI)
26. Zhang, L.H., Lai, S.K., and Yang, J. (2020), "A DSC regularized Dirac-Delta method for flexural vibration of elastically supported FG beams subjected to a moving load", *International Journal of Structural Stability and Dynamics*, 20(03), 2050039. (SCI)
27. Wen, F., Shan, S., and Cheng, L. (2020), "Third harmonic shear horizontal waves for material degradation monitoring", *Structural Health Monitoring*, 1475921720936983. (SCI)
28. Shan, S., and Cheng, L. (2020), "Mode-mixing-induced second harmonic A0 mode Lamb wave for local incipient damage inspection", *Smart Materials and Structures*, 29(5), 055020. (SCI)

International Conference Papers

1. Chi, H.L., Thedja, J., and Kim, M.K. (2020), "A vision-based formwork quality inspection enhancement by using laser scanning and augmented reality", *8th International Conference on Construction Engineering and Project Management* (ICCEPM 2020), Hong Kong SAR, 7-8 December 2020.

Keynote Speeches

1. Keynote speech "Integration of Artificial Intelligence and Robotics (AIR) into Sensing Technology (ST): ST meets AIR" at the 10th European Workshop on Structural Health Monitoring, 6-9 July 2020, Palermo, Italy;
2. Keynote speech "Online and on-board monitoring of high-speed rail and maglev systems" at the 20th World Conference on Non-Destructive Testing, 8-12 June 2020, Seoul, Korea;
3. Plenary speech "Probabilistic machine learning for interpretation of vibration monitoring data: Applications to railway and maglev systems" at the 11th International Conference on Structural Dynamics, Athens, Greece, 23-26 November 2020;
4. Keynote speech "Online monitoring of high-speed rail, maglev and urban rail transit" at the 1st Forum on Railway Vehicle Operation and Management, Nanchang, China, 13-15

November 2020;

5. Keynote speech “Online monitoring and machine-learning-empowered evaluation of rail transit and maglev systems” at the 2020 International Conference on Sustainable and Innovative Infrastructure, Tainan, Taiwan, 22-24 October 2020;
6. Keynote speech “Detection of incipient structural damage and material degradation using nonlinear ultrasonic guided waves” in ASME 47th QNDE (Annual Review of Progress in NDE), Minneapolis, USA, 25-26 August 2020 (Prof. Cheng, L.).

Awards and Patents

1. Professor Yi-Qing Ni, Director of the Center, was appointed Chair Professor of Yangtze River Scholars of the Ministry of Education in 2020;
2. Professor Yi-Qing Ni, Director of the Center, was awarded the title of "Yim, Mak, Kwok & Chung Endowed Professorship in Smart Structures".
3. Recipient of the Second Prize Award of Science and Technology, Chinese Society for Vibration Engineering, 2020 (Ni, Y.Q. (2019), "Intelligent magnetorheological control theory and method for random vibration of Bridges and building structures"); (Figure 2.22)
4. Recipient of the Second Prize Award of Academic Activity, China Railway Society, 2019 (Han, B.G., Ding, S.Q., Dong, S.F., and Ni, Y.Q. (2019), "Application prospect of intrinsic self-sensing concrete in in-situ monitoring of high-speed railway civil infrastructure"); (Figure 2.23)
5. Professor Yi-Qing Ni, Director of the Center, was awarded the honorary title of Advanced Worker of China Railway Society in 2019; (Figure 2.24)
6. Y.Q. Ni, C.Y. Wang, H.L. Wang, C. Zhang, M.D. Yuan “A angluar transducer based on fiber bragg grating technology”, Chinese Patent No. 2017 1 0120696 5, Issued on 30 October 2020; (Figure 2.25)
7. S.M. Sajjadi Alehashem, Y.Q. Ni, C.S. Lin, C. Zhang “Modular rail particle damper (MRPD) and damper’s fixture for noise and vibration mitigation of railways”, Chinese patent submitted;
8. Y.Q. Ni, S.M. Wang, Y. Lu “Maglev suspension control system and method” Chinese patent submitted;
9. S.M. Wang, C.L. Liao, Y.Q. Ni “A vedio analysis system, method, and device for track detection” Chinese patent submitted.

