2024

ANNUAL REPORT

IWHR

China Institute of
Water Resources and
Hydropower Research
中国水利水电科学研究院

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Dear colleagues, partners, and friends,

As we usher in another promising year, I would like to extend my warmest greetings and heartfelt gratitude to all of you. Your continued trust and support have been the foundation of IWHR's growth, innovation, and international outreach. Looking back on 2024, we are filled with pride and inspiration, having made significant strides in scientific research, technological breakthroughs, and global partnerships to advance sustainable water development for the benefit of both people and the planet.

In 2024, IWHR stepped up efforts to accelerate the digital transformation of water science and technology by centering our efforts on the development of digital twin technologies for the water sector. With research focus on climate-driven changes in water cycles, flood and drought risk mitigation amid extreme precipitation events, and holistic ecological protection strategies extending from source to sea, we pushed forward a coordinated digital empowerment framework that connects satellites in space, drones in air, gauges and equipment on ground, water system, and water projects. Our research teams advanced the development of multi-scale digital twin models covering watersheds, national water networks, and engineering projects, culminating in the SkyLIM toolbox composed of over 50 specialized models incorporating physical mechanisms, applied processes, and data-driven approaches. These models were iteratively enhanced in real-world scenarios through the integration of cloud computing, big data, and AI technologies. We strengthened intelligent monitoring and sensing capabilities to create a robust "acquisition-preprocessing-intelligent extraction-real-time simulation-dynamic evaluation" data chain, laying a solid foundation for high-quality model computation and decision-making. Collectively, these efforts positioned IWHR at the forefront of fostering new quality productive forces in the water sector, highlighting the strategic role of scientific and technological innovation in China's water governance.

We also upheld our commitment to the principle that talent is the foundation of innovation and development. A full-chain, tiered talent development system was further institutionalized, supporting differentiated pathways for nurturing our researchers. Initiatives such as the "New Talent Acceleration Program" and the launch of flagship projects, whose leaders are empowered to build cross-disciplinary and cross-institutional teams, have created more dynamic environments for talent to thrive. Through a dual-track "full-time plus flexible" recruitment model, we actively attracted top-tier professionals in key areas. Several renowned experts joined IWHR

MESSAGE FROM THE PRESIDENT

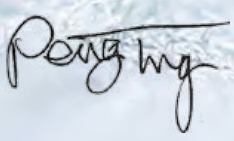
through this effort, enhancing our global competitiveness. Over the past five years, we added 35 national-level talents and one collective team to our ranks, with 58 individuals and five teams recognized at the provincial or ministerial level. Notably, another foreign expert affiliated to IWHR, adding to the total of three, were honored with the prestigious China Government Friendship Award.

The year also saw our commitment to openness and international cooperation and efforts to contribute China's wisdom and solutions to global water governance. By leveraging our roles as the host of 10 water-related international organizations or national secretariats, we actively expanded bilateral and multilateral partnerships. We successfully organized and co-hosted a series of major international events, such as the 15th International Conference on Hydroinformatics (HIC2024) and the 3rd Asia International Water Week (3rd AIWW). At the 10th World Water Forum, we released the report *River Ethics and China's Practices* to introduce China's principles and efforts to boost harmonious co-existence between humans and nature. We also continued hosting the International Seminar on Water Culture, now in its fourth edition, to promote global dialogue on the cultural dimensions of water management. We co-authored the UNESCO-led World Water Science Report as part of our commitment to knowledge sharing. Our "Lancang-Mekong Sweet Spring Action" project was selected as a best global poverty reduction case, reflecting our proactive role in advancing water solutions in developing countries. Today, over 20 of our experts hold key positions in major water-related international organizations, and several of our research disciplines are listed in the top 1% of the ESI global rankings – all of which reflect our growing influence in the global water community.

Reflecting on these achievements, we are deeply aware that none of them would have been possible without the passion, creativity, and dedication of our staff and the unwavering trust of our partners. As we look ahead, we will continue to embrace innovation and accelerate the development of new productive forces in water science and engineering to build a worldclass research institute. We will reinforce talent development, foster interdisciplinary integration, and enhance institutional capacities for basic research, applied innovation, and international cooperation.

Looking into 2025 and beyond, we remain firmly committed to serving the goals of sustainable development and climate resilience. We believe that by advancing water science and fostering international partnerships, we can help build a future in which water is well managed, ecosystems are protected, and communities are empowered.

Let us work hand in hand to create a water-secure and sustainable world!



Dr. Peng Jing
President of IWHR


1935
Central Hydraulic Laboratory
1956
Hydraulic Research Division, Chinese Academy of Sciences
1950
Nanjing Water Conservancy Division
1956
Beijing Institute of Water Resources, Ministry of Water Conservancy
1956
Hydropower Research Institute, Ministry of Electric Power Industry
1935
Tianjin Hydraulic Laboratory
1933
China First Hydraulic Laboratory
1957
Institute of Water Conservancy and Hydroelectric Power Research

HISTORY

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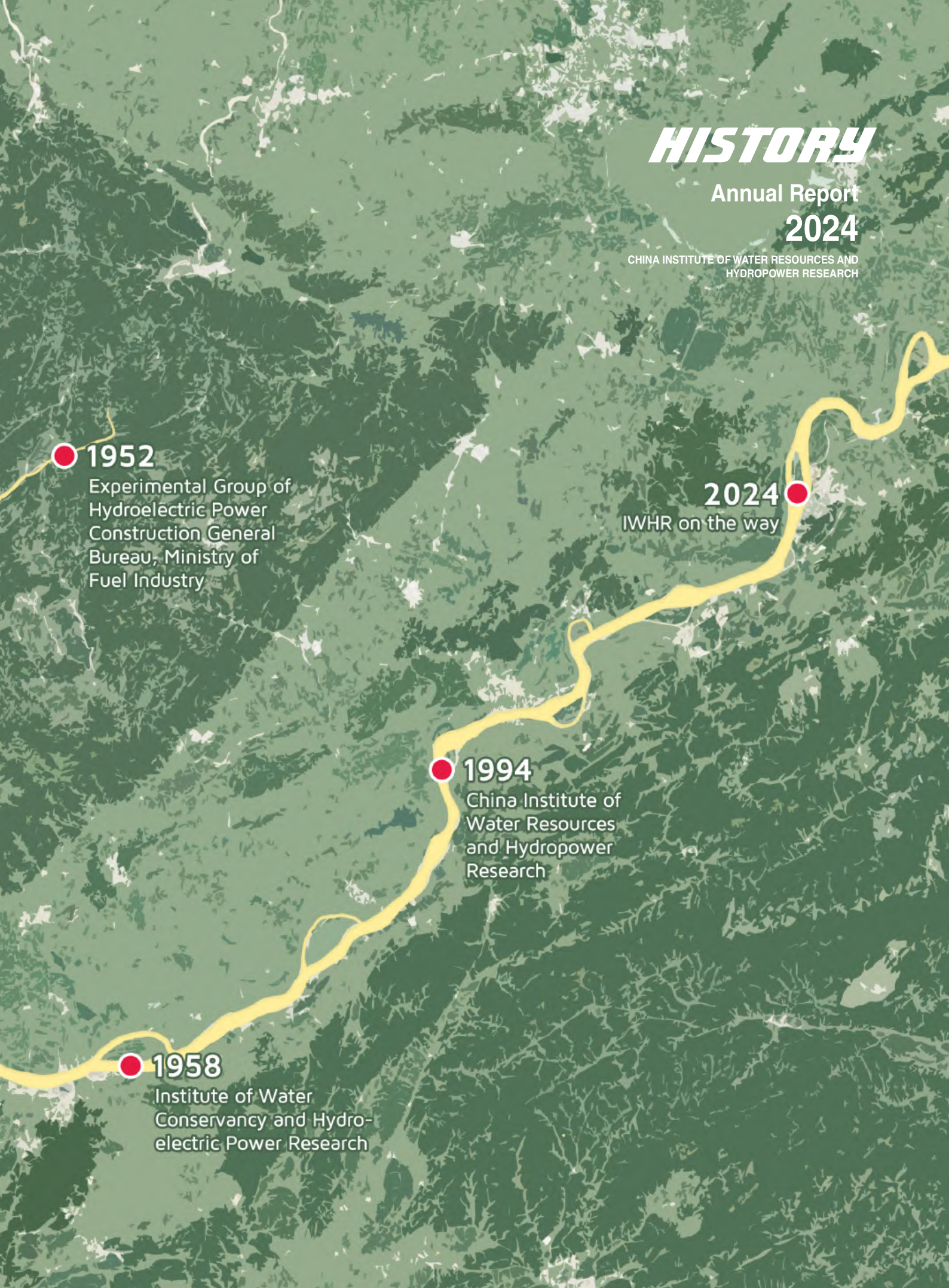
2024

CHINA INSTITUTE OF WATER RESOURCES AND HYDROPOWER RESEARCH



IWHR IN MAPS

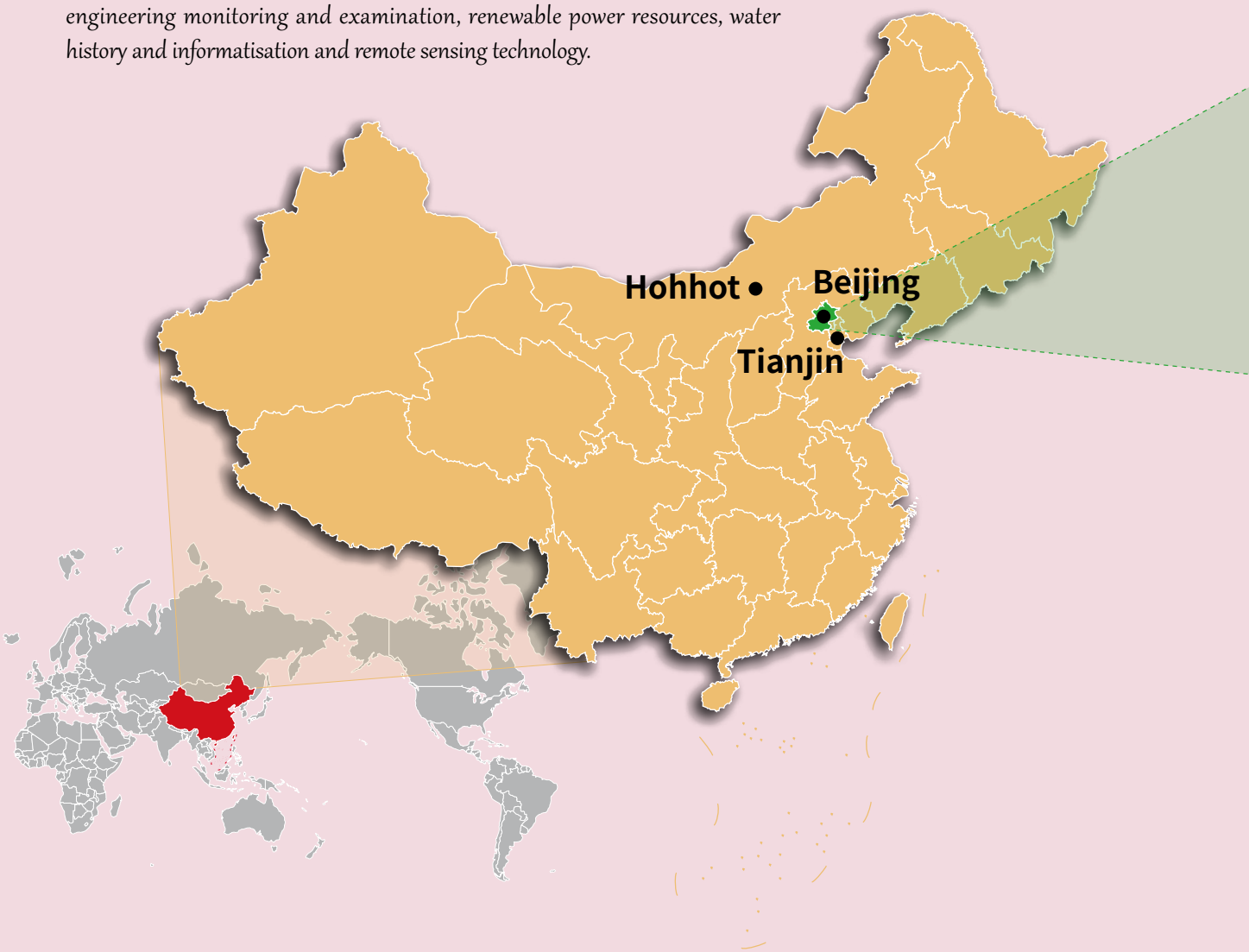
China Institute of Water Resources and Hydropower Research (IWHR) is a national research institution under the Ministry of Water Resources of China, and is engaged in almost all the disciplines related to water resources and hydropower research.

With over 60 years of development, IWHR has grown into an indispensable think tank of the Chinese government for decision making and a backbone technical consultant in water related areas. It is at the same time the host of multiple international organisations or their Chinese branches, including WASER, WASWAC, IAHR, ICFM, ICOLD, ICID, GWP, IHA and ARRN.

With 13 research departments and four affiliated enterprises, IWHR is endowed with research capacity in: hydrology and water resources, water environment and ecology, flood control, drought relief and disaster reduction, soil and water conservation, river and lake management, water resources in rural and pastoral areas, hydraulics, geotechnical engineering, hydraulic structures and materials, earthquake engineering, hydro machinery and electric equipment, automation, engineering monitoring and examination, renewable power resources, water history and informatisation and remote sensing technology.

Department of Water Resources for Pastoral Areas (**Hohhot**, Inner Mongolia)

Tianjin Institute of Hydroelectric and Power Research (**Tianjin**)



The map of Beijing here is modified from Beijing Tourist Map (2016) by © Beijing Municipal Commission of Tourism Development

Scan to find IWHR Headquarter (South) in **Google Maps**

Scan to find IWHR Headquarter (South) in **Baidu Maps**

IWHR Headquarter (South)

IWHR Headquarter (North)

Daxing Experimental Base

Yanqing Experimental Base

CHINA INSTITUTE OF WATER RESOURCES AND HYDROPOWER RESEARCH

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中国水科院

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Annual Report

2024

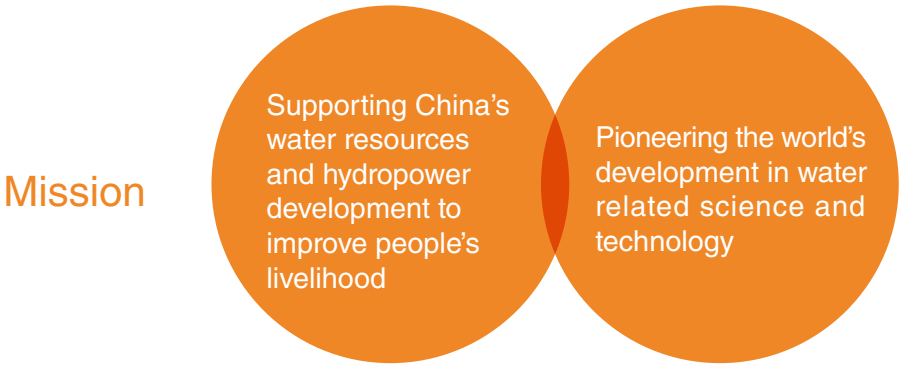
CHINA INSTITUTE OF WATER RESOURCES AND HYDROPOWER RESEARCH

Photo: LI Tong

Vision and Strategy

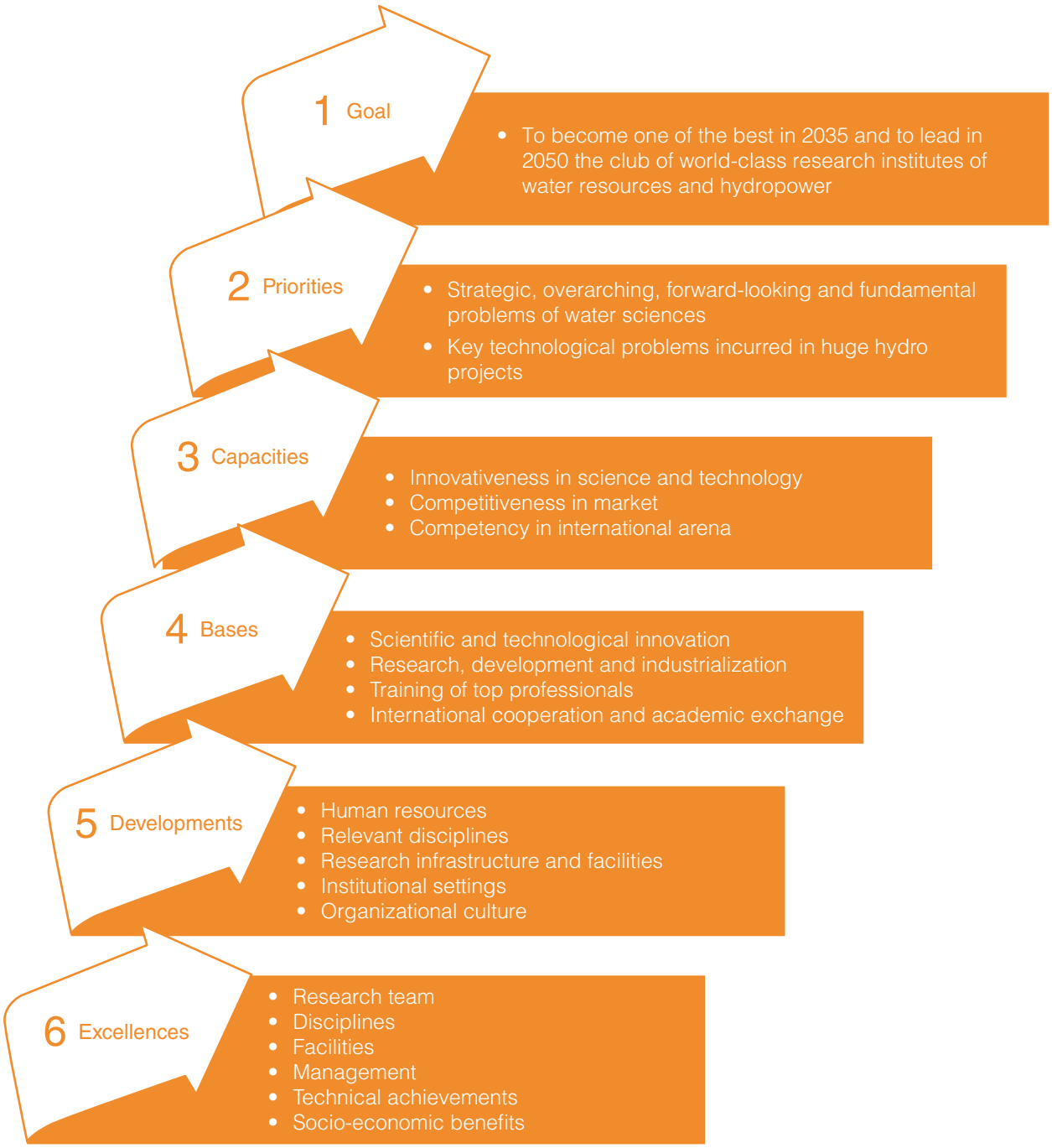
Vision


Vision
Striving to be the pioneer for creation and innovation of water related frontier science and technology


Mission
Supporting China's water resources and hydropower development to improve people's livelihood
Pioneering the world's development in water related science and technology


Spirit
Innovation
Practicality
Devotion
Dedication

Strategy


1 Goal
To become one of the best in 2035 and to lead in 2050 the club of world-class research institutes of water resources and hydropower
2 Priorities
Strategic, overarching, forward-looking and fundamental problems of water sciences
Key technological problems incurred in huge hydro projects
3 Capacities
Innovativeness in science and technology
Competitiveness in market
Competency in international arena
4 Bases
Scientific and technological innovation
Research, development and industrialization
Training of top professionals
International cooperation and academic exchange
5 Developments
Human resources
Relevant disciplines
Research infrastructure and facilities
Institutional settings
Organizational culture
6 Excellences
Research team
Disciplines
Facilities
Management
Technical achievements
Socio-economic benefits

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CHINA INSTITUTE OF WATER RESOURCES AND HYDROPOWER RESEARCH

Photo: LI Tong

Mission Achievement

IWHR Innovation

Time-varying Differentiation Mechanism of Watershed Runoff Generation and Concentration and Technology of Building Digital Twin Model Platform

Main Participants: LIU Changjun, WU Zebin, MA Qiang, LIU Jie, CHANG Siyuan, KAN Gcuangyuan, KANG Aiqing, CHEN Sheng, ZHAI Xiaoyan, LI Guang, LIU Yuanyuan, LI Qing, LIU Yesen, YU Haijun, REN Minglei, YU Wangyang, TANG Rong, YAO Shunyu, LU Guowei, NING Yawei

Background

Smart water is a prominent sign of high-quality development of water conservancy during the new phase. Digital twin water conservancy serves as the implementation measure to achieve smart water, with the model platform providing core algorithmic support. In response to the new demands of digital twin water conservancy for model algorithms, efficiency and management, this research reveals the time-varying differentiation mechanism of compound runoff generation and nonlinear runoff concentration in small- and medium-sized watersheds. It proposes intelligent flood forecasting and dispatching technologies for digital twin watersheds and develops a digital twin model platform based on a multi-node serial-parallel computing engine, providing the core driver for the Four Precautionary Measures (forecasting, early warning, simulation, and contingency planning) in flood control. The achievements have been practically applied in multiple watersheds and cities, supporting the response to and retrospective evaluation of several major emergencies, and yielding significant benefits.

Contents

- Research on the time-varying differentiation mechanism of compound runoff generation and nonlinear runoff concentration in small- and medium-sized watersheds: developing a structural equation linking watershed attribute factors to runoff volume, analyzing the causal relationship among rainfall-runoff influencing factors, and proposing a distributed spatio-temporal variable-source simulation approach of compound runoff generation and concentration.

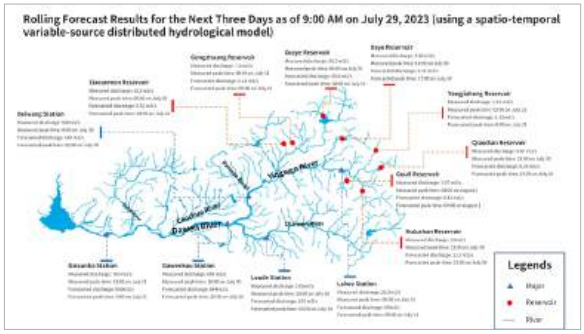

Fig.1 Flood Season Support for the Dawen River System in Shandong Province

Fig.2 "Four Precautionary Measures" System for the Zhangwei River in the Haihe River Basin

- Research on intelligent flood forecasting and dispatching technology for digital twin watersheds: establishing a new artificial intelligence flood inundation model based on the Fourier Neural Operator network, developing a spatio-temporal downsampling training and inference method, and constructing a data-mechanism dual-driven flood inundation model.
- R&D and application of digital twin model platform for the Four Precautionary Measures in flood control: exploring the ultra-large-scale parallel computing method for hydrology and hydrodynamics, practically testing the developed model platform in multiple watersheds such as the Huaihe River basin and the Haihe River basin, and integrating the platform into several Four Precautionary Measures systems for flood control. This achievement has received multiple acknowledgments and commendations from the Ministry of Water Resources, the Ministry of Emergency Management, and the Ministry of Housing and Urban-Rural Development.

Achievements

- Having revealed the time-varying differentiation mechanism of compound runoff generation and nonlinear runoff concentration in small and medium-sized watersheds: having elucidated the mixed mechanism of runoff generation, concentration, storage and infiltration, as well as the spatio-temporal transformation mechanism in small and medium-sized watersheds, established a spatio-temporal mapping relationship between runoff generation/concentration classification and geomorphic heterogeneity, and proposed an adaptive distributed hydrological simulation method for runoff generation and concentration algorithms.
- Having proposed intelligent flood forecasting and dispatching technologies for digital twin watersheds: having introduced a data-mechanism dual-driven flood and waterlogging forecasting technology, significantly enhancing the generalization capability of artificial intelligence models under changing underlying surface conditions; having developed a new artificial intelligence flood routing model based on the Fourier Neural Operator network, and proposed a flood dispatching technology based on mutual feedback optimization for complex engineering groups, enabling multi-objective joint optimization under strong interference conditions.
- Having developed a digital twin model platform based on a multi-node serial-parallel computing engine: having established standards for multi-scale model development coupling and phased topological operation monitoring, proposed a technique for free combination of multi-paradigm models and CPU/GPU heterogeneous parallel accelerated computing, and constructed a digital twin model platform featuring multi-model modular assembly, multi-solution containerized encapsulation, and serial-parallel isolation of computing units.

Application

The research outcomes have supported the “Four Precautionary Measures” for flood control in the Huaihe River and the Haihe River basins and have also been promoted and applied in Shandong, Henan, Tianjin, and other regions, supporting newly signed projects worth 420 million yuan. They have provided robust support for the investigation of the 7.20 flood disaster in Zhengzhou city, the response to the breach of the frontline levee at Dongting Lake in Tuanzhou embankment in Hunan province, the response to the 23.7 flood in the Haihe River basin, and the retrospective analysis of the bridge collapse incident in Zhashui County, Shangluo, Shaanxi province.

Fig.3 “Four Precautionary Measures” System for the Daqing River in the Haihe River Basin

Fig.4 Minute-level Simulation and Calculation for the Entire Haihe River Basin

Fig.5 Levee Breach Incident at Tuanzhou Embankment in Dongting Lake

Representative Research

Synergistic Regulation Technology of Water, Nitrogen and Salt and its Application in Drip Irrigated Fields in Arid Regions

Main Participants: LI Jiusheng, WANG Zhen, LI Yunkai, WANG Jun, XIAO Yang, LI Yanfeng, ZHAO Weixia, CHE Zheng, MA Chao, BO Xiaodong, GUO Yanhong, SUN Zhanghao, ZHANG Minne, LIU Hao, LIU Ke

Background

The agricultural development of arid regions in Northwest China faces two major environmental and resource challenges: water scarcity and soil salinization. Achieving water conservation and salinity control is at the heart of efficient water resources utilization and sustainable agricultural development in the arid regions of Northwest China. Centered on this critical issue and with the support of the National Natural Science Foundation of China's Major Research Program, this research has explored synergistic regulation mechanisms and technologies of water, nitrogen and salt for drip irrigation in arid regions, laying a solid foundation for the sustainable development of agriculture in arid regions of Northwest China.

Contents

- Having explored the mechanism and regulation path of emitter clogging under the coupling effect of nitrogen and water quality, established an emitter clogging control technology that takes into account the sustained effect of clogging control, crop safety and soil environment security, and proposed an optimized performance layout model for large-scale drip irrigation systems.
- Having researched the transmission pattern of uniformity from the outflow of drip irrigation systems to the distribution of soil water and salt, and subsequently to crop growth, evaluated the sensitivity of soil water and salt distribution uniformity to the regulation of drip irrigation system uniformity, and proposed an appropriate drip irrigation uniformity coefficient to prevent secondary soil salinization in arid regions.
- Having studied the drip irrigation salinity control methods that meet the water and salt thresholds in the crop root zone under complex water flux conditions, revealed the coupling mechanism of water, nitrogen and salt transport and absorption within the soil-crop system, and established a regulation method for drip irrigation water, nitrogen and salt based on the dynamic thresholds of water and salt levels in the root zone.

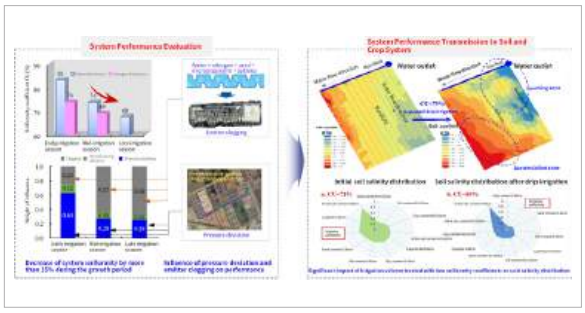

Fig.1 Evaluation of System Performance and Its Mechanism Affecting Soil Water and Salt Distribution

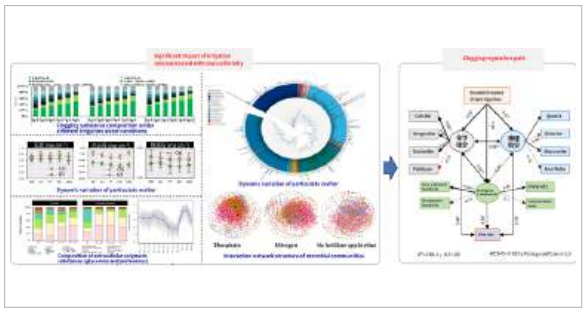

Fig.2 Emitter Clogging Mechanism and Regulation Path

Achievements

- Having revealed the mechanism underlying emitter clogging under the effects of water, salt and nitrogen, and innovatively proposed new technologies for emitter clogging control, such as applying acidic fertilizers and antagonistic microorganisms and the magnetization of irrigation water, enhancing the anti-clogging capability of emitters by 40%; having established new pipeline layout models at both unit and system scales, improving system uniformity by 9%.
- Having innovatively introduced a comprehensive evaluation method for assessing the distribution of water and nitrogen as well as energy efficiency performance of the system, improving the testing accuracy by 30%; having identified for the first time pressure deviation and clogging as the critical factors respectively affecting uniformity during the early and mid-to-late stages of the irrigation season. Non-uniform drip irrigation (with a uniformity coefficient below 70%) significantly increases the nonuniformity of salt within irrigation units; and a soil salinity threshold of 5 g/kg was identified as the critical level that significantly elevate the risk of cotton yield reduction at the system scale.
- Having elucidated the mechanism by which a moderate increase in nitrogen application reduces soil salt content, and innovatively proposed a synergistic regulation technology for water, nitrogen and salt that takes into account the salinity threshold difference across various growth stages. This approach reduces the nitrate nitrogen leaching rate by 9%- 18%, thereby resolving the conflict between salt leaching and nitrogen leaching loss.

Application

- The project has achieved remarkable outcomes, including 79 published papers, 15 invention patents (with 2 granted in the United States), 2 monographs, 3 standards, and training of 19 graduate students. Core team members were granted the 2024 ICID International Water-Saving Technology Award.
- Research achievements have been directly applied to 98,000 mu of farmland, improving irrigation uniformity by 30%, extending system lifespan by more than 1.5 times, increasing water and nitrogen use efficiency by over 10%, andreducing farmland soil salinity by 8%. These advancements have played a crucial role in improving the performance of drip irrigation systems, increasing the water and nitrogen use efficiency, and controlling soil salinity accumulation, thereby yielding significant economic and social benefits.

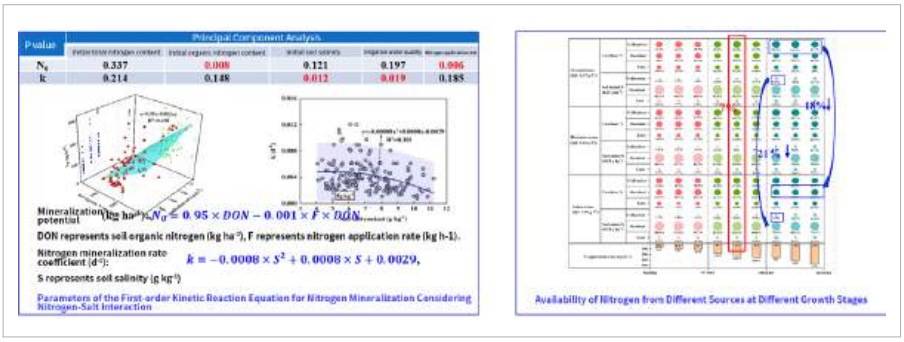

Fig.3 Interaction Mechanism and Quantitative Characterization of Water-Nitrogen-Salt in Drip Irrigation

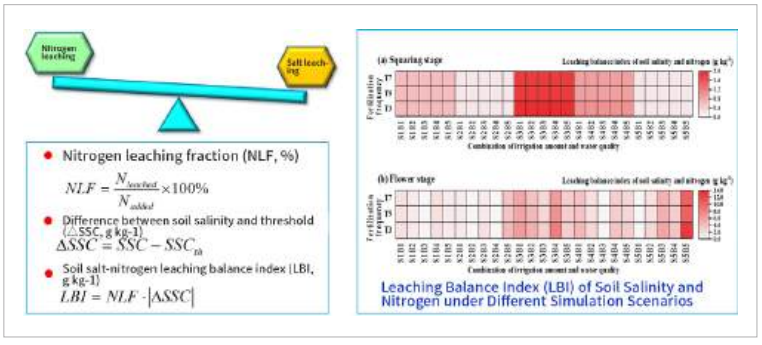

Fig.4 Optimization of Synergistic Regulation Parameters of Water, Nitrogen and Salt for Drip Irrigation in Arid Regions in Northwest China

IWHR

Inspection and Continuous Monitoring Technologies and Application in Large Buried Pipelines of Water Diversion Projects

Main Participants: ZHU Xinmin, MIAO Hong, CHEN Chunhao, FENG Shaokong, LU Zhengchao, MA Baolong, HUANG Tao, HAN Ruihua, MENG Shiqian, WANG Jinsong, NIE Ding, YANG Lufei, CUI Wei, ZHANG Shilei, LI Lianggeng

Background

Long-distance pressure water pipelines in water diversion projects, characterized by large diameter, extended transport distance, and high pressure, are prone to leakage and pipe burst accidents. Traditional monitoring and inspection methods have blind spots, making it difficult to comprehensively monitor project safety. Moreover, water shutdown for inspection affects operation efficiency and may even induce new structural damage.

With accelerating urbanization and aging pipeline infrastructure, the risks of pipeline leakage and burst are intensifying, resulting in an urgent need for efficient and accurate monitoring and inspection technologies. The development of new continuous monitoring and inspection technologies enables real-time diagnosis of pipeline health status and early warning of potential risks without affecting project operation. This not only provides a strong guarantee for the safe operation of water diversion projects, but also promotes technological advancement in the water conservancy industry, enhances project management standards, and offers vital support for the development of water ecological civilization and the sustainable socioeconomic development, demonstrating significant social benefits and scientific value.

Contents

- Having developed continuous monitoring technologies for large buried pipelines in water diversion projects by utilizing distributed optical fiber vibration continuous monitoring systems, hydroacoustic detectors, and fiber bragg grating hydraulic pressure gauges.
- Having developed inspection and evaluation technologies for FRP pipes in water diversion projects by employing cross-sectional laser scanning combined with segmented elliptic curve fitting; summarizing deformation patterns of flexible pipelines based on project cases.
- Having developed the inspection and evaluation technologies for PCCPs in water diversion projects by utilizing remote field eddy current, soil resistivity, and high-density surface wave methods, and proposed a pipeline safety assessment methodology.
- Having developed the wire breakage diagnosis and pipe burst early warning technologies for PCCPs in water diversion projects based on deep learning, and proposing evaluation methods for early warning and alarm

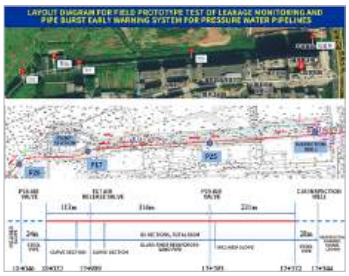

Fig.1 Layout Diagram for Field Prototype Test of Leakage Monitoring and Pipe Burst Early Warning System for Pressure Water Pipelines

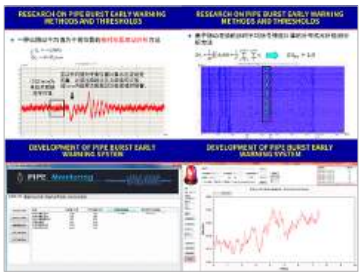

Fig.2 Research on Pipe Burst Early Warning Methods and System Development

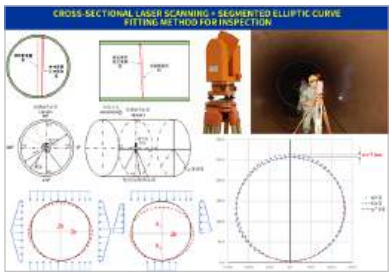

Fig.3 Cross-sectional Laser Scanning + Segmented Elliptic Curve Fitting Method for Inspection

thresholds for wire breakage and pipe bursts.

Achievements

- Having obtained a national invention patent titled “Continuous Monitoring Method for Leakage and Early Warning System for Pipe Bursts in Large Buried Pressure Water Pipelines” (Patent No. ZL 2013 1 0544612.2), one of the earliest patents in this field. The core research content has been included in Section 4.3 “Pipeline Monitoring Technology” in chapter 1 of Key Technologies for Design and Safety Protection of Long-distance Water Pipelines (ISBN978-7-5630-6198-3), edited by Li Jiang of Xinjiang.
- Having obtained multiple national invention patents, including “Method for Deformation Degree Detection and Evaluation of Buried Pipelines” (Patent No. ZL 2017 1 0707788.3), and participated in the drafting of the building material industry standards: Glass Fiber Reinforced Plastic Continuously Wound Sand Pipes (JC/T 2538-2019) and Glass-reinforced Plastic Continuously Wound Hollow Structure Pipes (TCSTM 00592-2021).
- Having obtained the national invention patent titled “Method for Structural Safety Detection and Method for Structural Safety Evaluation of Buried Pipelines" (Patent No. ZL 2017 1 0707788.3); having participated in the compilation of the national standard - Technical Requirements for Non-destructive Testing of Prestressed Concrete Cylinder Pipes (Remote Field Eddy Current Electromagnetic Method) (GB/T 41055-2021) and the Technical Specification for Rehabilitation of Drainage Pipelines with Grouting Anchor Lining (T/CECS 1007-2022), and led the review of Structural Safety Risk Assessment of Urban Municipal Pipelines (T/CECS 1120-2022).
- • Having obtained multiple national invention patents, including "Online Monitoring System and Real-time Early Warning Method for Prestressed Concrete Cylinder Pipelines" (Patent No. ZL 2021 1 1037619.6), and participated in the drafting of the national standard “Technical Requirements for Distributed Acoustic Optical Fiber Monitoring System on Prestressed Concrete Cylinder Pipe” (GB/T 41057-2021).

Application

The continuous monitoring technologies have been applied in major water resource projects, including the Water Source Project in North Shenzhen City, the Irrigation Zone Reservoir in Baise in Guangxi Province, the Water Diversion Project from Chaor River to Liaohe River in Nei Mongol, and the Water Resources Allocation Project around the Beibu Gulf in Guangxi Province.

The inspection and evaluation technologies have addressed frequent pipe bursts in the Water Source Project in North Shenzhen City and the PCCP Water Conveyance Project in the 38th Regiment Irrigation Area of the Second Division of Xinjiang Production and Construction Corps. Such technologies have also been applied in projects such as the East Main Canal of the Beijing section of the South-to-North Water Diversion Project and Underground Channel of the North Juma River.

The partner team, Beijing Besttone Pipeline Technology Co., Ltd., has built upon the patented technologies developed in this research to upgrade and expand services tailored to the monitoring needs of gas and petrochemical pipelines. These technologies have already been applied in projects such as the Lingqiao section of the Fuyang Gas Pipeline and a petrochemical pipeline at a chemical terminal in Taixing.

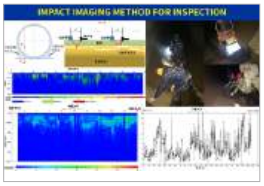

Fig.4 Impact Imaging Method for Inspection

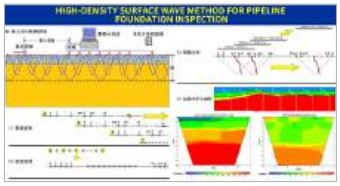

Fig.5 High-density Surface Wave Method for Pipeline Foundation Inspection

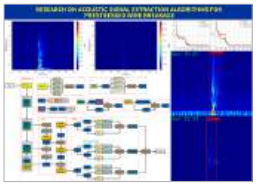

Fig.6 Research on Acoustic Signal Extraction Algorithms for Prestressed Wire Breakage

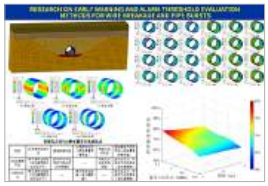

Fig.7 Research on Early Warning and Alarm Threshold Evaluation Methods for Wire Breakage and Pipe Bursts

Experimental Apparatus for Simulating In-situ Seepage-induced Weakening of Embankment Dams

Main Participants: DENG Gang, ZHANG Yanyi, ZHANG Yinqi, CHEN Han, HOU Weiya, SU Yu, LU Wei, WANG Xiangnan, CHENG Senhao, TIAN Jixue

Background

Embankment dams, widely constructed and covering extensive areas, frequently experience material degradation due to seepage-induced weakening. Minor seepage can lead to progressive wetting deformation of support structures and subsequent failure of the impermeable elements. Major seepage triggers continuous seepage deformation and even catastrophic failure. Examples include the collapse of concrete face slabs and cushion erosion in Hunan's Zhushuqiao and Baiyun dams, core wall defects in Sichuan's Shiziping dam, and the collapse of Qinghai's Gouhou concrete-face sand-gravel dam.