中国振动工程学会科学技术奖

证 书

为表彰中国振动工程学会科学技术奖获得者，特颁发此证书。

项目名称：桥梁及建筑结构随机振动智能磁流变控制理论与方法

奖励等级：二等奖

获 奖 者：香港理工大学

类　　别：基础研究

2020年1月8日

证 书 号：2019-KJ1-2-03-D02

中国振动工程学会科学技术奖

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奖励等级：二等奖

获 奖 者：倪　清

类　　别：基础研究

2020年1月8日

证 书 号：2019-KJ1-2-03-R02

Figure 2. 22 Second Prize Award of Science and Technology, Chinese Society for Vibration Engineering

韩宝国、丁思齐、董素芬、倪一清、欧进萍 同志：

您撰写的论文《本征自感知混凝土在高铁土建基础设施原位监测中的应用展望》被评为中国铁道学会2019年度学术活动二等优秀论文。

特发此证，以资鼓励！

中国铁道学会

2020年4月

Figure 2. 23 Second prize award of Academic Activity in 2019 organized by China Railway Society

荣誉证书

授予 倪一清：

2019 年度中国铁道学会分支机构先进工作者荣誉称号。

特发此证。

中国铁道学会

2020 年 8 月

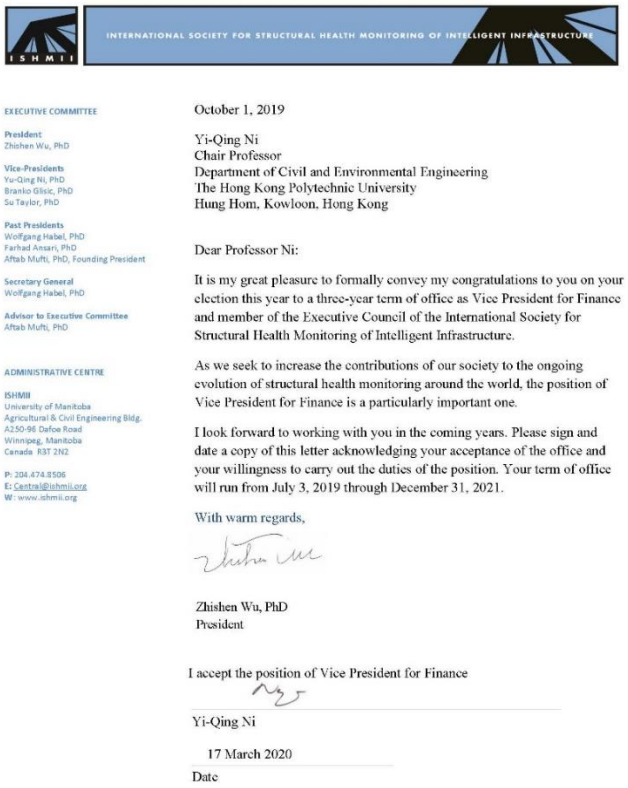
Figure 2. 24 Honorary title of Advanced Worker in 2019 of China Railway Society

Figure 2. 25 Authorized patent: An angluar transducer based on fiber Bragg grating technology

Professional Activities

1. Vice President (Finance) of International Society for Structural Health Monitoring of Intelligent Infrastructure (ISHMII); (Figure 2. 26)
2. Member of Editorial Board for Advances in Bridge Engineering (Publisher: Springer Nature Group); (Figure 2. 27)
3. Session Chair of the 3rd International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites, 11-12 January 2020, Shenzhen, China;
4. Guest editor for a special issue on “Structural Health Monitoring (SHM) of High-rise Buildings and Spatial Structures” in *Journal of Civil Structural Health Monitoring*, 2020;
5. Guest editor for a special issue on “Structural Monitoring Using Advanced NDT Techniques” in the international journal *MDPI Applied Sciences*, 2020;
6. Member of Organizing Committee of the 3rd International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites, 11-12 January 2020, Shenzhen, China;
7. Member of Experts Committee of the 3rd International Workshop on Structural Health Monitoring for Railway System, 22-23 October 2020, Qingdao, China;