The in-situ anisotropy induced by the layered compaction of embankment dams and long-term sedimentation of overburden, as well as the in-situ stress caused by overlying loads, significantly influences the seepage-induced weakening effects on dam materials. Existing experimental apparatus inadequately replicate in-situ anisotropy, stress, and hydraulic gradients, necessitating advanced apparatuses to simulate in-situ seepage-induced weakening characteristics for the predictive evaluation of the embankment dam safety.

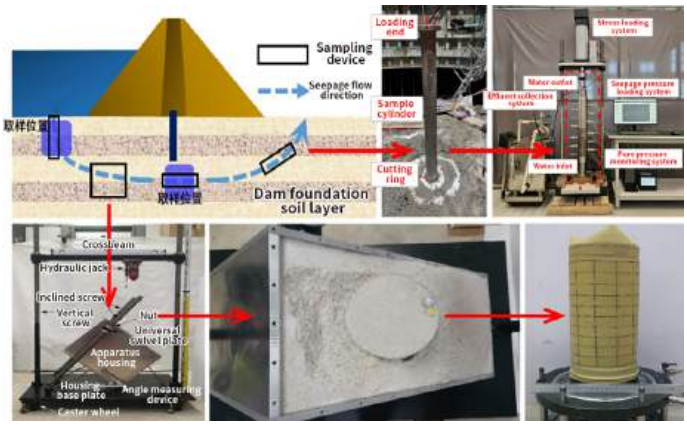

Fig.1 Experimental Apparatus for Field Sampling and Laboratory Preparation to Reproduce In-situ Anisotropy

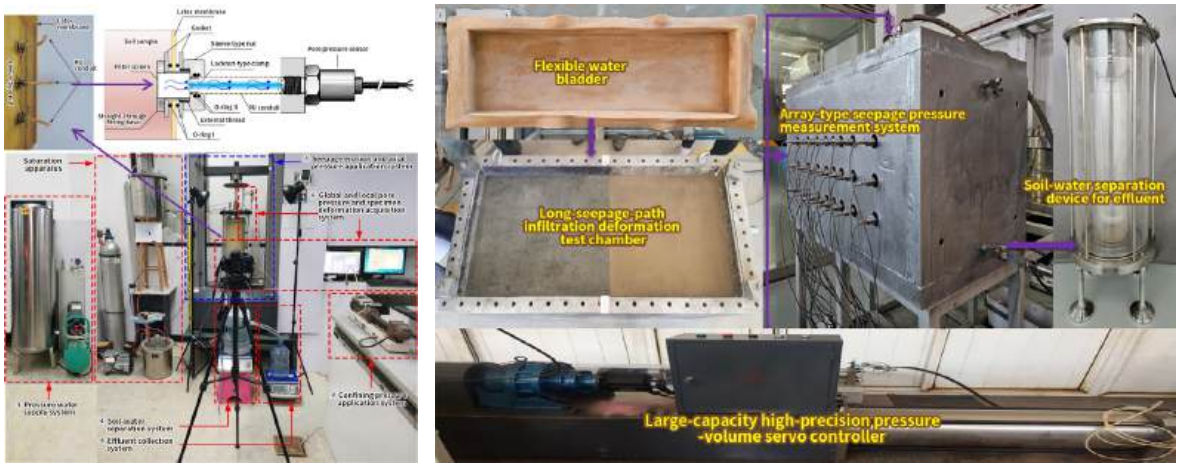

Fig.2 Experimental Apparatus for Simulating Progressive Seepage Deformation Under In-situ Anisotropy

Contents

- Development of an experimental apparatus for field sampling and laboratory sample preparation to reproduce in-situ anisotropy;
- Design of an experimental apparatus for simulating progressive seepage deformation under in-situ anisotropy;
- Innovation of an experimental apparatus for simulating progressive wetting deformation under in-situ stress.

Achievements

- An apparatus for simulating the seepage deformation characteristics of overburden under in-situ stress has been developed, and a device for preparing anisotropic soil samples of coarse-grained overburden has been invented. The combination of field-oriented and laboratory-oriented methods enabled the preservation of in-situ anisotropy and the determination of directional combinations.
- An "Oreo"-style sleeve osmometer has been developed for sidewall installation on the flexible latex membranes. A soil-water separation technique for seepage deformation tests with controllable outlet hydraulic head has also been established. Furthermore, a triaxial seepage deformation testing system has been innovatively developed to realize the full-scale measurement of deformation, hydraulic gradients, and particle migration.
- A progressive wetting process control device that simulates steam or drip effects under in-situ stress has been invented, a graded-load wide-range force sensor has been created, and a measurement device for progressive water absorption and wetting processes under in-situ hydraulic head has been developed.

Application

The developed experimental apparatus has been successfully applied to critical projects, including the Lijiayan concrete-face rockfill dam, the Shuangjiangkou gravelly soil core rockfill dam, and a key hydropower project. It has provided robust support for engineering demonstration, process consulting, and real-time adaptive design, generating substantial social benefits. The apparatus demonstrates strong potential for widespread application.

Fig.3 Experimental Apparatus for Simulating Progressive Wetting Deformation Under In-situ Stress

IWHR

Key Technologies and Application of Multi-source Rainfall Monitoring and Forecasting, and Nowcasting and Early Warning of Flash Flood Disasters

Main Participants: LIU Ronghua, WU Zebin, TIAN Jiyang, KAN Guangyuan, SUN Chaoxing, DOU Yanhong, LIU Qi, ZHANG Xiaolei, ZHAI Xiaoyan, LIU Xiao

Background

The forecasting and early warning of flash floods triggered by heavy rainfall is a primary technical means for the prevention of flash flood disasters and also a globally recognized technical challenge. At present, China has basically achieved two methods for flash flood disaster prevention, i.e., the geological hazard risk early warning based on meteorological factors and the early warning based on real-time monitoring. The former offers a long forecast lead time but suffers from low accuracy, while the latter boasts higher accuracy but lacks sufficient lead time. In order to achieve an effective balance between lead time and accuracy of flash flood early warning and scientifically guide the evacuation and risk avoidance of populations in mountainous regions, the research team has been engaged in the research on heavy rainfall monitoring and forecasting, as well as nowcasting and early warning of flash flood since 2018, and has achieved notable results. The related findings have been put into practical use on the national flash flood disaster monitoring, forecasting and early warning platform, as well as provincial platforms in Fujian, Shaanxi and other provinces. These achievements provide robust technical support for the implementation of the national flash flood disaster prevention projects, and play a vital role in enabling China's Ministry of Water Resources to grasp the overall situation of flash flood disaster risks across the country during the flood season and to supervise and guide local efforts in flash flood disaster prevention.

Contents

- Developing a multi-source rainfall monitoring method integrating satellite, radar and ground station data, with consideration of the localized rainfall characteristics.
- Developing a nowcasting technology applicable to forcasting of different types of rainfall utilizing various radar wavelengths in different regions across China.

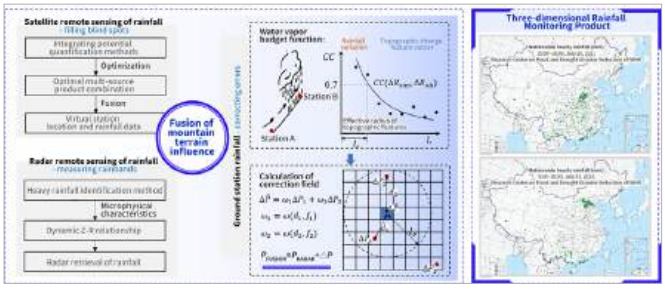

Fig.1 National High-resolution Three-dimensional Rainfall Monitoring and Fusion Technology

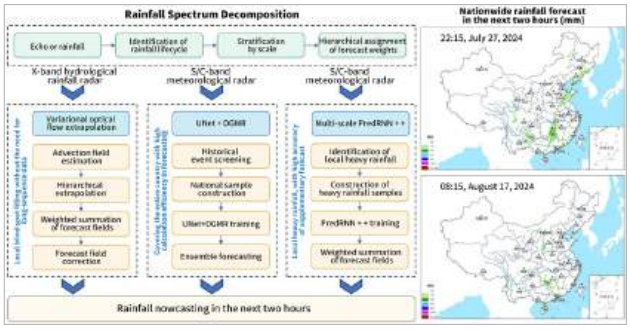

Fig.2 Rainfall Nowcasting Technology

- Developing a soil moisture simulation technology based on the water-heat balance theory and coupled equations has been developed.
- Establishing a dynamic rainfall warning indicator analysis method has been developed and a technical system of flash flood disaster nowcasting and early warning.

Achievements

- A multi-source rainfall monitoring approach that integrates "utilization of global products to fill monitoring blind spots, rainfall radar to capture rainband trends, and ground stations to correct rainfall errors" has been proposed, a multi-source rainfall monitoring method with consideration of localized rainfall characteristics has been developed, and "sky-space-ground" three-dimensional rainfall monitoring products that cover mountainous regions across the country have been created.
- A rainfall spectrum decomposition method has been proposed and a nowcasting technology for predicting rainfall in mountainous regions across the country in the next two hours has been developed based on spectrum decomposition techniques and deep learning, thereby improving the accuracy of rainfall nowcasting by 20%.
- Bidirectional coupled equations for the water and heat balance processes have been established, a quantification scheme for key physical quantities has been proposed, and a dual-time-step finite volume spatial-temporal discretization method has been developed, thereby improving the simulation accuracy by 10%.
- A forward trial calculation method for dynamic rainfall warning indicators that considers soil moisture changes and spatial-temporal heterogeneity of rainfall has been proposed and a sample database of dynamic early warning indicators for villages and a surrogate model based on random forests have been established, thereby increasing the forecast and early warning hit rate to over 75%.

Application

The achievements have been applied in China's Ministry of Water Resources, 29 provinces, the Xinjiang Production and Construction Corps, and 2,076 county-level organizations, benefiting more than 300 million people. From 2021 to 2024, a total of 550 nowcasting and early warnings were issued at the national level, while local authorities issued 5,775 forecasts and early warnings,and sent over 4.203 million text messages on early warning. As a result, 370,000 people were evacuated accordingly. This significantly enhanced the level of flash flood disaster early warning, providing strong support for the decision-making and deployment in flash flood disaster prevention efforts, and yielding substantial benefits in disaster prevention and mitigation.

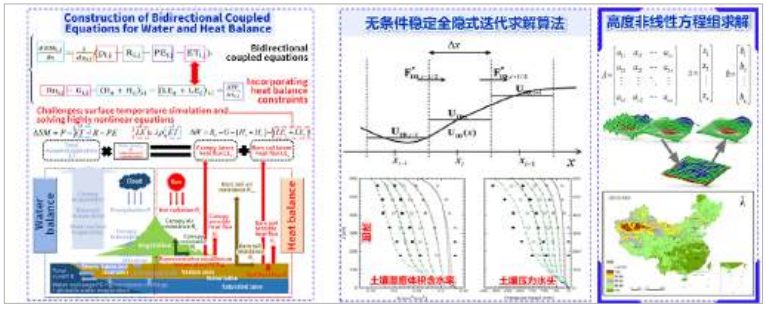

Fig.3 Soil Moisture Field Construction Technology

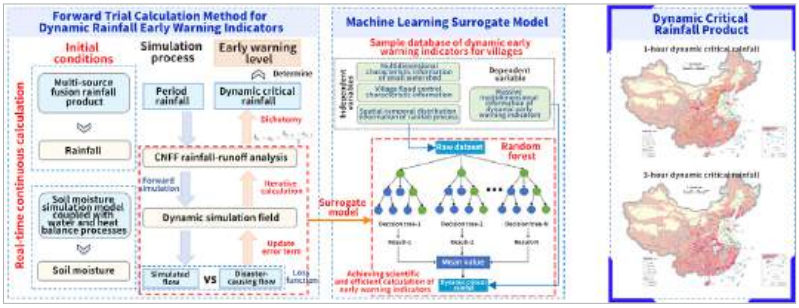

Fig.4 Dynamic Early Warning Indicator Analysis Technology

IWHR

Evapotranspiration Mechanism and Precise Irrigation Regulation Mechanism for Irrigation District

Main Participants: CAI Jiabing, ZHANG Baozhong, XU Di, YU Yingduo, LIU Yu, WEI Zheng, PENG Zhigong, CHEN He

Background

The decision-making network is the core of irrigation district modernization and the precise implementation and realization of digital irrigation districts. The accurate estimation of farmland evapotranspiration and the precision irrigation management system forms the foundation of this decision-making network. Focusing on this pivotal aspect, and with the support of multiple National Natural Science Foundation projects and National Science and Technology Support Program initiatives, relevant scientific research has been conducted for nearly 20 years to explore farmland evapotranspiration mechanism and precision irrigation decision-making simulation in irrigation districts, which has yielded significant results and thus advanced agricultural water conservancy, hydrology, and water resources disciplines.

Contents

- In response to the unclear scale effects of crop evapotranspiration, the ambiguous conversion relationship between temporal and spatial scales, the difficulties in real-time forecasting of crop water requirements based on farmland conditions and the impracticality of existing models, this research profoundly reveals the variation pattern of farmland evapotranspiration at different spatio-temporal scales and its driving mechanisms. In addition, efficient models for simulating reference evapotranspiration and forecasting crop water requirements has been established, thereby resolving the issues of farmland data traceability, analytical methods and accuracy. These advancements provide foundational models for decision-making theory and technology of precision irrigation.
- In response to issues such as ambiguous parameter scaling for remote sensing of evapotranspiration in irrigation districts, insufficiently detailed characterization of process parameters, and the urgent need to improve simulation accuracy, this research has innovated precision characterization methods and models for key parameters in remote sensing inversion of evapotranspiration. It has clarified the mechanisms for enhancing the accuracy of simulation models for remote sensing inversion of evapotranspiration and overcome the issue of inaccurate ET estimation caused by light saturation of vegetation indices during the mid-to-late stages of crop growth. These advancements provide scientific insights for the in-depth development of remote sensing mechanisms for evapotranspiration in irrigation districts.
- In response to issues such as the unclear sensitivity and thresholds of decision-making indicators for farmland irrigation, the simplicity and lack of systematicness of decision-making models, and data asynchrony in precision irrigation decision-making management in irrigation districts, a decision-making theory and

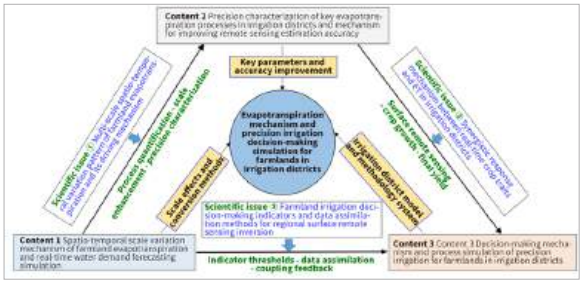

Fig.2 Main Research Content and the Scientific Challenges Addressed

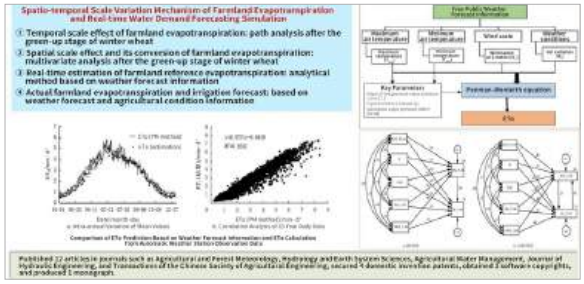

Fig.2 Mechanism Revelation

methodology for precision farmland irrigation has been developed. In addition, a precision irrigation simulation model and system for irrigation districts has been constructed based on multi-data fusion and assimilation, thereby addressing the multidimensional and nonlinear challenges in precision irrigation decision-making and forecasting. These advancements provide core technologies and methods for the modernization of irrigation districts and the realization of smart irrigation districts.

Achievements

- The scale effects and process mechanisms of farmland evapotranspiration and remote sensing-based evapotranspiration inversion in irrigation districts have been systematically addressed, and a method for identifying and differentiating component temperatures of heterogeneous surface pixels has been proposed, thereby overcoming the accuracy and applicability issues of the classical dual-source remote sensing evapotranspiration model caused by the inconsistency between its assumptions and the actual heterogeneous surface conditions.
- A two-stage precision characterization method based on the red-edge chlorophyll index has been proposed for the first time to differentiate the expression forms of leaf area index for C3 and C4 crops, which significantly improves the accuracy, validation efficiency and reliability of remote sensing monitoring of evapotranspiration and advances major progress in addressing the long-standing "evapotranspiration challenge" critical to agricultural and forest meteorology, hydrology and water resources.
- A fuzzy logic-based precision irrigation simulation model and system for intelligent multi-index integrated decision-making has been established and a regional precision irrigation methodology and system based on multi-data fusion and assimilation has been developed. These achievements proactively align with the requirements of building modern and digital irrigation districts under the rigid constraints of water resources.

Comprehensive Comparison with Similar Studies at Home and Abroad

- This work has led the way in agricultural and forest meteorology and evapotranspiration research, with some findings and conclusions being widely recognized and cited both domestically and internationally. It has advanced the development of agricultural water conservancy, hydrology and water resources disciplines, making foundational contributions to the efficient utilization of water resources. The research findings have been published in 44 high-level papers and yielded 13 national invention patents, 7 software copyrights and 2 monographs.
- According to a search in the SCIE database (Web of Science Core Collection), 9 representative papers have been cited a total of 535 times, with non-self citations amounting to 461 times. Among these, the paper "Estimating reference evapotranspiration with the FAO Penman–Monteith equation using daily weather forecast messages" has been cited 257 times; "Dual crop coefficient modelling applied to the winter wheat–summer maize crop sequence in North China Plain: Basal crop coefficients and soil evaporation component" has been cited 108 times; and "Responses of field evapotranspiration to the changes of cropping pattern and groundwater level in large irrigation district of Yellow River basin" has been cited 65 times.

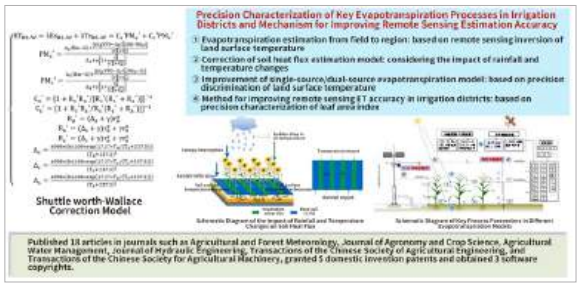

Fig.3 Estimation Method Improvement

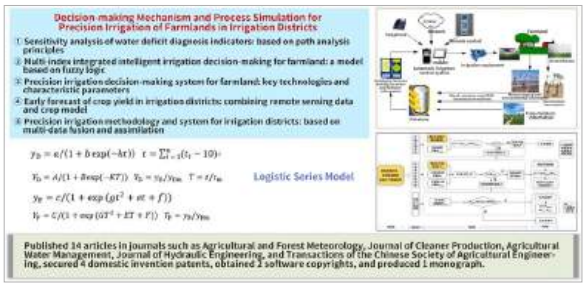

Fig.4 Precision Decision-making Simulation

IWHR

Development and Application of Eco-Friendly Epoxy Grouting Materials

Main Participants: ZHAO Weiquan, ZHANG Jinjie, ZHOU Jianhua, WANG Wenzhao, LI Yonghui, TIAN Gensheng, WANG Xinchun, ZHAO Lei

Background

Epoxy grouting materials are characterized by low viscosity, excellent groutability, high mechanical strength of the solidified mass, and strong adhesive properties. They can be used for both seepage prevention and structural reinforcement, thus being widely applied in fields such as water, hydropower and transportation. Currently, most epoxy grouts use furfural-acetone as the diluent, which can reduce the viscosity of the epoxy while maintaining excellent mechanical properties. However, furfural is highly toxic, volatile, and strongly irritant, classified as a Group 3 carcinogen. The commonly used curing agents are also low toxic, threatening human health and the environment. As a result, its application is increasingly restricted, and alternative eco-friendly epoxy grouting materials are much needed.

Contents

- Research on low toxicity of epoxy grouting materials and optimal selection of raw materials.
- Experimental study on the basic formulation of eco-friendly epoxy grouting materials.
- Research on reinforcement and toughening modification of eco-friendly epoxy.
- Research on the curing reaction mechanism of epoxy grouting materials.

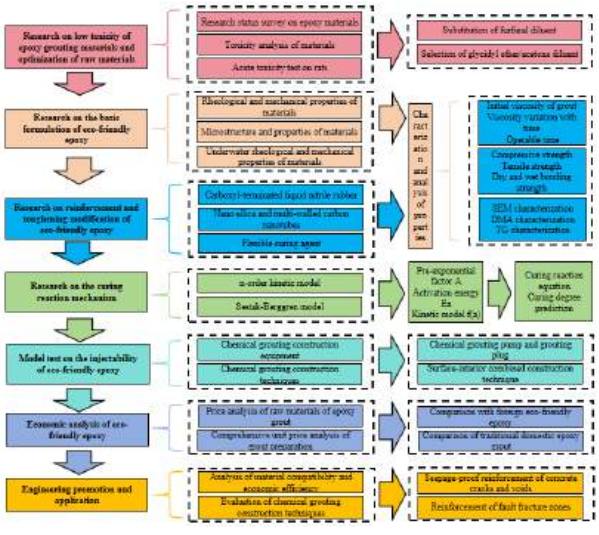

Fig.1 Technical Route for the Research and Development of Eco-friendly Epoxy Grouting Materials

Type		Ordinary type	Quick-setting type	High-permeability type	High-elasticity type	Low-temperature type	Underwater type
Component A	Epoxy resin	100	100	100	100	100	100
	Diluent	RDGF 20–30 Acetone 40–70	RDTF 10–20 Acetone 10–30	RDGF 10–30 Acetone 40–80	RDGF or RDTF 10–30 Acetone 10–30	RDGF 10–30 Acetone 40–70	RDGF 10–20 Acetone 10–30
	Nano fillers	/	Nano silica or multi-walled carbon nanotubes 1.0–2.0	/	Nano silica or multi-walled carbon nanotubes 1.0–2.0	/	/
Component B		25–40	(Flexible curing agent) 35–50	20–30	(Flexible curing agent) 35–50	(Low-temperature curing agent) 25–40	(Underwater curing agent) 30–50
Gelation time (min)		>30	10–60	>30	30–80	>30	10–60
Grout viscosity (mPa·s)		20–40	500–1200	<10	500–1200	20–40	600–1200
Bonding strength (MPa)	Dry bonding	3.7–4.1	4.2–5.1	3.4–3.8	3.9–4.7	3.2–3.9	4.0–4.8
	Wet bonding	2.2–2.7	3.6–4.3	2.1–2.4	3.1–4.1	2.1–2.4	2.0–2.3
Tensile strength (MPa)		25–35	20–40	15–20	15–20	10–15	8–12
Compressive strength (MPa)		55–70	70–90	50–65	70–80	55–70	55–65
Elongation at break (%)		/	5–15	/	50–70	/	30–50
Toxicity (LD50)		>5000	>5000	>5000	>5000	>5000	>5000

Fig.2 Typical Formulation and Properties of Eco-friendly Epoxy

- Simulation test on the groutability of eco-friendly epoxy.
- Research on grouting construction techniques.
- Engineering promotion and application.

Achievements

- Adopting glycidyl ether-acetone as the diluent and modified amine as the curing agent, the eco-friendly epoxy grouting formulations have been developed for various working conditions, including ordinary type, quick-setting type, high-permeability type, high-elasticity type, low-temperature type, and underwater type.
- These formulations, both in its slurry and gel states, have achieved a non-toxic level (LD50 > 5000mg/kg), and cost only 1/3 to 1/2 of imported products.
- A surface-interior combined construction technique has been developed for concrete crack treatment. The surface is coated with quick-setting epoxy for rapid sealing, while the interior of the cracks is drilled and filled with epoxy. This technique significantly improves construction efficiency and the engineering performance.
- The curing reaction process of eco-friendly epoxy has been studied using the non-isothermal DSC method. A curing mechanism model has been established to simulate the curing reaction process of the grouting material and predict the curing reaction degree.

Application

The research achievements have been successfully applied to defect repairs in more than 10 projects, including leakage treatment in the well chamber of the South-to-North Water Diversion Project East Main Canal in Beijing, seepage treatment in the lining of headrace tunnel of the Zhelin Hydropower Plant, leakage treatment in the gallery cracks of the Hohhot Pumped Storage Hydropower Station, separation treatment in the tailwater cone pipe of the Wanjiakouzi Hydropower Station, and foundation reinforcement of wind turbines in the Huade Wind Power Plant. All these repair have achieved excellent results, demonstrating significant economic, social, ecological and environmental benefits of the eco-friendly epoxy materials and their supporting techniques.

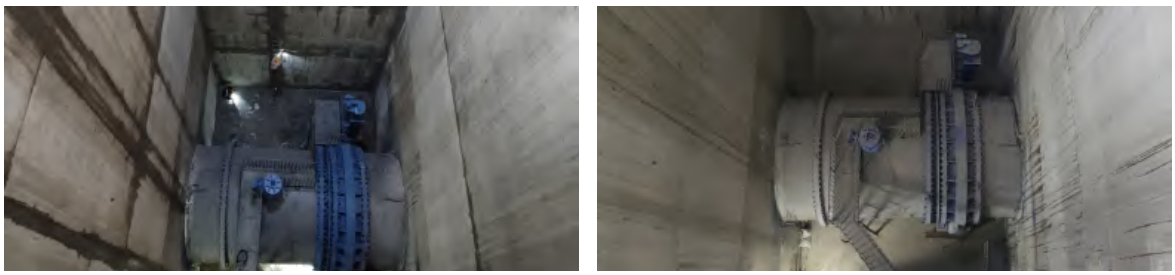

Fig.3 T Comparison Before and After Leakage Treatment in the Valve Chamber of the South-to-North Water Diversion Project East Main Canal

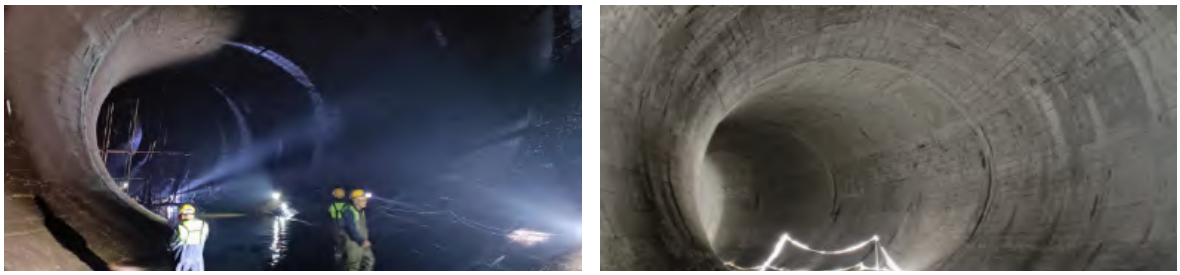

Fig.4 Comparison Before and After Leakage Treatment in the Lining of Headrace Tunnel of the Zhelin Hydropower Plant

Multi-scenario Utilization of Solar Energy and Intelligent Water Supply Equipment in Alpine Pastoral Areas

Main Participants: NIU Junkui, ZHU Junfeng, WANG Shifeng, YAO Jianan, WANG Xingtian, HOU Shiwen, LIU Wenbing, HUANG Yun

Background

China has a vast territory of pastoral areas, primarily distributed in the northern and northwestern alpine regions. The pastoral areas are remote, with harsh natural environment, scattered settlements, lack of conventional energy, insufficient infrastructure, and primitive water supply facilities. Water pumping is mainly powered by gasoline and diesel generators, and local herders mainly carry water to their homes for daily use, leading to low convenience in water access. During frigid and long winter, livestock have to directly drink cold well water or lick snow and ice, leading to severe cold stress reaction that causes significant weight loss, reduced milk production, and constraints on the economic efficiency of livestock farming. At the same time, under sustained low-temperature conditions, blocking and crack frequently occur in water supply equipment and pipelines. The harsh environment poses even greater challenges to the already fragile water supply systems for both humans and livestock in pastoral areas, greatly impacting the drinking water safety and the healthy and sustainable development of livestock husbandry. Meanwhile, the vast pastoral areas are abundant in solar energy resources,which is favorable for utilization of solar energy technologies.

Contents

- Developing photovoltaic water pumping technology that is directly powered by solar energy and automatically adjust load power without the need for power storage;
- Achieving 24-hour water supply to herder households and enabling "one well for multiple households" while overcoming energy limitations and utilizing pressure tanks and other technologies;
- Studying the use of free solar energy and information technology to achieve automatic drinking and the supply of warm water during winter for livestock;
- Studying the encapsulation forms of phase-change materials and the phase change-water combined thermal energy storage technologies that are complementary to thermal energy storage in water bodies;

Fig.1 Photovoltaic Water Pumping Project in Gangcha County, Haibei Xizang Autonomous Prefecture, Qinghai Province

Fig.2 Water Supply to Households Using Photovoltaic Technology and Pressure Tanks in Xilin Gol League, Inner Mongolia

- Studying solar heating and anti-freezing technology based on phase change-water combined thermal energy storage, utilizing abundant solar energy for heating and anti-freezing of water supply facilities.

Achievements

- Having developed a specialized solar-powered water pump, enabling efficient matching between water pump and solar energy, resulting in an approximately 30% enhancement in system operating efficiency and a 18-25% increase in daily water pumping capacity;
- Having overcome the limitations of traditional energy sources and developed a solar-powered water pumping technology without the need for power storage. The system can adjust load power in real time based on resource changes with a maximum pumping head of 200m and a flow rate of up to 30m^3/h.
- Having achieved intelligent warm water supply for livestock during winter by utilizing solar thermal technology for the first time. Having achieved automatic drinking control for livestock and zero energy consumption of system operation through machine recognition technology;
- Having formulated a phase-change material compatible with solar heat-collecting temperature, and encapsulated it within a water-based thermal energy storage system, increasing storage capacity to 200%. This maximizes the absorption and storage of solar heat energy, improving solar heat collection efficiency by about 6%;
- Having studied the dual-vacuum superconductor heat collection and temperature-differential air evacuation technology to deal with the leakage in glass tube heat collectors under extreme cold conditions. Free and abundant solar energy has been utilized for heating and anti-freezing of water supply facilities, achieving energy savings of over 75%.

Application

Since 2013, multi-scenario utilization of solar energy and intelligent water supply equipment for alpine pastoral areas have been widely applied in Inner Mongolia, Qinghai, Xinjiang, and other regions. With a total installed capacity of 1060kW, this technology helps guarantee drinking water supply of 7,424 herder households and over 285,000 livestock, covering 15,900 square kilometers of natural grassland. The results have been very significant and highly recognized by herders. This also brings an annual economic benefit of 20.406 million RMB, with a total economic benefit of 408.1205 million RMB in 20 years. It also yields significant social benefits, playing a crucial role in improving the quality of life for herders and ensuring border stability, rural revitalization and environmental protection.

Fig.3 Solar-powered Intelligent Constant-temperature Drinking Water Equipment for Livestock in Baotou City, Inner Mongolia

Fig.4 Solar Heating and Anti-freezing Project for Water Purification Room in Ulanqab City, Inner Mongolia

Integrated Platform for Intelligent Ship Lock Management and Control of Navigation and Hydropower Junction Project

Main Participants: DENG Xiaogang, HE Ting, HAN Changlin, ZHU Xueqin, CHEN Xiaosong, ZHANG Xiaocheng, ZHANG Hongyan, GU Yafei

Background

The Xinjiang Navigation and Hydropower Junction Project is a key waterway construction initiative in Jiangxi Province, aiming to establish a smooth, efficient, safe and green modern comprehensive transportation network. Traditional ship lock management systems typically separate the management and control functions, with operators allocated separately, leading to significant waste in human resources and information silos. Targeting the Jiangxi Xinjiang Navigation and Hydropower Junction Project, this research focuses on the development and application of an integrated platform for intelligent ship lock management and control based on the lock monitoring system and intelligent navigation system. The platform aims to resolve the conflict between navigation and surplus water, maximize the utilization of water resources, and achieve the health, safety and performance perception of equipment, as well as predictive analysis and diagnostic evaluation. The ultimate goal is the "intelligent, standardized, precise and convenient" operation and management of the navigation and hydropower junction.

Contents

The "Complete Pack of Technologies for Intelligent Management and Control of Centralized Water Supply in Rural Areas" includes water lifting/supply system, water metering instrument, water filtration, purifying and quality monitoring devices, and automatic monitoring system platform, among others.

- Studying the overall architecture of the integrated platform for intelligent ship lock management and control, and establishing a comprehensive and station-wide data center.
- Studying the interaction of data with different standards through a unified data interface, and achieving automatic control of the lockage process with minimal surplus water and high efficiency.
- Studying the technology for cross-security partition data interconnection between the lock management system and the monitoring system.
- Studying the user-friendly human-machine interface of the integrated management and control platform to enhance the monitoring efficiency.

Fig.1 Interface of the Integrated Platform for Intelligent Lock Management and Control of Navigation and Hydropower Junctions

Fig.2 Nanchang Centralized Control Center of JXPG

- Studying a three-dimensional simulation system that integrates hydropower stations and ship locks for improving personnel skills and emergency response capabilities.

Achievements

- Having developed an integrated platform for intelligent ship lock management and control, which incorporates data from various systems including control, intelligent navigation, industrial television, information management, operation and maintenance, scheduling, and hydraulic structure monitoring. This platform also enables the connected function of broadcasting and video playing.
- Having developed the intelligent data interaction technology for the intelligent lock management and control system. This technology enables intelligent lockage scheduling based on constraints such as ship conditions and power plant generation status. It initiates the lockage process through an automated control procedure.
- Having developed the technology for cross-security partition data interconnection, which collects data from various perception and monitoring systems across the entire station into the integrated platform. This platform forms a comprehensive and station-wide data center encompassing navigation, power, water, and dam conditions. Key elements such as restricted stopping lines, meteorological conditions, status diagnosis, and dam safety data are incorporated as navigational safety constraints and are visually displayed in the monitoring system.
- Having developed a user-friendly human-machine interface for the integrated management and control platform, incorporating interactive controls such as edit boxes, check boxes, two-dimensional tables, and ECharts charts, seamlessly integrating JavaScript scripting capabilities, thereby enhancing interactive operation functions.
- Having developed a technologically advanced operation simulation system, established a library of mathematical mechanism models for ship lock equipment simulation, and constructed an underlying model of lock system in a visual, zero-code manner; having established a three-dimensional operation and maintenance platform for ship locks, which is driven by the simulation equipment mathematical model to form a closed-loop process of monitoring, operation and feedback.

Application

The integrated platform for intelligent lock management and control of navigation and hydropower junctions integrates lock scheduling, management, control, and intelligent navigation, all managed and analyzed within a single platform. This integration facilitates better planning of the economic dispatching control of power stations, ensures smooth navigation through the locks, enhances the utilization of water resources in the basin, reduces the workload of operation and maintenance personnel, and improves the efficiency of ship passage. The technology of the integrated platform for intelligent lock management and control of navigation and hydropower junctions has been applied to various locations, including the Antai Navigation and Hydropower Junction, Taihe Navigation and Hydropower Junction, Xingan Navigation and Hydropower Junction, Bazizui Navigation and Hydropower Junction (including the Hushanzui Power Station and Mopiling Power Station), Shuanggang Navigation Junction, and Nanchang Centralized Control Center of JXPG. It has significantly enhanced the overall social image of the navigation and hydropower junctions.

Fig.3 Central Control Room of Shuanggang Navigation Junction

Fig.4 Central Control Room of Bazizui Navigation and Hydropower Junction

Fig.5 Ship Lock Simulation Training Room

Scientific Innovation Expedition of Yinshanbeilu Grassland Eco-hydrology National Observation and Research Station: League-City Collaboration, Science-Water Synergy

Main Participants: XU Xiaomin, WANG Lixia, YUCHI Wensi, BI Jiawei, YANG Jialin

Background

In order to thoroughly implement scientific and technological innovation, popularization of science, and development of new productive forces, to fully leverage the unique role of water conservancy and the functional positioning of Yinshanbeilu Grassland Eco-hydrology National Observation and Research Station, and to commemorate the first anniversary of the full launch of the "Three-North" Shelterbelt Program, the Institute of Water Resources for Pastoral Areas, MWR (IWRPA), in collaboration with the Department of Science and Technology of Inner Mongolia Autonomous Region and other organizations, meticulously planned and organized a series of distinctive water science outreach activities. These activities, themed "Promoting the Spirit of Scientists and Stimulating Innovation Vitality Across the Society", and titled "Scientific Innovation Expedition to Yinshanbeilu Grassland Eco-hydrology National Observation and Research Station: League-City Collaboration, Science-Water Synergy, focusing on the "Three-North" Project, and Strengthening the Ecological Barrier", were held during the National Science and Technology Week and the National Science and Technology Workers Day from May 24 to 31. These activities aim to harness scientific leadership and innovation drivers, unite various stakeholders to jointly advance water conservancy science and technology innovation in Inner Mongolia and across the nation, thereby achieving the beautiful vision of "league-city collaboration, interaction between science and water conservancy, and jointly fortifying the ecological security barrier of China's northern frontier".

Contents

- Participating in the major scientific and technological achievements exhibition: On May 25, attending the opening ceremony of the Science and Technology Week of Inner Mongolia Autonomous Region, where an interactive exhibition area showcasing scientific and technological achievements was set up at the event.
- Sharing stories of water scientists: On May 30, the eighth "National Science and Technology Workers Day", sharing the stories of water scientists and researchers working on the frontline of pastoral areas.
- Showcasing regional policy highlights: On May 31, at the closing ceremony of the Science and Technology Week hosted by the Department of Science and Technology of Inner Mongolia Autonomous Region, organizing a special session titled "Promoting Science and Technology Innovation Policies to Empower High-quality Development".
- Hosting a high-end academic forum: On May 31, inviting several renowned experts to deliver academic reports focusing on the new "Three-North" Shelterbelt Program, new productive forces in water conservancy, and ecological security barrier.
- Visiting a science popularization demonstration base: On May 31, organizing a field visit to Yinshanbeilu Grassland Eco-hydrology National Observation and Research Station for regional science and technology management personnel and water conservancy technicians.

Achievements

- This event was selected as a 2024 National Science and Technology Week distinctive public science activity and recognized as a key water conservancy-themed activity.
- By comprehensively showcasing major scientific and technological innovation achievements for pastoral areas and conducting live science broadcasts, this event enhanced the influence of pastoral water conservancy science and technology support.
- By sharing the stories of water conservancy scientists and researchers dedicated to critical issues such as the intensive

and efficient management of water resources, grassland ecological protection, and the use of clean energy for water lifting and supply in rural pastoral areas, this event has highlighted the advancement of high-quality development of water conservancy through scientific and technological innovation, and also vigorously promoted the scientific spirit.

- Through road shows by the heads of science and technology management departments from 12 leagues and cities in Inner Mongolia, showcasing local scientific and technological innovation policies and their implementation, the event facilitated the policy implementation and promoted science and technology water conservancy integration. This event was recommended by the Department of Science and Technology of Inner Mongolia and selected as a 2024 National Science and Technology Week distinctive public science and technology activity.
- Science and technology workers and water experts from Inner Mongolia's 12 leagues and cities discussed on high-quality development topics, delving into innovation challenges in fields such as grassland ecological protection, national water network planning, and the "Three-North" desertification control. They also discussed the future water science and technology directions, contributing to the resolution of related issues and the future development in these fields.
- Through sand table explanation, equipment demonstration and other methods, the latest achievements in water conservancy science and technology for pastoral areas in Yinshanbeilu Grassland Eco-hydrology National Observation and Research Station were showcased to regional science and technology management personnel and water technicians. These achievements covered fields such as eco-hydrology, new energy water supply, and smart water conservancy, effectively promoting application and adoption.

Application

This event attracted over 700 participants, including representatives from science and technology management departments, alongside experts, scholars, and primary and secondary school students from across Inner Mongolia's 12 leagues and cities. Comprehensive and multi-channel publicity was conducted through seven media outlets, including Inner Mongolia Radio and Television Station, Benteng Media, Inner Mongolia Daily, and the Chinese Hydraulic Engineering Society's Toutiao account, with a total of 10 news articles published. The event marked a new chapter of "league-city collaboration and science-water synergy", significantly raising public awareness and industry influence of pastoral water science and technology. It stimulated deeper integration between technological innovation and science popularization while making a positive contributions to fortifying the ecological security barrier of China's northern frontier.