8. Member of Conference Editorial Board of the 5th International Conference on Railway Technology: Research, Development and Maintenance, 7-10 September 2020, Palma de Mallorca, Spain;
9. Member of Scientific Committee of the 15th International Workshop on Advanced Smart Materials and Smart Structures Technology, 17-20 July 2020, West Lafayette, Indiana, USA;
10. Member of International Scientific Committee of the 10th European Workshop on Structural Health Monitoring, 6-9 July 2020, Palermo, Italy;
11. Member of International Advisory Board of the 2020 International Conferences on Modern Materials and Technologies – Symposium FN: Embodying Intelligence in Structures and Integrated Systems, 20-23 June 2020, Montecatini Terme, Italy;
12. Member of Scientific Committee of the 20th World Conference on Non-Destructive Testing, 8-12 June 2020, Seoul, Korea;
13. Member of Scientific Committee of the 11th International Conference on Structural Dynamics, 23-26 November 2020, Athens, Greece;
14. Co-Chair of the 2020 International Conference on Sustainable and Innovative Infrastructure, 22-24 October 2020, Tainan, Taiwan;
15. Member of Program Committee of the 2020 SPIE Smart Structures/NDE Conference on Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems, 26-30 April 2020, Anaheim, California, USA;
16. Member of Organizing Committee of the 3rd International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites, 11-12 January 2020, Shenzhen, China;
17. Member of Organizing Committee of the 3rd International Workshop on Seawater Sea-sand Concrete (SSC) Structures Reinforced with FRP Composites, 11-12 January 2020, Hong Kong.



INTERNATIONAL SOCIETY FOR STRUCTURAL HEALTH MONITORING OF INTELLIGENT INFRASTRUCTURE

ISHMII

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P: 204.474.8506
E: Central@ishmii.org
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October 1, 2019

Yi-Qing Ni
Chair Professor
Department of Civil and Environmental Engineering
The Hong Kong Polytechnic University
Hung Hom, Kowloon, Hong Kong

Dear Professor Ni:

It is my great pleasure to formally convey my congratulations to you on your election this year to a three-year term of office as Vice President for Finance and member of the Executive Council of the International Society for Structural Health Monitoring of Intelligent Infrastructure.

As we seek to increase the contributions of our society to the ongoing evolution of structural health monitoring around the world, the position of Vice President for Finance is a particularly important one.

I look forward to working with you in the coming years. Please sign and date a copy of this letter acknowledging your acceptance of the office and your willingness to carry out the duties of the position. Your term of office will run from July 3, 2019 through December 31, 2021.

With warm regards,

Zhishen Wu, PhD
President

I accept the position of Vice President for Finance

Yi-Qing Ni

17 March 2020
Date

Figure 2. 26 Professor Yi-Qing Ni, Director of the Center, Appointed as Vice President (Finance) of International Society for Structural Health Monitoring of Intelligent Infrastructure (ISHMII)

Letter of Appointment

Hereby appointed

Prof. Yi-Qing Ni

The Hong Kong Polytechnic University

As Editoral Board Member of Advances in Bridge Engineering

From 2020 to 2022

Prof. Shunquan Qin
Editor-in-chief

Prof. Yongle Li
Editor-in-chief

Advances in Bridge Engineering
Dept. of Bridge Engineering, Southwest Jiaotong University, China

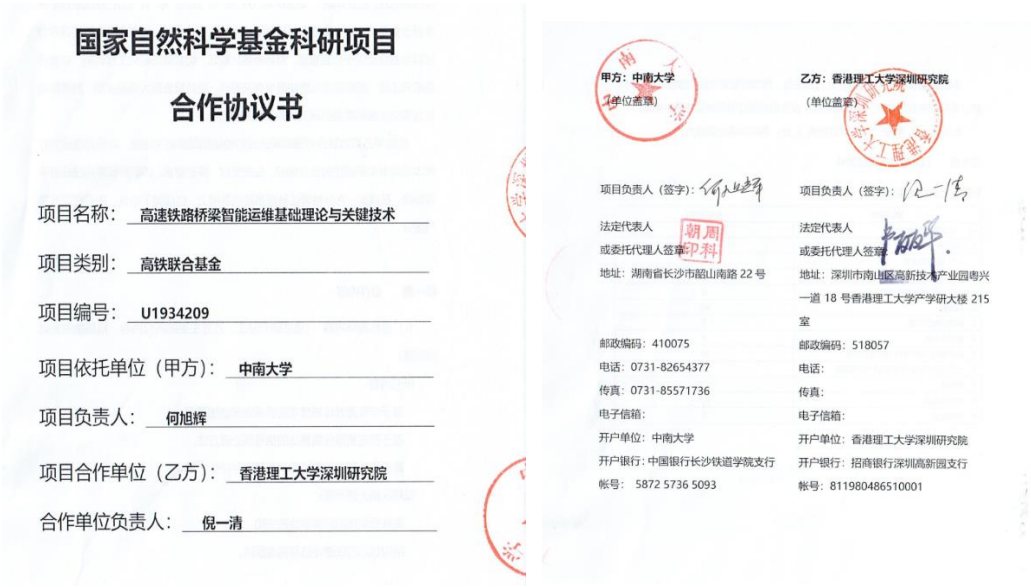
Figure 2. 27 Professor Yi-Qing Ni, Director of the Center, Appointed as Member of Editorial Board for Advances in Bridge Engineering