Fig.1 Exhibition of Representative Scientific and Technological Achievements

Fig.2 Sharing Stories of Water Scientists

Fig.3 Regional Policy Highlights Exhibition

Fig.4 Hosting an Academic Forum

Fig.5 Water Science & Technology Discussion and Exchange

Fig.6 Science Outreanch Activities During the National Station Open Day

The First "Harmonious Coexistence Between Human and Nature" Short Video Competition for Soil and Water Conservation Science Popularization

Main Participants: PAN Qingbin, CHEN Yin, ZHAO Ying, SONG Ruhua, LI Liang

Background

In order to respond to national science outreach directives, and embrace the principle that "lucid waters and lush mountains are invaluable assets", the IRTCES, in collaboration with the Chinese Society of Soil and Water Conservation and other organizations, hosted the "Harmonious Coexistence Between Human and Nature" Short Video Competition for Soil and Water Conservation Science Popularization. It aims to disseminate scientific knowledge, regulations, and conservation achievements to the public, porpelling soil and water conservation toward a new stage of high-quality development.

Contents

- The competition, themed "Harmonious Coexistence Between Human and Nature", captured zeitgeist and carried profound significance.
- The submitted works elaborated the relationship between human and nature through soil and water conservation knowledge, case-based legal interpretation, and hometown stories. They reveal the profound meaning of "if we humans do not fail nature, nature will not fail us", helping the audience grasp the essence of General Secretary Xi Jinping's emphasis that "The environment has a significant impact on quality of life. Green mountains display beauty, and blue skies bring happiness."

Fig.1 Review Meeting

Fig.2 Award Ceremony

- The competition was open to all with no participation barriers, attracting active participation from government agencies, research institutes, enterprises, institutions, and the general public. It enhanced public awareness and a sense of social responsibility.
- The competition encouraged innovation, allowing submissions to adopt diverse forms of expression in terms of genre and language, thereby offering participants great creative freedom and imaginative space. The submitted works demonstratred excellence in scientific rigor, technical proficiency, creativity, artistic value, and popularity.

Achievements

- The competition gathered approximately 4,000 submissions on Douyin, with 221 entries officially recognized on the 1ZP.TOP platform. The topic on Douyin achieved a total of 24.6 million views, yielding significant social publicity effects.
- The competition organizers conducted a public voting event for the finalist entries on the 1ZP.TOP platform. The total number of votes reached 395,338, reflecting the enthusiastic industry and public participation in soil and water conservation.
- The competition attracted widespread attention, with numerous entries not only popularizing legal knowledge, practical techniques and successful case studies that offer valuable lessons for other regions.
- The competition received high praise from all sectors of society, with in-depth media coverage, further amplifying its social influence.

Application

This competition garnered widespread attention and enthusiastic participation from all sectors of society. It is not only a successful science outreach initiative but also a powerful practice in advancing high-quality soil and water conservation. With its unique creativity, broad participation and profound social impact, the competition achieved its expected goals of popularizing knowledge and regulations while promoting conservation achievements. Delivering remarkable results, it has reinvigorated China's soil and water conservation efforts with new energy and momentum.

Fig.3 Representative Competition Entries

Fig.4 Showcasing Representative Entries in Primary and Secondary Schools

Fig.5 Event Promotion

Outstanding Teams

Hydro-Sediment Environment Simulation Team

Team Members: HUANG Hai, GUAN Jianchao, FANG Chunming, MAO Jixin, ZHANG Lei, WANG Dayu, LIN Jiaqi, LI Linqi

Team Introduction

Ecological civilization construction has been elevated to China's national strategy, with the concept of systematic governance gaining widespread acceptance. The digital twin technology in water conservancy has become a crucial tool for achieving high-quality development of water conservancy in the new stage. The river system is an organic whole, and there is an urgent need to break down disciplinary barriers to study the multi-element coupling mechanism of sediment-related environment elements and construct a comprehensive multi-element process model, thereby creating a domestically developed, technologically advanced multi-element coupling simulation system for sediment-related environment. In order to better reflect the interdisciplinary interaction between water-sediment dynamics and sediment-related environment elements, and to comprehensively improve the theoretical and technological capabilities in simulating multi-element interactions within sediment-related environment in rivers, lakes, reservoirs, estuaries and coasts, the Hydro-Sediment Environment Simulation Team was established in January 2021. This team is dedicated to theoretical research, technological breakthroughs, product development, and application of sediment-related environment processes. Their research direction has been identified as a key research priority by the Ministry of Water Resources.

Dr. HUANG Hai, the principal contributor, serves as the Deputy Director of the section of Hydro-Sediment Environment Simulation at the Department of Sediment Research. He is engaged in the research of hydraulics and river dynamics, the theory and simulation technology of sediment-related environment. Dr. HUANG has led and participated in over 20 national, provincial-level research projects, including the National Natural Science Foundation of China (NSFC) Youth Fund Project, the 13th Five-Year National Key Research and Development Program, the NSFC Joint Fund, major scientific and technological projects of the Ministry of Water Resources, and the "Three-type Talents" Program of the China Institute of Water Resources and Hydropower Research (IWHR). He has published more than 20 academic papers, including 12 SCI/EI indexed articles, obtained 9 invention patents and 3 software copyrights, and published one monograph. Dr. HUANG has been awarded a Special Prize for Scientific and Technological Progress by the China National Committee on Large Dams, a First Prize for Dayu Scientific and Technological Progress Award, a Special Prize and a First Prize for Science and Technology by IWHR. Additionally, he has been honored with the title of "Three-type Talents" during the "14th Five-Year Plan" period by IWHR and has received a "Meritorious Service" commendation from IWHR.

The team integrates talent from three generations - senior, middle-aged, and young, forming a well-structured, experienced and dynamic echelon team. The senior members, all renowned experts in the field, offer decision-making support to the team. The middle-aged and young members, serving as the backbone of the team, propelling the team forward with their acute market insight and innovative spirit. The team is dedicated to the theoretical research, technological breakthroughs, product development, and application of sediment-related environment, and has achieved numerous innovative results.

Theoretical Advancement

- Established the statistical theory of bedload transport and the energy dissipation theory.

Technological Breakthroughs

- Developed a multi-dimensional (1D, 2D, 3D) integrated water-sediment mathematical model system based on Academician HAN Qiwei's original theory of non-uniform and non-equilibrium sediment transport.
- Made breakthroughs in the multi-element (such as P and C) coupling simulation technology for sediment-related environment.

- Established an analysis method for the impact of sediment replenishment on hydro-sediment environment.
- Achieved rapid prediction techniques for water-sediment dynamics in river networks across large spatiotemporal scales and optimized allocation methods for sediment resources using machine learning.

Product Development

- Built a standardized, full-process operation platform system for general mathematical model for sediment transport, leveraging cutting-edge technologies such as database management, geographic information systems, and 3D simulation earth, providing robust support for digital twin application in water conservancy.

Application

- Delivered critical technical support for maintaining the effective storage capacity and enhancing the comprehensive benefits of the Three Gorges Reservoir.
- Provided strong support for the China-Russia negotiations and governance on transboundary water, with the related achievements earning letters of appreciation from both the Ministry of Water Resources and the Ministry of Foreign Affairs.

Since its establishment in 2021, the team has led and participated in more than 20 national, provincial and ministerial research projects. The related research achievements have been awarded one special prize, one first prize, and one second prize at provincial and ministerial-level, as well as one special prize and one first prize for science and technology from IWHR. Their work has been selected for inclusion in the Ministry of Water Resources' Key Promotion Guidance Catalog of Advanced Practical Technologies, the Mature and Applicable Water Resources Science and Technology Achievements Promotion List, and the Ministry of Science and Technology's Technology List for Sustainable Development in Belt and Road Countries. The team has published 16 SCI-indexed papers and has been granted more than 10 invention patents. In terms of talent cultivation, one team member has been recognized as a Young Top-notch Talent by the Ministry of Water Resources; three have been awarded the "Three-Type Talents" title by IWHR; one has been included in the Youth Talent Support Program of the China Society for Hydropower Engineering; and one has been included in the Youth Talent Support Program of IWHR. Additionally, the core members of the team have been included in two ministerial-level innovation teams.

The Department of Sediment Research is an important component of the State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, and it is also the supporting unit for the Key Laboratory of Sediment Science and Northern River Regulation. Leveraging the platforms of these national and ministerial-level key Laboratories, the department provides the necessary software and hardware conditions to support the innovative development of the research team. At the same time, the team benefits from stable funding support through national, provincial and ministerial-level research projects, which also lays a solid material foundation for team building, talent cultivation, collaborative exchange, and equipment support. In the future, the team will continue to strengthen its expertise in the traditional field of sediment research, while also expanding its efforts in the field of sediment-related environment, aiming to advance numerical simulation of water-sediment dynamics and contribute to solving sediment-related environment challenges in China.

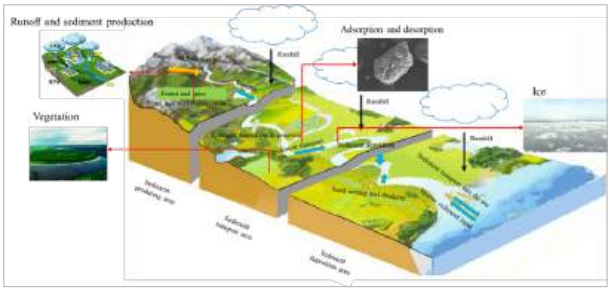

Fig.1 Schematic diagram of sediment-related environment processes

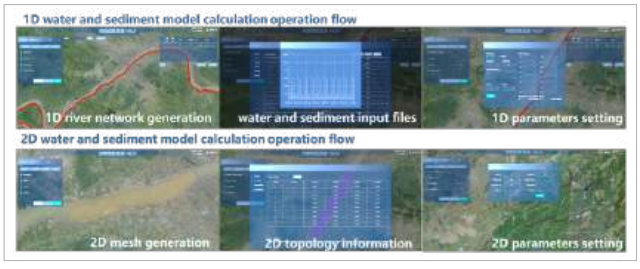

Fig.2 Schematic Diagram of the cross-scale all-dimensional environment simulation system workflow

Research & Development Innovation Team for Giant Hydropower Station Control System

Team Members: HAN Changlin, WANG Guiping, WEN Zhengguo, ZHANG Weijun, GONG Chuanli, YUAN Hong, YANG Chunxia, ZHAO Yongfei, DENG Xiaogang, ZHU Xueqin, CHEN Xiaosong, ZHANG Xu, CHI Hailong, ZHANG Jie, HE Ting

Team Profile

The Research & Development Innovation Team for the Intelligent Integrated Control Technology of Hydropower and New Energy has been consistently committed to the research of key technologies and the development of products for the automatic control systems of giant hydropower stations. With a history traced back to the early 1980s, the team is the earliest group in China to engage in the research and development of computer monitoring system technology for hydropower stations. It was honored with the first National Science and Technology Progress Award in the specialized field of hydropower station computer monitoring. The monitoring systems for China's landmark projects in the localization of hydropower units, including Longyangxia, Gongboxia, Three Gorges, and Xiangjiaba, were all developed by this team. Through the unremitting efforts of successive generations, and in response to the demands of intelligent and smart technologies and the critical issue of achieving autonomous control in the control systems of giant power stations, the team has built upon its independently developed H9000 computer monitoring system for hydropower stations to successfully develop the next-generation iP9000 intelligent integrated platform for water resources and hydropower. This platform encompasses the I/II/III zone application of automation systems for hydropower stations/centralized control centers (hubs). It has provided the control systems essential for the full operation of the Baihetan Hydropower Station and the successful remote control of the Kunming West-to-East Power Transmission Control Center. At present, this series of products have been successfully applied to the localization upgrading of monitoring systems for all 34 units at the Three Gorges Hydropower Plant, as well as in major water resources and hydropower projects such as Longyangxia, Gongboxia, Wuqiangxi, Liyuan, Fengtan, Nierji, and Xiajiang. Additionally, they have been deployed in cascade centralized control centers of the Yellow River Upstream and Hunan Wuling projects under the State Power

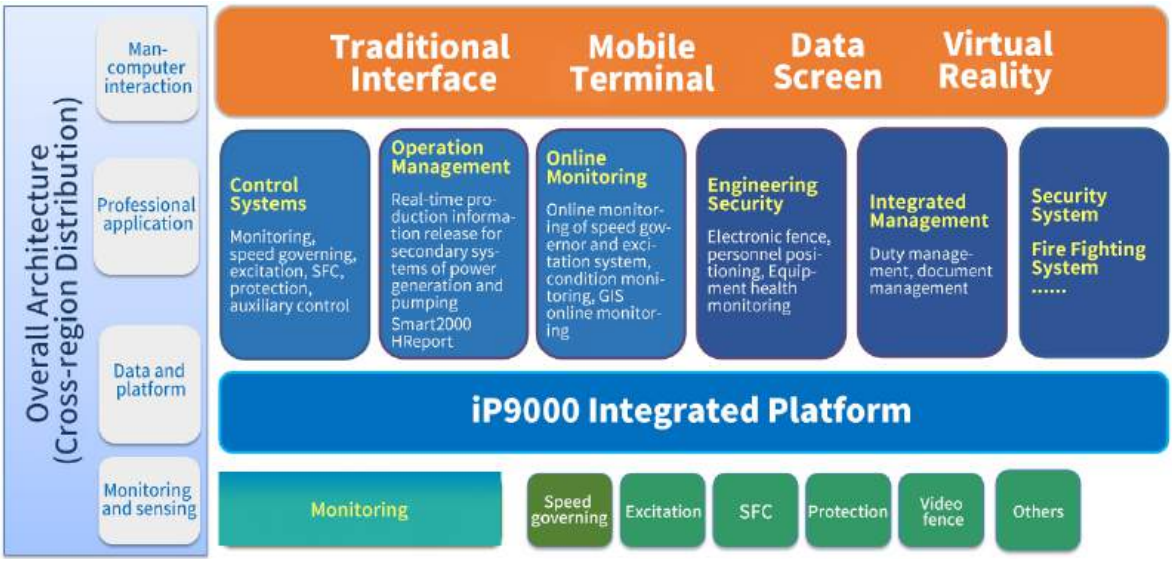

Fig.1 Overall Architecture of iP9000 Intelligent Integrated Platform for Water Resources and Hydropower

Investment Corporation. At the same time, the systems have been extended to numerous foreign medium and large-sized power stations and centralized control centers, including ILHA and JUPIA in Brazil, and the Karot project in Pakistan. The application of these systems has also been widely expanded into sectors such as new energy, irrigation districts, and wastewater treatment, making a positive contribution to solving the key technology challenges of domestic autonomous control in the field of hydraulic and hydropower industrial control, and safeguarding national energy security.

In 2022, the Baihetan Hydropower Station, recognized as one of the top ten super projects of central state-owned enterprises, achieved full operation and power generation, marking the completion of the world's largest "Clean Energy Corridor" along the Yangtze River by China. The four giant hydropower stations on the "Clean Energy Corridor": Three Gorges, Baihetan, Xiluodu, and Xiangjiaba, as well as the world's three largest remote centralized control centers: Three Gorges-Gezhouba, Baihetan-Wudongde, and Xiluodu-Xiangjiaba, all utilize the iP9000 intelligent integrated platform or the H9000 computer monitoring system. These systems ensure secure, stable and reliable control, safeguarding the safe and stable operation of the hydropower stations and fulfilling President Xi Jinping's directive that "critical national infrastructure must remain firmly in our own hands".

Fig.2 iP9000 Supported the Full Operation of Baihetan Hydropower Station, reported by CCTV

Fig.3 China Southern Power Grid Dual-Regulation Centralized Control Center, China's First Centralized Control System Focused on Pumped Hydro Storage

Best Papers

Assessment of Urban Rainwater Resources in the Water-Receiving Areas of the South-to-North Water Diversion Project under Climate Change

First Author: SHAO Weiwei

Corresponding Author: LI Yuxing

Journal: *Journal of Cleaner Production*

Abstract: The prediction of future rainwater resources plays a key role in assessing the potential impacts of rainwater utilization on natural and social systems. However, research on the impact of climate change on future rainwater resources remains insufficient, particularly with respect to large-scale water diversion projects. This study, based on global climate model data, future land use data, and the SCS-CN (Soil Conservation Service Curve Number) model, proposes a method for evaluating rainwater resources potential under multiple climate change scenarios (SSP1-2.6, SSP2-4.5, SSP5-8.5).

The method is applied to the water-receiving areas of the South-to-North Water Diversion Project for analysis. The results indicate that:

- (1) The annual potential of rainwater resources in the studied area from 2021 to 2100 shows a growth trend, with a spatial distribution characterized by higher levels in the south and lower levels in the north. Under the SSP5-8.5 scenario, the water-receiving areas of the eastern route project increase by more than 70% compared with the baseline period in 2020, with significant growth observed in the city clusters in northern Jiangsu Province.
- (2) Future spatial distribution patterns of rainwater resources exhibit normal distribution with single peak in the water-receiving areas of the east- and west-route projects, while the water-receiving areas of the central route project display prominent bimodal features.
- (3) Based on fitting with the Pearson type III distribution curve, the potential of rainwater resources in the studied areas under different assurance rates in the future is as follows: 5.06×10^{10} m^3 at P=25%, 3.53×10^{10} m^3 at P=50%, and 2.46×10^{10} m^3 at P=75%.

This study provides a case for quantifying the uncertainty of rainwater potential under climate change, and also offers reference for the construction and scheduling schemes of large-scale water diversion projects worldwide.

Keywords: Climate change; CMIP6; South-to-North Water Diversion Project; Rainwater resources

Flood Forecasting in Hilly Areas Based on Rainfall Characteristics

First Author: LIU Yuanyuan

Corresponding Author: LIU Yesen

Journal: *Atmosphere*

Abstract: Floods in hilly areas are characterized by rapid onset and destructive force. This paper introduces a novel machine learning–based method to address this problem, aiming to improve the accuracy and predictability of flash flood forecasting in small catchments within mountainous and hilly regions. The method is mainly applicable to small watersheds under 600 km^2.

The proposed approach analyzes the spatiotemporal characteristics of rainfall dynamics and identifies rainfall-flood events in the history that present high similarity to current model patterns, thereby enabling real-time forecasting by "learning from the past to predict the present." The method demonstrates significant accuracy: the average error in peak

flow prediction is 8.33%, the mean error in total runoff prediction is 14.27%, and the error in peak arrival time prediction is within just 1 hour, meeting the precision requirements of flood forecasting.

Keywords: Artificial intelligence; Machine learning; Rainfall spatiotemporal characteristics; Flood risk management; Flood forecasting; LSTM neural networks

Monitoring Winter Wheat Drought Stress with UAV Thermal Infrared Data

First Author: LIU Hongjie

Corresponding Author: SONG Wenlong

Journal: *Remote Sensing*

Abstract: Accurate monitoring of drought threshold value at different growth stages of crop is of great importance for drought monitoring. In this study, using a UAV system equipped with high-resolution thermal infrared and multispectral sensors, canopy temperature (Tc) was extracted for the winter wheat cultivar *Weilong* 169 at three key growth stages. Based on Tc, the canopy temperature difference (ΔT) was calculated, and the crop water stress index (CWSIsi) was developed.

Using field experimental data, Tc and CWSIsi were applied to monitor drought threshold value at different growth stages. Results show that canopy temperature (Tc) derived from the normalized difference vegetation index-Otsu method (NDVI-OTSU) had strong correlation with ground temperature measured (R^2 = 0.94). For drought stress classification of winter wheat, CWSIsi proved to be more stable than ΔT. The ranges of CWSIsi thresholds under different drought stress at different growth stages were as follows:

- Jointing–booting stage: threshold values under no stress, mild stress, moderate stress, and severe stress conditions are <0.30, 0.30–0.42, 0.42–0.48, and >0.48, respectively.
- Heading–flowering stage: <0.33, 0.33–0.47, 0.44–0.53, and >0.53.
- Filling–maturity stage: <0.41, 0.41–0.54, 0.54–0.59, and >0.59.

These results demonstrate that the UAV-derived canopy temperature method can significantly improve the accuracy of drought monitoring and hold great potential for early identification of crop drought disasters.

Keywords: Drought classification; UAV thermal infrared; Threshold value; CWSIsi; Yield; Winter wheat

A Historical Study on the Establishment of the Institute of Water Resources under Chinese Academy of Sciences and Ministry of Water Resources

First Author: ZHANG Weibing

Corresponding Author: ZHANG Weibing

Journal: *Studies in the History of Natural Sciences*

Abstract: In 1957, under the guidance of the Chinese State Council's Science Planning Committee, an agreement was reached among the Chinese Academy of Sciences (CAS), the Ministry of Water Resources, the Ministry of Electric Power, and the Ministry of Communications to merge the CAS Department of Hydraulic Engineering Research with the Beijing Research Institute of Water Resources under the Ministry of Water Resources. This merger created a new scientific research institution jointly led by CAS and the Ministry of Water Resources and dedicated to water science research.

This merger, driven by the intervention of the State Council and coordinated by four ministerial-level institutions, was highly unusual and carries great significance in the history of water science and technology development in the People's Republic of China. Drawing on archival materials, biographies, reports, and historical records, this paper explores

the origins, process, and outcomes of this merger, as well as the decisive role of the State Council's Science Planning Committee.

The study finds that this was a nationwide effort under state leadership to optimize and adjust the distribution of water research forces. It also represented a bold attempt at establishing an effective water research system during the early years of the People's Republic of China. The new institution not only embodied the spirit of boosting output and efficiency but also optimized the distribution of water research talent across the country. It confirmed the central role of the new institute in water science research, laying the foundation for successfully implementing the 12-Year Science and Technology Plan in the water sector.

Keywords: Chinese Academy of Sciences Hydraulic Engineering Research Office; Beijing Research Institute of Water Resources under the Ministry of Water Resources; State Council Science Planning Committee; Research institutions; Merger

Source Analysis of Microplastics in Urban Water Bodies Based on a Conditional Fragmentation Model

First Author: NIU Jinqiong

Corresponding Author: GAO Bo

Journal: *npj Clean Water*

Abstract: As an emerging pollutant of global concern, microplastics have become an important issue and research focus in ecological and environmental protection worldwide. Studies have shown that microplastics are widely present in urban water bodies, road dust, sediments, and rainfall, indicating that microplastic pollution in urban environments cannot be ignored and poses a potential threat to the health and stability of urban aquatic ecosystems.

This study focuses on urban water bodies in Beijing, including rivers, lakes, rainfall, and suburban sewage. Microplastic particles (10–5000 μm) in these water bodies were analyzed using Raman spectroscopy for both qualitative and quantitative assessments to reveal their abundance (concentration, size, morphology, polymer types) and associated pollution risks. Results show that different types of water bodies in Beijing all contain detectable microplastic pollution. Of particular concern, a high abundance of microplastics was observed in untreated wastewater. Lakes exhibited higher microplastic abundances than rivers, reflecting the accumulation of microplastics in lentic water systems. In addition, rainfall facilitated the migration of microplastics into urban aquatic environments through surface runoff and deposition.

Based on microplastic diversity and conditional fragmentation modeling, the sources of different microplastic polymers were traced. The results indicated that riverine and lacustrine microplastics in Beijing shared a high similarity, primarily originating from sewage, road dust, and sediments. Among polymer types, PP (polypropylene) was mainly associated with soil and dust inputs, whereas PET (polyethylene terephthalate) fibers primarily contributed to sewage-derived microplastics.

This study provides a new perspective for source apportionment and pollution risk analysis of urban microplastics, offering scientific insights for better understanding the environmental fate of microplastics and informing urban pollution prevention strategies.

Keywords: Microplastics; Beijing; Water bodies; Conditional fragmentation model; Source analysis

Experimental Study on Intelligent Decision-Making Methods for Greenhouse Tomato Drip Irrigation and Fertigation

First Author: LI Yonglin

Corresponding Author: WU Wenyong

Journal: *Irrigation and Drainage*

Abstract: To realize intelligent decision-making for water and fertilizer management in drip irrigation, and to make full use of current fertigation theories to improve efficiency, this study developed three irrigation and fertilization decision-making methods based on evapotranspiration (ET, T1), canopy temperature (T2), and soil moisture and temperature (T3). These

methods were integrated into an automatic control system.

Using greenhouse tomatoes as the experimental subject, a smart fertigation control system was designed, which included real-time monitoring of microclimatic conditions, soil moisture, and irrigation system operation, as well as an automatic control module for implementing fertigation decision-making strategies. Three irrigation modes were tested.

Results showed that the automatic control system maintained irrigation volumes and fertigation application rates with average errors of only 1.1% and 0.8%, respectively. The system operated stably, and the precision of decision-making schemes was verified. Compared with conventional control, tomato yields under the three intelligent decision-making methods increased by 7.8%, 11.7%, and 6.7%, respectively, while irrigation and fertilizer consumption decreased, significantly improving water- and fertilizer-use efficiency.

Although ET- and canopy temperature-based methods showed lower accuracy in the measurement of soil water content compared to field measurements, their overall trends were consistent with actual conditions, confirming the reliability of these strategies when supplemented with experimental data. This study provides valuable insights for the development of intelligent fertigation decision-making and control systems, contributing to further improvements in water-use efficiency.

Keywords: Drip irrigation; Environmental monitoring; Fertigation; Intelligent decision-making model

Seismic Failure Analysis of High Arch Dam-Foundation Systems with Multiple Nonlinear Couplings

First Author: YAN Chunli

Corresponding Author: TU Jin

Journal: *Soil Dynamics and Earthquake Engineering*

Abstract: This study, for the first time, establishes a high arch dam-foundation coupled finite element analysis model with tens of millions of degrees of freedom, comprehensively accounting for dam body damage, sliding instability, and their coupling effects. Nonlinear dynamic response analyses under different seismic overload factors were carried out, and performance indicators based on maximum damage depth ratio and sliding surface ratio were proposed. These indicators reveal the seismic failure mechanisms of high arch dam-foundation coupled systems.

To further evaluate the seismic safety of high arch dams, this study introduced relative displacement between the dam crest and the dam base as a performance indicator, and proposed an ultimate seismic capacity evaluation criterion based on cumulative damage at different overload factors. Results show that dam body strength failure and sliding instability evolve dynamically with seismic motion intensity. When seismic intensity is low, energy dissipation is dominated by a single failure mode; with increasing seismic intensity, both failure modes jointly contribute to energy release. Moreover, the ultimate seismic capacity of large arch dams corresponds to an overload factor of about 2.0.

Keywords: High arch dam; Multi-nonlinear coupling model; Damage failure; Instability failure; Failure mechanism; Evaluation indicators

Study on Stress Redistribution during Shear Failure of Gap-Graded Soils

First Author: LI Weichao

Corresponding Author: DENG Gang

Journal: *Computers and Geotechnics*

Abstract: Gap-graded soils are commonly found in thick overburden, landslide deposits, and rockfill materials, characterized by unique mechanical properties and high susceptibility to seepage failure. The coarse-fine particle interactions largely control the overall mechanical behavior of such soils; however, these interactions cannot be directly observed in laboratory tests, limiting in-depth understanding of the underlying mechanisms.

This paper first points out that the Imperial College (IC) method for calculating the stress-partition ratio essentially does not take porosity into account and therefore cannot faithfully represent particle-scale interactions or shear deformation. To overcome this, we propose and employ a stress-partition ratio calculation method based on Thiessen polygons. Using

this scheme, we analyze stress redistribution between coarse and fine fractions in gap-graded soils during shearing, considering the influences of shear stress level, density, and fines content. Results show that the critical state shear strength of gap-graded soils increases with the increase of confining pressure but exhibits a decreasing trend when fine particle content is high.

This research deepens the understanding of the mechanical behavior of gap-graded soils, and highlights the importance of evaluating critical-state shear strength under different conditions for engineering safety.

Keywords: Stress partitioning; Seepage failure; Critical-state shear strength; Potential erosion; Stress transmission

Case Study on Millimeter-Scale Debonding Nondestructive Testing at the Steel-Concrete Interface of Immersed Tunnel Segments

First Author: LI Songhui

Corresponding Author: ZHANG Yan

Journal: *Structural Health Monitoring*

Abstract: The structural form of composite immersed steel-shell concrete immersed tube (SSIT) is highly complex. During the casting of dense concrete, voids are likely to form at the steel-concrete interface, leading to debonding defects. Such defects can adversely affect the overall structural safety and service life of the tunnel. However, nondestructively detecting debonding beneath thick steel plates at the millimeter scale remains a major technical challenge in engineering practice.

To address this, this paper proposes a novel nondestructive testing method for detecting millimeter-scale debonding at the steel-concrete interface of immersed tunnel segments by combining impact-echo imaging with the “intercept method”. First, based on near-field wave theory and the intercept algorithm, the calculation methods for debonding depth and height were derived. Second, a multi-level approach for debonding detection and defect quantification was proposed. Third, by covering the steel-concrete interface with transparent pipe segments, experimental verification of debonding detection effectiveness was carried out. Finally, the method was applied to the quality inspection of immersed tunnel construction for the ShenZhong Link Project.

Results indicate that the proposed method, when used with impact-echo imaging, can effectively identify the location and shape of debonding defects, though it cannot achieve highly accurate quantitative depth estimation. The intercept method, in contrast, provides more accurate depth evaluation, but suffers from issues such as a limited detection unit size and relatively high test cost. Experimental tests demonstrated that the positional accuracy of debonding defect detection exceeded 95%, and the debonding area determination accuracy reached 89%. When the thickness deviation was within ±2 mm, the depth detection accuracy was 87.5%.

This method provides deep insight into the mechanisms of debonding at the steel–concrete interface of immersed tunnels. Moreover, by summarizing experimental patterns, it highlights the importance of construction processes such as vibrating concrete adequately during pouring, thereby offering practical guidance for improving construction quality. The method thus provides an important technical basis for quality assurance of SSIT projects.

Keywords: Immersed tunnel; Steel-concrete interface; Nondestructive testing; Impact-echo imaging; Intercept method; Full-scale model test

Sediment Transport Dynamics in Mountain-Alluvial Transition Zones: Autogenic Mechanism of Grain-Size Fraction Deficiency and Its Influence on Gravel-Sand Transition

First Author: AN Chenge

Corresponding Author: FU Xudong

Journal: *Geophysical Research Letters*

Abstract: Mountain rivers are characterized by steep gradients and wide grain-size distributions, while alluvial plain rivers have gentler slopes and finer sediments. At the mountain–alluvial transition, dramatic variations in flow regime lead to the

sorting and deposition of sediment mixtures. The strong selective sorting of wide-grading sediments results, on the one hand, in abrupt changes in riverbed material composition (the gravel-sand transition), accompanied by a deficiency of intermediate-size grains in the 1–5 mm range; and on the other hand, in sharp spatial variability and instability of channel morphology.

Traditional fluvial dynamics often treat mountain streams and alluvial rivers separately, with relatively few studies addressing sediment sorting and transport processes in the transition zone. This study focuses on the grain-size sorting processes in the mountain–alluvial transition and analyzes sediment transport dynamics, particularly the change in sediment transport mode (from traction to suspension) induced by grain-size fraction deficiency. Special attention is given to the role of bimodal sediment transport, where fine sand and coarse gravel jointly enhance the mobility of intermediate grains (the “magic sand” effect).

Findings reveal that even when the initial grain-size distribution of bed material is unimodal, under boundary conditions, the transport system evolves toward a bimodal distribution with a persistent deficiency of 1–5 mm grains. This self-organized deficiency phenomenon is caused by the enhanced mobility of medium grains when fine sand fills pore spaces between coarse gravel, thereby increasing entrainment probability.

Field evidence further shows that local flow acceleration in the mountain-alluvial transition is a key driver of gravel-sand transition formation. Increased transport of fine sediment accelerates the transition from bedload-dominated to suspended-load-dominated transport, and the abrupt shift in transport mode leads to the distinctive grain-size composition and abrupt textural break observed in gravel–sand transition reaches.

Keywords: Mountain–alluvial transition zone; Gravel-sand transition; Grain-size deficiency; Sediment transport mode; Sediment texture

Machine Learning–Based Individual-Based Swimming Dynamics Model: A Case Study of Fish Passage Through Hydraulic Structures

First Author: WANG Jingyang

Corresponding Author: BAIYIN Baoligao

Journal: *Ecological Modelling*

Abstract: Because of the disconnection between hydraulic design of fishways and fish behavioral theory, the operational efficiency of fishways is still significantly lower than that of natural rivers. Fish behavior models, as emerging research tools, can accurately capture the dynamic interaction between fish and their hydrodynamic environment, thereby improving the prediction of fish behavior during passage and providing essential technical support for fishway design.

This study innovatively constructed a fish behavior prediction framework (ML-IBM) that integrates machine learning (ML) with individual-based modeling (IBM). Specifically, the framework integrates the random forest (RF) algorithm with the Eulerian–Lagrangian Agent Method (ELAM), thereby significantly improving prediction accuracy of fish behavior.

Using upstream monitoring data of *Schizothorax prenanti* in a vertical-slot fishway, the model validation demonstrated that ML-IBM achieved an accuracy of 83.4% for swimming behavior classification. The R^2 for swimming velocity prediction reached 0.77, with a root-mean-square error (RMSE) of 7.35 and mean absolute error (MAE) of 6.26, both lower than those of existing models.

Feature importance analysis revealed that hydrodynamic factors such as turbulence intensity, flow velocity gradient, and total force response were the dominant drivers of fish swimming behavior. The results highlight that ML-IBM enhances model interpretability, allowing fish swimming behavior to be explained more mechanistically from a hydraulic perspective.

This research provides an effective approach to developing fish behavior models driven by both hydraulics and individual traits, offering important practical value for optimizing fishway design and supporting eco-hydraulic engineering.

Keywords: Fish behavior model; Individual-based model (IBM); Machine learning; Fishway

Contribution of Long-Term Continuous High Stocking Rates to the Reduction of Microbial Necromass Carbon Contribution to Soil Organic Carbon in Semi-Arid Grasslands of Inner Mongolia

First Author: ZHAO Tianqi

Corresponding Author: ZHANG Bin

Journal: *Journal of Environmental Management*

Abstract: Grazing exerts a significant influence on the accumulation of soil organic carbon (SOC) in grasslands. However, the relationship between SOC dynamics under different grazing intensities and changes in microbial necromass carbon (MNC) remains unclear.

In this study, a long-term continuous sheep grazing experiment was established in 2004 in the semi-arid steppe of Inner Mongolia, including a non-grazed control and multiple stocking rate treatments. After 17 years of grazing, soil samples were analyzed for physical, chemical, and microbial properties. Results showed that grazing reduced both SOC and MNC contents and the contribution of MNC to SOC.

Structural equation modeling (SEM) and enhanced regression analyses revealed that, with increasing grazing intensity, reduced plant carbon input led to a decline in MNC. Declines in plant carbon input, microbial abundance, and microbial diversity directly lowered MNC levels, which in turn decreased SOC content.

This study suggests that continuous heavy grazing likely reduces the contribution of MNC to SOC, though it may simultaneously enhance the cycling efficiency of grassland ecosystems. Maintaining low stocking rates helps preserve higher MNC and SOC contents, thereby contributing to grassland soil carbon sequestration and supporting the sustainable utilization of grassland resources.

Keywords: Nitrogen addition; Carbon sequestration; Semi-arid steppe; Microbial necromass; Stocking rate

Deformation Classification Prediction of Tunnel Surrounding Rock Using an Improved One-Dimensional Convolutional Neural Network

First Author: WU Hao

Corresponding Author: YUE Qiang

Journal: *Journal of Basic Science and Engineering*

Abstract: Understanding deformation of tunnel surrounding rock is a prerequisite for recognizing the dynamic response of surrounding rock and support structures, as well as for elucidating the mechanism of spatial deformation. Establishing reliable deformation classification criteria is therefore essential for stability assessment and effective design of supporting structures.

This paper proposes a deformation classification prediction model for tunnel surrounding rock based on an improved one-dimensional convolutional neural network (1DCNN) integrated with a support vector weighting (SVW) module. The model considers major influencing factors and feature types of tunnel deformation, including support strength, surrounding rock lithology, and burial depth. Using these indicators, a classification framework for four deformation grades was constructed.

A dataset of 159 groups of surrounding rock deformation cases from domestic tunnel projects was compiled. Full normalization and feature weighting were applied before feeding the data into the improved CNN. A fully connected layer and Softmax classifier were then employed for grade classification. The improved 1DCNN automatically captured hidden feature patterns of tunnel deformation. Training strategies included learning rate decay and Dropout regularization, ensuring robustness against overfitting.

Results show that the proposed 1DCNN+SVW model achieved an accuracy of 90.8%, outperforming traditional machine learning approaches in precision and generalization ability. Comparative analysis with other methods further confirmed its higher accuracy and stability. Application to the Erlang Mountain Tunnel project demonstrated that predicted deformation grades were consistent with field observations, thereby validating the model's accuracy and practical applicability.

This study enhances the theoretical framework and reliability of tunnel deformation prediction, providing important technical support for tunnel engineering.

Keywords: Tunnel engineering; Deformation; Prediction; Deep learning; Improved one-dimensional convolutional neural network (1DCNN)

Study on Crack Depth of Concrete Surface Cracks Using Surface Wave Method at the Mesoscale

First Author: SUN Linyuan

Corresponding Author: HUANG Hao

Journal: *Journal of Hydraulic Engineering*

Abstract: Surface-wave cut-off frequency detection is an effective nondestructive method for determining the depth of concrete surface cracks. At present, the frequency-transmission-coefficient method is commonly used to identify the cut-off frequency; however, this approach is largely affected by the mesostructure of concrete, resulting in limited accuracy.

To improve the precision of cut-off frequency identification, this study proposes a multi-signal phase-shift scattering analysis method. Finite element simulations are carried out to model surface wave propagation and the interaction with mesoscale concrete cracks. Detection mechanisms and identification performance are compared between the traditional frequency-transmission-coefficient method and the proposed multi-signal phase-shift scattering method, leading to the establishment of a more reliable cut-off frequency identification criterion.

Furthermore, the influences of aggregate size, porosity, and detection frequency on the performance of the multi-signal phase-shift scattering method are systematically analyzed. Results show that this method demonstrates superior identification accuracy, and is less affected by mesostructural variations and crack-to-wavelength ratios. Variations in aggregate size, content, and elastic modulus had negligible impact on the method's ability to detect cut-off frequency effectively. When the surface wavelength-to-thickness ratio exceeds 4.0, the proposed method still achieves robust identification performance.

This study provides a theoretical basis for the quantitative detection of concrete surface crack depth in engineering practice.

Keywords: Concrete surface crack depth; Mesostructure; Cut-off frequency; Frequency-transmission-coefficient method; Phase-shift scattering analysis

A New Stress-Strain Model of Cemented Material Dams and Intelligent Quality Control Technology

First Author: JIA Jinsheng

Corresponding Author: JIA Jinsheng

Journal: *Journal of Intelligent Construction*

Abstract: Cemented Material Dams (CMDs) can make full use of locally available sand, gravel, and rockfill for construction. They offer the advantages of impermeability, environmental friendliness, cost-effectiveness, and rapid construction. Since first being proposed by the present first author, CMDs have been rapidly promoted and applied in engineering projects both in China and abroad.

This paper reviews the origin of CMDs, introduces a new stress-strain model of cemented materials and an intelligent production quality control system, and presents results of model tests on CMDs subjected to anti-seepage and overtopping scenarios. Furthermore, the engineering applications of CMDs in soft rock and weathered rock regions of low strength are described.

Keywords: Cemented material dam; Stress-strain model; Intelligent quality control; Low-strength rockfill; Weathered rock material; Anti-overtopping model test

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Photo: LI Tong

Management Achievement

Highlights of the 2024

1. SkyLIM Water Science Model

IWHR released its multi-scenario, high-precision, and smart SkyLIM Water Science Model, which builds a vast multimodal water knowledge base covering 17 disciplines and 103 specialized fields within the water resources and hydropower domain. It has been successfully applied in Henan, Shandong, Sichuan provinces, Tianjin and Beijing municipalities, facilitating scientific and precise flood control decision-making, water resources management, and hydraulic engineering oversight in these areas.

2. Digital Twin for Flood Control

IWHR has continuously refined and optimized its digital twin watershed flood control technology system, which has supported China's emergency disaster response efforts for the Tuanzhou Dike event in Dongting Lake, the Hanyuan flash flood in Sichuan, and the Ussuri River Basin emergency, providing scientific-based support for disaster prevention and mitigation decision-making.

3. River Ethics and China's Practices

IWHR completed the compilation of *River Ethics and China's Practices*, a report based on the institute's in-depth, cross-disciplinary research on the human-river relationship. The multilingual version (Chinese, English, and Russian) of the report was released at the 10th World Water Forum and the 3rd Asia International Water Week, sharing with the world China's idea and efforts in building a new paradigm of harmonious coexistence between humans and rivers.