Collaborations & Communications

Signed Collaboration Agreements

Collaboration with Central South University

On January 1, 2020, the 2019 high-speed railway fundamental research fund project "Basic Theory and Key Technologies of Intelligent Operation and Maintenance of High-speed Railway Bridges" jointly declared by CNERC-Rail and Central South University was funded by the National Natural Science Foundation of China. The funding amount is as much as 2.31 million, with the period from January 2020 to December 2023. The two sides signed a cooperation agreement on June 5, 2020.



国家自然科学基金科研项目

合作协议书

项目名称：高速铁路桥梁智能运维基础理论与关键技术

项目类别：高铁联合基金

项目编号：U1934209

项目依托单位（甲方）：中南大学

项目负责人：何旭辉

项目合作单位（乙方）：香港理工大学深圳研究院

合作单位负责人：倪一清

甲方：中南大学
（单位盖章）

项目负责人（签字）：何旭辉

法定代表人
或委托代理人签章：

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开户银行：中国银行长沙铁道学院支行
帐号：5872 5736 5093

乙方：香港理工大学深圳研究院
（单位盖章）

项目负责人（签字）：倪一清

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传真：
电子信箱：
开户单位：香港理工大学深圳研究院
开户银行：招商银行深圳高新园支行
帐号：811980486510001

Figure 3. 1 Cooperation Agreement on High-Speed Rail Joint Funding

Attended Conferences

World Transport Conference Chengdu Forum and Online Activity Week

The World Transportation Conference (WTC) is an international academic conference in the field of transportation sponsored by the China Association for Science and Technology, the Ministry of Transport, and the Chinese Academy of Engineering, organized by the China Highway Society, and supported by domestic and foreign transportation technology organizations. The World Transportation Conference established since 2017, has been successfully held for three consecutive sessions. The World Transport Congress Executive Committee and the China Highway Society jointly held the World Transport Congress Chengdu Forum in Chengdu from November 9th to 10th, 2020, as well as an online event week. Dr. Xiang-Yun Deng, a member of CNERC-Rail, participated in the online forum of the conference and gave an invited report on the Key Technology Frontiers of Rail Transportation Equipment and Systems, organzied by the Division of Rail Transit.

Figure 3. 2 Dr. Xiang-Yun Deng gave a report at WTC Chengdu Forum

2020 Taizhou International Talent Cooperation Conference

The 2020 Taizhou International Talent Cooperation Conference is hosted by the Taizhou Municipal People's Government. It is intended to attract high-level talents to Taiwan with technologies and projects to carry out entrepreneurial project landing, innovative project cooperation and technological achievement transfer. On December 11-13, 2020, members of CNERC-Rail, Dr. Masoud Sajjadi, Dr. Xiang-Yun Deng, Mr. Chao Zhang, Mr. Yun-Ke Luo,

and Mr. Qian-Huai Yu attended this conference. During the conference, Mr. Chao Zhang introduced R&D outcomes of CNERC-Rail, and Dr. Masoud gave a report on a new type of rail particle damper developed by CNERC-Rail.

Figure 3. 3 Center members participated in the 2020 Taizhou International Talent Cooperation Conference

Technical Communications

Visit to Guangzhou Metro Group Co., Ltd.

In order to strengthen cooperation with Guangzhou Metro Group Co., Ltd., on November 11, 2020, Dr. Xiang-Yun Deng and Mr. Chao Zhang, members of CNERC-Rail, went to Guangzhou Metro Group to meet with Dr. En-Quan Fang from the National Engineering Laboratory of Guangzhou Metro Group and to conduct technical exchanges with Mr. Yang-Yi Duan, the direct of Guangzhou Metro Group vehicles. The two sides conducted in-depth discussions on subway track irregularity detection. The content of the discussion included: subway track inspection car inspection content, track irregularity detection technology, rail corrugation detection technology and corrugation measurement technology etc. The two sides also discussed possible cooperation in subway track monitoring in the near future. Finally, the two sides reached a preliminary agreement on the basis of the dynamic inspection of the track inspection car of Guangzhou Metro Line 8. The two sides will carry out preliminary cooperation on the detection and identification of track irregularities.