4. 3rd Asia International Water Week

IWHR led the organization of the 3rd Asia International Water Week which was co-hosted by the MWR of China and the Asia Water Council (AWC), bringing together approximately 1,300 participants from 70 countries and regions and over 20 international organizations and water-related institutions. The Beijing Declaration --- Asia to World Statement of the 3rd AIWW was released which outlined Asia's commitments to water policy innovation, digital transformation, climate change resilience, water-food-energy nexus, river protection and restoration as well as knowledge base and dissemination.

5. Standardization and Metrology Building for Water

IWHR have been approved to establish the first National Water Resources Metrology Station in China's water sector. The institute's Static Mass Method Flow Measurement Standard Device, the country's first national highest-level water-related metrology standard, has also successfully passed evaluation.

6. Lancang-Mekong Water Cooperation under the Belt and Road Initiative

IWHR had its national aid project "Sweet Spring Action for Rural Poverty Reduction in Lancang-Mekong Countries (LMCs)" recognized in the fifth edition of the Global Best Poverty Reduction Practices. The project has secured safe drinking water access for approximately 10,000 LMCs rural residents, significantly improving local capacities in rural water supply infrastructure construction, securing drinking water safety, and improving public welfare.

7. Plateau Water Science

IWHR witnessed the completion of the program "Runoff Variation and Adaptive Utilization in the Source Regions of Rivers in Southwest China." A major research program under the National Natural Science Foundation of China (NSFC) and chaired by IWHR expert, the program has shaped a distinct Chinese school of thought in Third Pole hydrology after eight years of exploration, setting a new benchmark in plateau water science.

8. Science and Technology Support for Xizang and Xinjiang

IWHR's research team actively addressed the flood overflow risks of Siling Lake, the largest lake in Tibet, supporting flood safety in the Siling Lake basin during the 2024 flood season and provided a model for climate adaptation in plateau lakes. The institute has also continued advancing science and technology support for Xinjiang Autonomous Region, making substantial progress in joint scientific and technological research, innovation platform development, talent exchange programs, and public education in water science.

9. Journal Development & Science Communication

IWHR accomplished remarkable breakthroughs in journal development, with four of its academic journals selected for Phase II of the China Science and Technology Journal Excellence Action Plan. Its popular science performance piece "Beneath the Surface: The Weighted Flow of Density Currents", which highlights the ecological restoration of the Yellow River through Xiaolangdi Project's water and sediment regulation, won first prize at China's 7th National Science Experiment Exhibition and Performance Showcase.

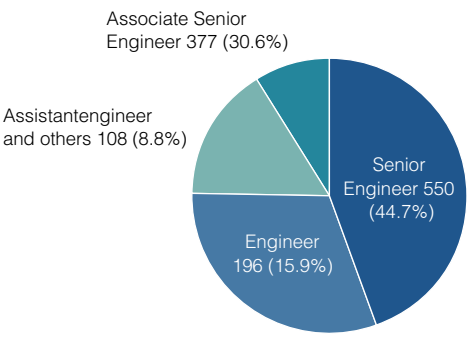
10. Talent Cultivation

IWHR has strengthened its "tiered" and "full-chain" talent cultivation, with nearly 20 experts named to China's National Distinguished Engineer, National Leading Talent in Scientific and Technological Innovation, and the Stanford University-Elsevier World's Top 2% Scientists list. In addition, 10 of the institute's young researchers were granted China's Outstanding Young Engineer, Young Top Talents in China's Water Sector, and other honorable awards.

Statistics

Human Resources

By the end of 2024, IWHR has 1231 technical professionals.



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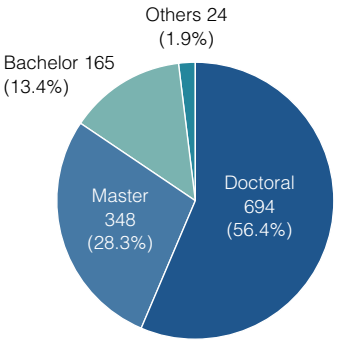
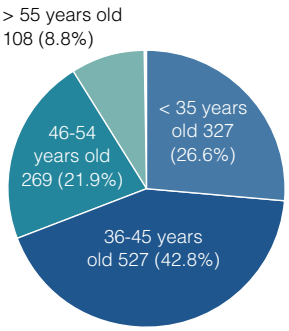


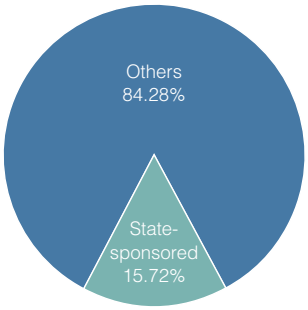
By educational level



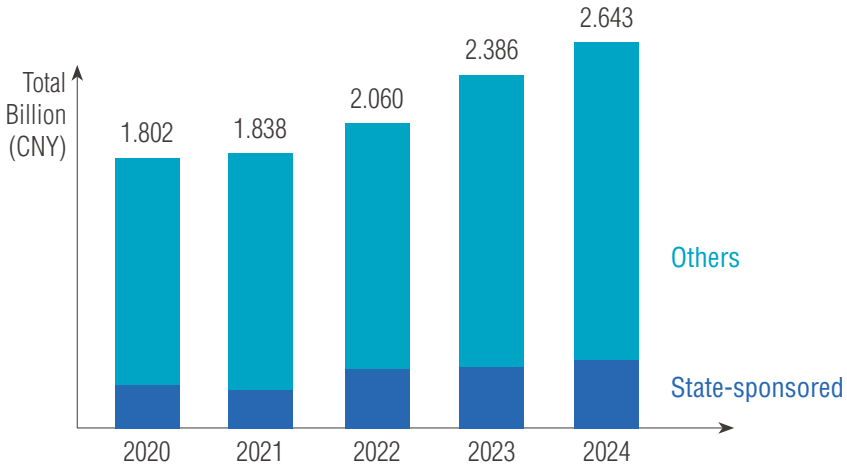
By age

Research Contracts

Research contracts signed in 2024: CNY 2.643 billion in value.



Financial sources of contracts signed in 2024



Awards

In 2024, 2 completed researches are granted state level prize and 77 are at provincial/ministerial level.

Type	Amount	Grade
State level	2	Second prize (2)
Provincial (ministerial) level	77	Special Prize (6)
		First prize (25)
		Second prize (36)
		Third Prize (10)

Some of the prized research projects:

- Technologies and Applications of Remote Sensing Observation System based on Light and Small UAV Network
- Key Technologies for Life-cycle Safety Control on High-steep Slopes in Water Resources and Hydropower Engineering
- Xiangjiaba Hydropower Station on Jinsha River
- Key Technologies for Synergistic, Efficient and Environmental Friendly Utilization of Energy and Water
- Key Technologies for Determination of Water Level of Rivers, Lakes and Reservoirs in Drought Season and Their Application
- Key Technologies and Application of Nature-social-trading Water Cycle Theory and Safety Control and Regulation for Inland River Regions in Northwest China
- Continued Construction and Modernization of Dujiangyan Irrigation District in Sichuan Province (2021-2035)
- Research and Demonstration of Key Technologies for Intelligent Control of Efficient Water-saving Irrigation System
- Key Technologies and Application for Full Link and Efficient Management and Intelligent Interpretation of Domestic Satellite Images
- Key Technologies for Simulation and Control of Urban Stormwater Process and Their Application
- Key Technologies and Application of Multi-scale Modeling of Urban Floods Supported by Spatial Information
- Key Technologies for Holographic Monitoring of Water Security and Domain-wide Forecasting and Early warning in River Basins
- Habitat Evolution Law and Adaptive Regulation of Water and Sediment in Three Gorges Reservoir
- Key Technologies for Systematic Construction of Sponge City for District Development
- Key Technologies and Application of Precise Evaluation and Synergistic Management of Eutrophication of Lakes and Reservoirs
- Key Technologies and Application of Precise Regulation of Water Use in Irrigation Districts based on Agricultural Water Price Reform of Corps
- Research on the Strategy of Water-saving Agriculture in Main Potential Areas for Grain Production
- R&D and Application of Key Technologies and Equipment for Efficient and Precise Water Use in Northeastern Paddy Fields
- Technology for Dynamic Evaluation and Demand Prediction of Agricultural Water Use and Its Application
- Research and Application of Disaster Reduction Technology by Coordinated Farmland Drainage, Water Storage and Flood Control
- Key Technologies and Applications of Remote Sensing Quantitative Inversion and Data Fusion for Water Cycle Elements with High Spatial and Temporal Resolution
- R&D and Demonstration of Key Technologies for Drinking Water Safety in Alpine and Arid Pastoral Areas
- Key Technologies for Intelligent Construction of Concrete Face Rockfill Dam in Xujixia Hydropower Station and Their Application
- Sliding Resistance Effect of Prestressed Anchor in Slopes and Key Technologies for Service Life Extension
- Safety Control Theory and Key Technologies for High CFRD with Deep Overburden
- Key Technologies of Integrated Management System and Digital Construction for Large-scale Water Conservancy and Hydropower Project Design and Construction
- Key Technologies for Intelligent Temperature Control of Wudongde Super-High Arch Dam and Their Engineering Application

- Key Technologies and Application of Environmentally Friendly Construction of RCC Dam under Complex Conditions of Tibetan Plateau

Intellectual Properties

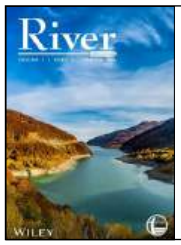
WHR obtains 447 patents in 2024, including 358 inventions, 50 utility models, 1 design and 38 new international patents, participates in the editing of 76 technical codes, and also publishes 40 books and 375 papers.

	Patents				Technical codes		Books	Papers
	Inventions	Utility models	Design	International	Chief edited	Co-edited		
Amount	358	50	1	38	43	33	40	375

Journals

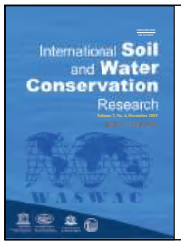
Journal of Hydraulic Engineering

Journal of China Institute of Water Resources and Hydropower Research



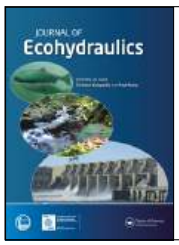
River

International Journal of Sediment Research

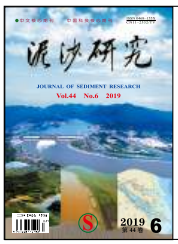


International Soil and Water Conservation Research

China Flood and Drought Management



Journal of Ecohydraulics



Journal of Sediment Research

Mechanical & Electrical Technique of Hydropower Station

International Cooperation

International Exchange

IWHR co-hosted the 2024 World Water Day Open Day event with UNESCO Regional Office for East Asia, on March 22 in Hangzhou, China, to foster global cooperation and dialogue towards sustainable water management. Representatives from various countries, including Pakistan, Mongolia, and Brazil, shared their country-based perspectives in accelerating SDG 6.

In May, IWHR participated in the 10th World Water Forum in Indonesia, sharing its expertise in sustainable hydropower and aiding preparations for the upcoming 3rd Asia International Water Week. The institution's youth team achieved a top 10 placement in the Youth Short Video Competition.

From May 27-29, IWHR organized the 15th International Conference on Hydroinformatics (HIC2024), bringing together stakeholders from 34 countries and regions to discuss technology-aided water resources management in response to climate change. During the Conference, IWHR unveiled the SkyLIM Water Science Model.

IWHR organized in a series of ICFM webinars to spark inspiration for flood control and disaster relief amid surging climate change and global water challenges.

The 18th edition of the IWHR-KICT Joint Seminar, a bilateral exchange mechanism between IWHR and the Korea Institute of Civil Engineering and Building Technology, took place from June 18 to 21, fostering exchanges between experts from China and South Korea on topics like water resource management, smart dam construction, flood control, and water treatment.

IWHR organized the 3rd Asian International Water Week (3rd AIWW) during Sept. 23-26 in Beijing, China. Comprised of three plenary sessions, 25 thematic sessions, 16 side events, and 13 special sessions, this academic feast gathered over 1,300 representatives worldwide to explore critical water security issues in Asia amid the ongoing climate change.

Prof. Asit K. Biswas, a distinguished visiting professor at the University of Glasgow, United Kingdom and Chief Editor of the IWHR-initiated Journal River, contributed an article titled "Can water security in Asia be ensured?" to China Daily, emphasizing the need for Asian countries to find tailored water solutions in the face of the region's water challenges.

The IWHR-initiated Sweet Spring Action for Rural Poverty Reduction in Lancang-Mekong Countries (LMCs), a project dedicated to improving safe rural water supply in LMCs, has been recognized in the fifth edition of the Global Best Poverty Reduction Practices.

The 4th International Seminar on Water Culture, co-hosted by IWHR and UNESCO, was held at the Lingqu Canal in southwest China. With the theme "Connecting Rivers and Seas: Canal Development in Human Civilizations," the event explored the history and culture of canals alongside the engineering technological advancements behind them.

IWHR hosted the 12th Symposium of the Flash Flood Program (FFP12). Under the theme "New Approaches to Flash Flood Control in the Era of Digital Twin Technologies," the event focused on cutting-edge scientific issues and advanced practical technologies in flash flood disaster mitigation.

Partnership with Cooperative Agreements

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Photo: LI Tong

Appendix

Organizational Structure

President and Vice Presidents

Commissions	• Academic Commission • Board of Professional Title Assessment	• Board of Academic Degree Assessment
Administrative Divisions	• General Office • Division of Personnel, Labor and Education • Division of Research, Management and Planning • Division of International Cooperation	• Division of Finance and Assets Administration • Division of Supervision and Audit • Division of Platforms and Infrastructure (Office of State Key Lab)
Research Departments	• Department of Water Resources • Research Center on Flood and Drought Disaster Reduction • Remote Sensing Technology Application Research Center • Department of Water Resources History • Department of Water Ecology and Environment Research • Department of Irrigation and Drainage	• Earthquake Engineering Research Center • Department of Geotechnical Engineering • Research Center for Sustainable Hydropower Development • Department of Structures and Materials • Department of Sediment Research • Department of Hydraulics • Department of Water Resources for Pastoral Areas
Division of Comprehensive Business	• Graduate School • Standards and Metrology Center	• Information Center • Office of Retirement Services
Enterprises	• Beijing IWHR Corporation • Beijing IWHR Technology Co., Ltd.	• Beijing IWHR-KHL Co., Ltd. • Tianjin IWHR Mechanical & Electric Technology Co., Ltd.
Secretariats of International Organizations	• World Association for Sedimentation and Erosion Research (WASER) • World Association of Soil and Water Conservation (WASWAC) • Chinese National Committee on Large Dams (CHINCOLD) • Chinese National Committee on Irrigation and Drainage (CNCID)	• International Association for Hydro-Environment Engineering and Research (IAHR) • Global Water Partnership (GWP) China • China Office of International Hydropower Association (IHA) • International Conference on Flood Management (ICFM) • China River Restoration Network (CRRN)

Research Divisions

Department of Water Resources

Fundamental and applied research on the theories and applications in hydrology and water resources, including the fundamental theories and simulative technologies of water cycle, the assessment, planning, allocation, saving, regulation, management, protection and macro-strategy research of water resources, and the consulting and international cooperation in related fields.

Research Center on Flood and Drought Disaster Reduction

Research on key issues of flood control, drought relief and disaster reduction, including disaster formation mechanism, forecasting and warning, risk assessment, management and rescue technology of risk and emergency.

Department of Water Ecology and Environment Research

Evolution mechanisms and simulation technologies of water environment and ecology; methods and standards of assessment and monitoring, as well as protection and recovery technologies of water environment; guarantee technologies of drinking water safety; environmental impact assessment of projects; theories and information technologies of water environment management.

Department of Irrigation and Drainage

Strategies, planning and related standards of water resources development in rural areas; water. efficiency irrigation and management technologies of farmland water and soil environment; research, equipment development, transfer, promotion and application of water supply technologies in rural areas; quality inspection and product certification of equipment

Earthquake Engineering Research Center

Theories and anaiysis method of earthquake engineering; the arch dam and gravity dam seismic research; dynamic test of stuctures and equipment; monitbring and forecasting of reservoir earthquake; anti-sarthquake analysis and safety assessment of electrical and nuclear power equipment.

Department of Geotechnical Engineering

Property study of geotechnical materials; behavior simlation, safety assessment and centrifugal testing of geotechnical structures such as embankment dams, high slopes and underground tunnels and chambers.

Department of Structures and Materials

Temperature stress and control of hydraulic structures; numerical, visual and digital simulation of projedts; safety monitoring and inspection; anti-seepage, repair and reinforcement of projects.

Department of Sediment Research

River channel evolution and improvement; reservoir sedimentation and regulation; conservation and control of water and soil; sediment issues in estuary, coastal and hydraulic projeds; prevention and control of sediment disasters; fundamental theories and simulation technologies of sediment movement.

Department of Hydraulics

Hydraulics of high-velocity flow, flow-induced vibration and project layout; hydraulic controi and ice dynamics; cooling water and cooling tower research for thermal and nuclear power projects; river and ecological hydraulics; hydraulic prototype observation and equipment development.

Research Center for Sustainable Hydropower Development

Strategies, policies, planning and key technologies of sustainable hydropower development, including the theories, methods and assessment system of hydropower sustainability (green hydropower); strategic planning of hydropower development; ecological protection and reservoir resetlement policies of hydropower projects.

Remote Sensing Technology Application Research Center

Flood monitoring, forecasting and risk management system; drought monitoring evaluation and early warning system based on remote sensing; rivers and lakes monitoring system based on remote sensing; water and soil conservation monitoring and evaluation based on remote sensing; water environment-ecology information extraction and analysis software platform.

Department of Water Resources History

Research on water resources history and water conservancy archives; theoretical and technical research on protection of water resources heritage, survey and design of water works heritage protection; regional water culture; popular science education on water conservancy history, technical consultancy on relevant technical standards, planning and designing.

Department of Water Resources for Pastoral Areas

Water resources and water environment for pastoral areas; water-efficiency irrigationo and drainage, conservation of water and soil, and ecological recovery of grasslands; clean energy development and utilization, as well as water supply equipment, for pastoral areas.

Scientific Research Bases


Technology Innovation Base (South, Beijing)


Technology Innovation Base (North, Beijing)


Daxing Experimental Base (Beijing)

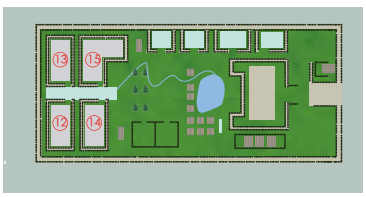

Yanqing Experimental Base (Beijing)


Base of Water Rescources for Pastoral Areas (Inner Mongolia)


Tianjin Institute of Hydroelectric and Power Research (Tianjin)

Laboratories in Daxing and Yanqing bases include:


Daxing Experimental Base

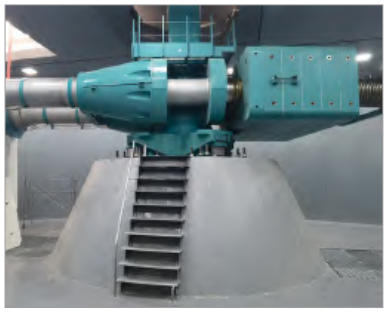

Yanqing Experimental Base

(1) Laboratory of Water Cycle and Deployment
(2) Laboratory of Water-Sediment Regulation and River Training
(3) Laboratory of Soil and Water Conservation
(4) Laboratory of Fundamental Theoretical Research on Sediment Transport
(5) Laboratory of Hydraulics
(6) National Center for Efficient Irrigation Engineering and Technology Research - Beijing
(7) Laboratory of Rural Drinking Water Safety, NCEIR
(8) National Center for Quality Supervision and Test of Agricultural Irrigation and Drainage Equipment
(9) Laboratory of Hydraulic Regulation
(10) Laboratory of River Environment
(11) Hydraulic Machinery Laboratory
(12) Laboratory of Automatic Control and Simulation
(13) Laboratory of Quality Inspection and Simulation for Speed Governing System of Small Hydro
(14) Integrated Laboratory of Engineering Technology on Water Resources and Soil-Water Conservation
(15) Integrated Laboratory of Engineering Mechanics

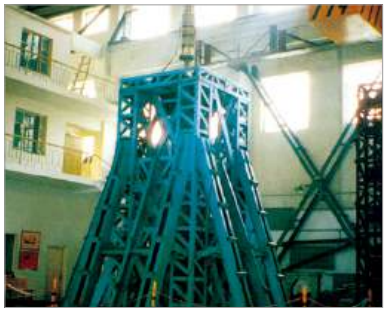
Large Equipment

Vacuum tank (vacuum percentage 98.7%; flow discharge 1.0 m³/s)

Universal test stand of advanced hydraulic machinery model



C86 geotechnical centrifuge



Tri-axial earthquake simulating shaking table with 6 degrees of freedom

15000 KN universal testing machine

Creep testing system for fully-graded concrete

Hydraulic flume and water tank

Eddy covariance system

Multi-functional GC-MS machine

Application Brochure for International Students

Major strengths of IWHR

China Institute of Water Resources and Hydropower Research (IWHR) is the largest specialized research institute under the Ministry of Water Resources, with a broad scope in water sector research since 1933. With over 1,200 staff members, including 600 PhD holders, IWHR operates across two campuses in Beijing, a city of history and modernity. It features 36 advanced labs and covers 18 disciplines, leading in national water research and graduate education.