Visit to Tongji University

On November 16-22, 2020, Dr. Xiang-Yun Deng, a member of CNERC-Rail, visited Tongji University, Shanghai, and had technical exchanges with Associate Prof. Yu Zhou from the Department of Urban Rail and Railway Engineering, Department of Transportation, Tongji University. Both sides were involved in track damage and rail corrugation. The mechanism was discussed, and the monitoring data over the years were discussed in detail. Afterwards, the two sides went to the subway line to carry out the on-site corrugation survey and test again. Dr. Xiang-Yun Deng applied the 3D scanner of CNERC-Rail to the in-situ test. The results showed that the 3D scanner can accurately capture the rail corrugation. In the end, the two sides reached a preliminary agreement to jointly develop the rail corrugation measurement technology and study the mechanism of rail damage and rail corrugation.

Figure 3. 4 Field test in Shanghai metro line

Visit to Zhejiang Tiantie Co., Ltd.

On December 15, 2020, Dr. Masoud Sajjadi and Mr. Chao Zhang, members of CNERC-Rail, visited Zhejiang Tiantie Co., Ltd. Mr. Bo Wang, the executive vice president and chief engineer of this company, received the Center members. The two sides exchanged views on technical issues such as rail damper R&D and smart fasteners and reached an agreement on the development of cooperation and product promotion.

Figure 3. 5 Center members visited Zhejiang Tiantie Co., Ltd.

Visit to Taizhou Rail Group Go., Ltd.

On December 15, 2020, Dr. Xiang-Yun Deng, Dr. Masoud Sajjadi, and Mr. Chao Zhang, members of CNERC-Rail, visited Taizhou Railway Group Co., Ltd. The chairman of the company, Mr. Hong-Bo Su, received our Center members. Dr. Xiang-Yun Deng and Mr. Chao Zhang jointly reported research results from our Center, and the two sides reached a consensus on future cooperation on the Taizhou S2 line.

Figure 3. 6 Center members visited Taizhou Rail Group Co., Ltd.

Organized Seminars

CEE Chair Professor Lecture Series

On October 29, 2020, Prof. Yi-Qing Ni, Director of CNERC-Rail, gave an online seminar

on "Structural Health Monoitoring Driven by Big Data and Machine Learning" in a lecture series organized by the Department of Civil and Environmental Engineering. The registered audience reached more than 420.

Figure 3. 7 Online lecture by Center Director Prof. Yi-Qing Ni

Visiting Scholars & Delegations

Visit by Mr. Kwok-Fai Yau, Executive Director of Able Engineering Holdings Limited

On November 12, 2020, Mr. Kwok-Fai Yau, Executive Director of Able Engineering Holdings Limited, visited the Hong Kong Polytechnic University and the Railway Engineering Laboratory. Prof. Yi-Qing Ni, Director of CNERC-Rail, introduced the latest R&D technology and scientific research projects of the Center to the guest. Prof. Xiang-Dong Li, Dean of the Faculty of Construction and Environment, and Dr. Wai-Man Tam, Deputy Director of the Industrial Centre, accompanied him.

Figure 3. 8 Visit by Mr. Kwok-Fai Yau, Executive Director of Able Engineering Holdings Limited

Appendix

A.1 Purchased Equipment

No.	Device/Sensor	Quantity
1	600 um Premium Bif. Fiber, VIS/NIR, 2m, BX Jacket P/N: QBIF600-VIS-BX. and Premium 400 um Reflection Probe, VIS/NIR, 2 m, BX Jacket P/N : QR400-7-VIS-BX	1
2	M-466A-154 Clamp Set, M-466A (P007), M-466A-147 Large Fixed Bracket, Slot Length 60mm, M-466A (P007), M-SA2-12X18 ALUMINUM PLATE SA2 SERIES (P004) and HR-13 High Resolution Micrometer, 0.5 um Sensitivity, 13 mm Travel (P007)	1
3	Fiber Bragg Grating Accelerometer P/N: AN-SSA-100	1
4	Fiber Bragg Grating Accelerometer P/N: AN-SSA-100HF	1
5	Auxiliary Table Kit-Horizontal & Vertical (113), Imperial Threads Item: 0078-1	1
6	466A-710 Bare Fiber Holder, Dual Arm, 466A Series (P007)	1
7	PLPET0199 PET 1" OD 3/4-32 THRD 2" LG, PLADC0002 ADAPTER CLAMP 1" 3/4-32, MISC 5" CYLINDRICAL LENS 0.75" DIA, PLGJM0105 GAS JET MANIFOLD 2.5 FL 1.25 S and PLCOL0115 3.0X COLLIMATOR 1.25ser 3/4-32	1
8	Metric oprical table (1.2m x 2 m x 210 mm) with active legs (T1220CK), Air filter (PTA013) and Air compressor - 220/ 240 V - 50z, UK power plug (PTA513)	1
9	Item XR25C/M Metric Linear Translation Platform with Metric Mini Lab Jack	1
10	PoE Power injector Power injector for MonoDAQ	1
11	Mono DAQ-E-ACC-4 IEPE & Voltage input	1
12	Battery pack for Q.station with M12 connector	1
13	NETGEAR portable router Support LTE bandwidth	1
14	PEPWAVE industrial 4G router MAX BR1 Slim LTE (Europe/Int'l GSM) - Rugged Mobile Wi-Fi	1
15	MICRON OPTICS os75xx Accessory: Triaxial mounting kit, Beta parts of MICRON OPTICS os7510 and Beta parts of MICRON OPTICS os7520	1
16	HRMS system to adopt the Wifi based RFID reader	1
17	system hardware to use Wifi network	1
18	Creation of client software for tablet (either Windows, iOS or Android)	1

19	Datalogging server software including various voltage input and temperature	1
20	Server setup for datalogging (MS SQL Server, user accounts, tables and indexes)	1
21	Provision of ELA Innovation active RFID sensors and relevant electronic circuits for DC voltage input	1
22	Surface Microphones for aerodynamics noise measurement sensitivity 50mV/Pa, 20 to 20kHz	1
23	Prepolarized Free-field 1/2" Microphone with Type 2671 (6Hz to 20kHz) TEDs (Type -4189-A-021-) and Cable coax single screen	1
24	"Channel" Fiber Bragg Grating (FBG) accelerator	1
25	LAURELL WS-650MZ-23NPPB spin coater	1
26	BY-S07 vibration Sensor	1
27	D3000 dynamic data acquisition instrument	1
28	OCEAN INSIGHT USB2000+VIS-NIR-ES spectrometer, LDC-1 LED single channel touchscreen controller for LSM LED product, LSM-365A individual light source module and HL-2000-LL tungsten halogen source	1
29	"Geomaster" MTM-15D dual axis inclinometer	1
30	"Young" 05103L anemometer	1
31	"Geomaster" portable collector	1
32	"Tokyo Sokushin" AS-301C1W5 accelerometer	1
33	"Geomaster" DSPL-24 dynamic synchronization collector	1
34	"Micron Optics" fibre optic interrogator, Four jumper bundle of LC/APC to FC/APC jumpers and four FC/FC bulkhead adaptors	1
35	SYNRAD CO_2 laser, laser controller, switching DC power supply	1
36	MTS 643.06A-01/02 compression platens (1 pair/set), MTS attachment kit	1
37	"Huawei" 2288H v5 GPU computing servers	1
38	NEWPORT ULTRAlign precision linear stage, motor controller/ driver and high-performance linear stage	1
39	DeweSoft option - software licence upgrade DSA, MonoDAQ-E-ACC-4 IEPE and voltage input, Input ranges: 10 V, 5 V, 1 V, 200 mV High-pass filter: off, 0.1 Hz, 1 Hz IEPE current: 4 mA, 8 mA TEDS over IEPE, 24 bit, up to 40 kS/s DeweSoft X Professional, PoE Power injector Power injector for MonoDAQ	1
40	"Q-Rail" CN060 Rail Tuned Mass Dampers for 2 locations in Guangzhou	1
41	DELL Precision 7820 Tower XCTO Base Computer PC system	1
42	"Binder" Model MKF115 climatic material test chamber	1

43	"DEWESOFT" SIRIUSi-HD-16xACC 16-channel data acquisition device	1
44	Main Frame of Multi-channel Analyzer with GPS function, Portable Frame for Array Acoustics Camera and other accessories	1
45	Specification for Measuring and Analysis Software for Array Acoustics, Rail Vehicles, Moving Source Beamforming	1
46	Long-Range 3D Terrestrial Laser Scanner	1
47	Tailor make an intelligent test platform for magnetic coupling vibration of 160km/h medium speed maglev train	1
48	Design and Implementation of Rail Damper in MTR	1
49	Workstation Laptop Computer	1
50	Constant resistance vibration exciter: RMB210000)	1
51	GPS system for speed measurement and 16 channels ACC DAQ with GPS sync	1
52	PECVD system	1
53	High voltage power amplifier: ATA-4052 (RMB107,000)	1
54	Planetary Vacuum mixer wih 500mL container	1

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