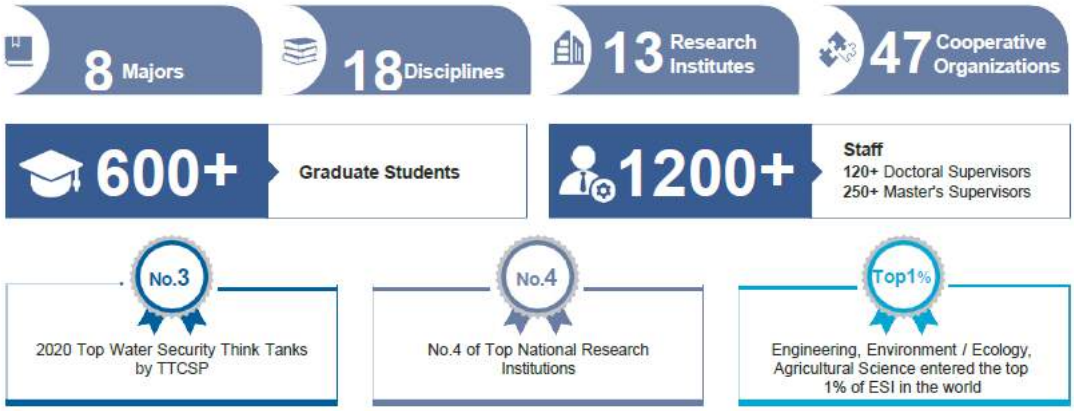
Cutting-Edge Research Hub

IWHR stands as a leading institution in the fields of engineering, ecology, and agricultural sciences, attracting exceptional researchers and students in water-related disciplines from across the globe.

By offering state-of-the-art facilities and a vibrant, stimulating academic environment, the Institute enables its researchers to thrive and grow as scholars, supporting the development of innovative, cutting-edge research projects. The academic freedom fostered by the Institute has resulted in numerous awards, including over 100 national prizes for science and technology.

World-Class Education Programs

IWHR provides a diverse range of exceptional education programs designed to guide students towards realizing their full potential. Students benefit from the Institute's rich academic environment, expert guidance, and experiences that only IWHR can provide. Furthermore, various extracurricular activities will equip students with the ability to lead, to cooperate, and to thrive into a new career future.

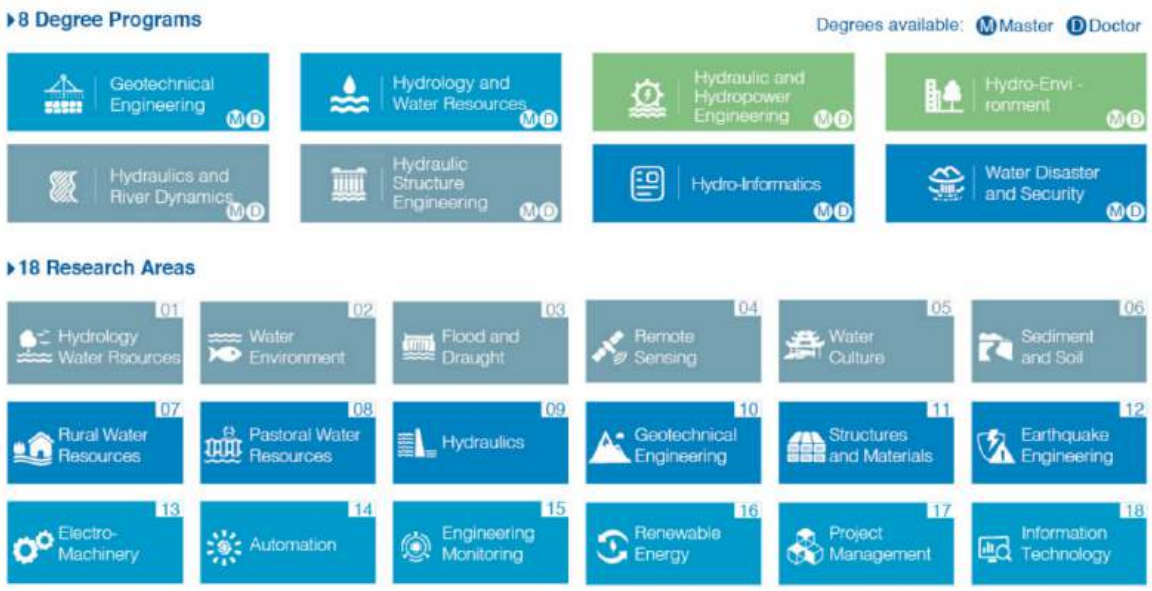


IWHR Degree Programs

IWHR offers a wide range of postgraduate programs covering all water sectors. There are 8 programs in total that apply to both master's and doctoral degrees. If students have a sparkle of research idea, they can easily find the corresponding experts in the field.

Duration of Study

Standard duration 3 years for master's degree and 4 years for doctoral degree.

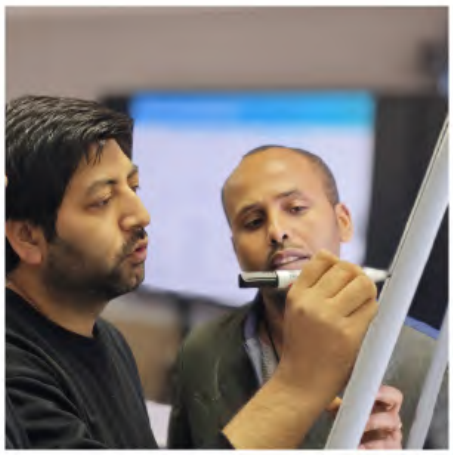


A degree program may have multi-related research areas. To find the specific area, please refer to our website and contact the Graduate School for more details.

IWHR Non-Degree Programs

Non-degree programs in IWHR are usually established between the Institute and the partnership institutions. The students may study at IWHR according to the MOU or agreements.

Not all programs take short-term international students; applicants are therefore advised to contact the Graduate School in advance for details.




Chinese Language

There is no requirement for Chinese language when applying for IWHR programs. However, the Chinese Ministry of Education requires that the graduates should pass the HSK 3 exam to obtain the degree. Chinese language courses will be offered by IWHR for free.

Tuition and Fees

- Application Fee: Free;
- Annual Tuition: CNY 26,000-CNY 39,000;
- Annual Accommodation: CNY 24,000;
- Annual Insurance: CNY 800.

Scholarships

IWHR Scholarships for International Students

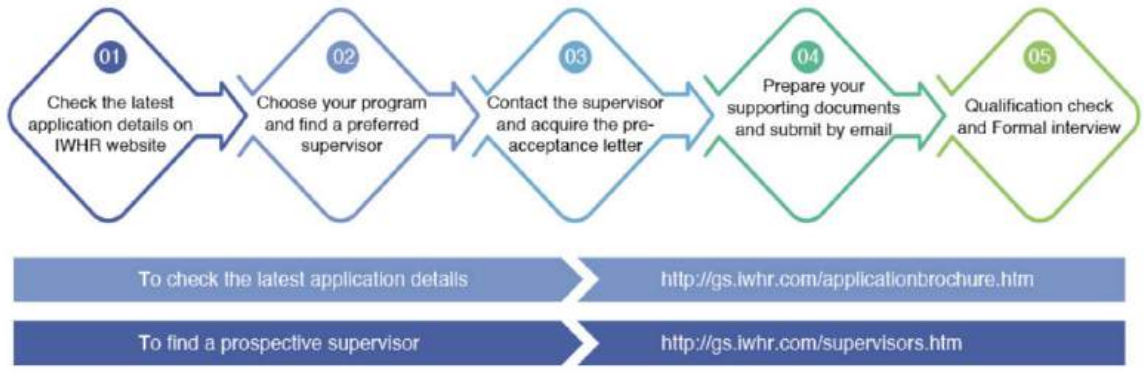
Scholarships of up to CNY 113,600 per year are available for outstanding applicants, including all or part of the following items:

- Waiver of the fees of tuition, accommodation.
- Waiver of two one-way international air tickets and medical insurance.
- Living stipend of up to CNY 49,800 per person per year.
- You can refer to the following website for more details regarding scholarships. http://gs.iwhr.com/iwhrscholarship.htm

Category	Scholarship Grade	Waiver of Tuition	Waiver of Accommodation	Waiver of Medical Insurance	Living Stipend	Total
Master	I	26000	24000	800	38400	89200
	II	26000	24000	800	19200	70000
	III	26000		800		26800
Ph.D.	I	39000	24000	800	49800	113600
	II	39000	24000	800	24900	88700
	III	39000		800		39800

How to apply for a degree program

General Procedure of the Whole Application Process



General Information

Application is open only to non-Chinese citizens who are in good health.

Educational Background and Age Limit

- The applicant for a master's program must be under the age of 35 and has a bachelor's degree.
- The applicant for a doctoral program must be under the age of 40 and has a master's degree.

Language Requirements

The applicants must satisfy one of the following requirements:

- Graduates from universities of English-speaking countries
- Graduates from universities where English is the official language
- IELTS: overall grade of 6.0 or above
- TOEFL: overall score of 80 or above

Application Methods

- Applicants for degree programs shall submit their application to IWHR by email: graduateoffice@iwhr.com

Required Application Documents

- Application materials include transcripts, certificates, personal information and etc. Please visit the website below for more details.

  http://gs.iwhr.com/howtoapply.htm

Important Dates

- Application Deadline

  No later than 30th April for the next academic year.
- Admission Notice Time

  Between 10th June and 15th July for the next academic year.
- Academic Year

  In early September.

International Student Apartment

IWHR provides in-campus suites for international students. 2-4 students will share one suite.

- Room facilities: bed, wardrobe, desk with bookshelf, air conditioner.
- Facilities in Common Area: bathroom, kitchen, refrigerator and washing machine.

Rent for accommodation will be CNY 2000/room/month, which can be waived by scholarships. The charge for water/ electricity/gas/ network will be beared by the students themselves.

Contact Us

Office of International Student Affairs, Graduate School
China Institute of Water Resources and Hydropower Research
20 Chegongzhuang West Road, Haidian District, Beijing, P.R.China
Zip Code: 100048
Telephone: +86-10-68786859
E-mail: graduateoffice@iwhr.com

IWHR Location

Beijing, the capital of China, is a vibrant city steeped in history and culture. It is a dynamic blend of ancient traditions and modern development, and also serves as a global center for technology, commerce, and education.

For international students, Beijing offers a unique opportunity to immerse in Chinese culture while accessing world-class education and career prospects

Turret

Summer Palace

Bird's Nest (National Stadium)

National Grand Theater

Beijing IWHR Corporation

History

Beijing IWHR Corporation (BIC) was a high tech enterprise established by IWHR in 1992. The company, serving as a technology transfer and application platform under the China Institute of Water Resources and Hydropower Research (IWHR), possesses robust technical capabilities and state-of-the-art production facilities. Its independently developed scientific and technological achievements have been successfully implemented in hundreds of major large and medium-sized projects both domestically and internationally, generating substantial economic benefits and delivering positive social impacts.

1992 Begin

2014 Development

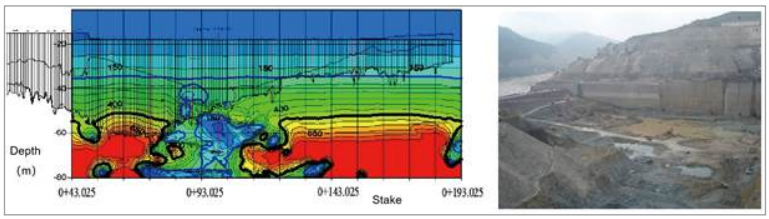
2024 Going Global

Main Business

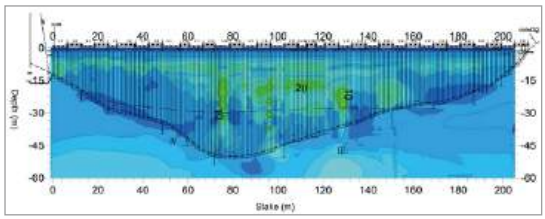
- Safety Monitoring
- Testing and Evaluation & Anti-seepage
- Development of Engineering Safety Information-based

Management Platforms

- Design and Construction of River and Lake Remediation Projects
- Development of Low-head Water Retaining Facilities



Results in Jinghong



Results in Zangmu

Main Products

Hydraulic Elevator Dam

This type of dam provides a solution to a series of technical problems such as safe discharge, operation in winter, operation simplicity, flotage, sedimentation, pier for dam, project cost, ground settlement and harmony with Landscape. All these problems are frequently encountered in projects such as steel gates, flap gates, pneumatic gates and rubber dams. It is widely used in water resources and hydropower projects for irrigation, reservoir capacity expansion and tide blocking.

Hydraulic Elevator Dam technology has obtained more than 20 patents for invention, and is recognized by China State Intellectual Property Office as a Model for Application and Demonstration.

This technology has been widely used in China and other countries in Southeast Asia, including Myanmar, Thailand and Bangladesh. Hundreds of projects have been completed. The highest one is 5.8m, which is located Guizhou Province and used for increasing the water head for hydropower generation.

The longest one is 261 m, which is located in Myanmar and used for irrigation. In Jilin Province in North China, there are six sets of HED along the Mudan River, which are serving as a cascade project to improve the landscape of the city.

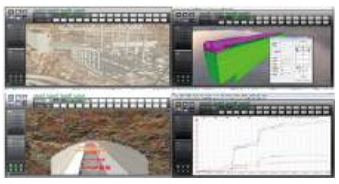
Containerized Water Treatment Plant

Consultation, Engineering and Construction For:

- Municipal Sewage Treatment
- Water Supply Projects
- Water Treatment for Safe Drinking

Safety Monitoring Project of Automatic Dispatching System of the Middle Route of South-to-North Water Division Project

Safety Monitoring Data Compilation and Analysis System for Hydraulic Structure



Three dimensional diagram of Baihetan Monitoring

Hydraulic Elevator Dam constructed for purpose of irrigation, landscape, power generation, flood control and flow scheduling

Gullubag Hydropower Plant in Turkey

Generator Floor of Gullubag Hydropower Plant in Turkey

Beijing IWHR Technology Co., Ltd.

History and Business Scope

Beijing IWHR Technology Co., Ltd. is an advanced and newtechnology enterprise, founded on December 23, 2004, a joint venture between China Institute of Water Resources and Hydropower Research (IWHR) and China Three Gorges Corporation (CTGC).The company is formed on the basis of the original Department of Automation and Department of Hydraulic Machinery of IWHR, and the staff are the optimum composition of all technical and the management backbones.

By the end of December 2024, the number of employees in the company had reached 257, including 78 with master's degree or higher ones, 146 with bachelor degree. There are 34 professor-level engineers, 47 senior engineers and 54 engineers. One of the staff is entitled to the Special Allowance of the State Council of China and another one enlisted by the New Century Talents Project of the country.

The company's primary business are the research and develop-ment of technologies and manufacturing of facilities for computer monitoring and the centralized control of water resources, hydro- power and renewable energy projects, including turbine governor, auxiliary control system, hydrological monitoring and forecasting system, reservoir dispatching automation, information application system, hydraulic machinery and electromechanical equipment, generation unit operation support, hydro-mechanical experimenta-tion as well as system integration, EPC (Engineering, Procurement, Construction) and related consultancy and services.

President Xi Jinping Listened to the Report in front of the H9000 System Monitor at the Control Center of the Three Gorges Hydropower Station

Generator Floor of Kozbuku Hydropower Plant in Turkey

Kozbuku Hydropower Plant in Turkey

Vice Premier Wang Yang Investigated at the Laboratory of Computer Monitoring System

The Cascade Dispatching Center Controlling the Three Gorges, Chengdu City and Jinsha River

Meteorological Telemetry Station for Rainfall and Water Level in Yalong River Basin

Model Unit and Model Runner of Hydraulic Turbine

Test Bench for Hydraulic Mechanical Model

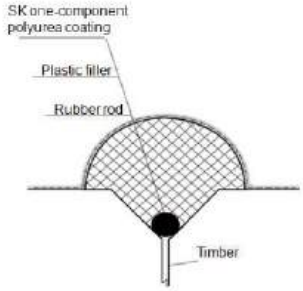
Beijing IWHR-KHL Co., Ltd.

Company Introduction

The Beijing IWHR-KHL Co., Ltd. (IWHR-KHL) was founded in 1993 as a technology-oriented enterprise. With the technical support of IWHR, the Company has developed the GB waterstop structure and the brush-coated flexible waterstop structure as well as a series of GB waterstop materials, which have been successfully applied in more than 100 Concrete faced rockfill dams (CFRDs) in the world, such as Shuibuya, Zipingpu, and Liyuan in China, Bakun in Malaysia, Nam Nugm II in Laos, Mazar in Ecuador, Gelevard in Iran, Merowe in Sudan, Glendoe in Scotland.

Typical Waterstop Structures for CFRDs

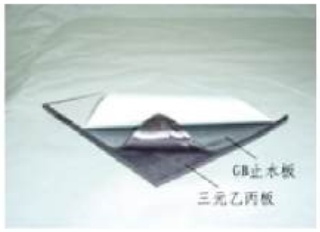
Mechanized installation of GB waterstop materials



Extrusion molding of GB plastic filler

Typical GB Waterstop Materials

GB plastic filler



GB EPDM composite cover

Corrugated rubber waterstop

Integrated construction technology for GB waterstop materials

Mechanized installation of GB waterstop materials

Extrusion molding of GB plastic filler

Applications of GB waterstop materials at Typical CFRDs

1 *Shuibuya CFRD of 233m high is the highest CFRD in the world. The total leakage is less than 60L/s.*

2 *Bakun CFRD of 203.5m high is the highest CFRD in Southeast Asia. The total leakage is less than 80L/s.*

3 *Zipingpu CFRD of 156m high has successfully withstood the 2008 Wenchuan Earthquake (Ms=8.0). The total leakage after the earthquake is less than 50L/s.*

4 *Liyuan CFRD of 155m high is the first one to use in large scale brush-coated flexible waterstop in the world. The total leakage is less than 30L/s.*

TJINST | Tianjin IWHR Mechanical & Electric Technology Co., Ltd.

Introduction and Business Scopes

The Tianjin IWHR Mechanical & Electric Technology Co., Ltd. was built in 1979. In 2002, according to the requirements of the reform of the national science and technology system, it was placed under the administration of IWHR.

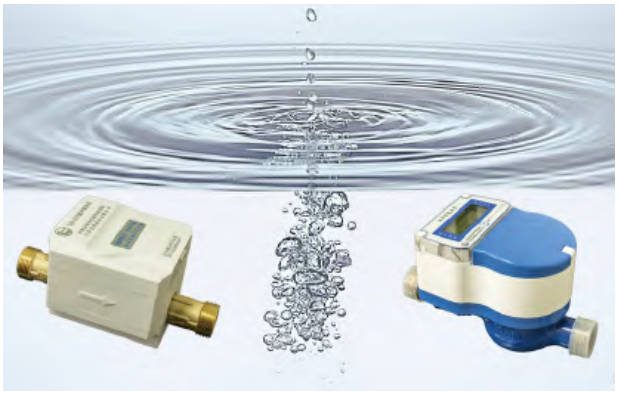
Main Business

- Developing and selling hydraulic machinery (pump-type) products
- Researching and marketing water metering products
- Developing and distributing automatic control components
- Manufacturing and supplying metal structure equipment
- Providing operation & maintenance diagnostic services for hydropower station/pump station units
- Offering complete equipment integration services for electromechanical systems
- Delivering power facility repair and testing services
- Providing installation guidance for general mechanical equipment
- Supplying safety production standardization consulting for water conservancy projects
- Delivering comprehensive engineering service solutions

Fluid Laboratory

Power equipment testing laboratory

Multi-channel Ultrasonic Flow Meter



Intelligent Wireless Remote Water Meter

FZLQ/CBWF Automatic Water Filter

Hot water circulating pump

《*Mechanical & Electrical Technique of Hydropower Station*》

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