

2015

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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A stylized, handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke.

KUANG Shangfu, Ph.D.
President of IWHR

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 50 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 organizations or their Chinese branches, including WASER, WASWAC, ICOLD, ICID, IAHR, GWP, IHA, ARRN, etc.

In 2016, IWHR received 259 foreign visitors and dispatched experts to 28 countries and regions in order to boost knowledge sharing as well as technical exchange and cooperation. We organized the 27th Sino-Japan River Engineering and Water Resources Conference in Beijing, the 13th Joint Seminar on Construction Technology with KICT and the 1st Seminar on Intelligent Water Network with K-water in Korea. Along with IAHR, we have jointly launched a new international journal, Journal of Ecohydraulics. An international water history seminar was convened in Beijing jointly sponsored by IWHR and CHES to discuss the history and future of water resources. We also participated in the first plenary session of AWC in Indonesia on which IWHR was successfully elected as a Board member. Among others, we continued following up major international water events such as the Stockholm Water Week and the Singapore Water Week.

WELCOME MESSAGE

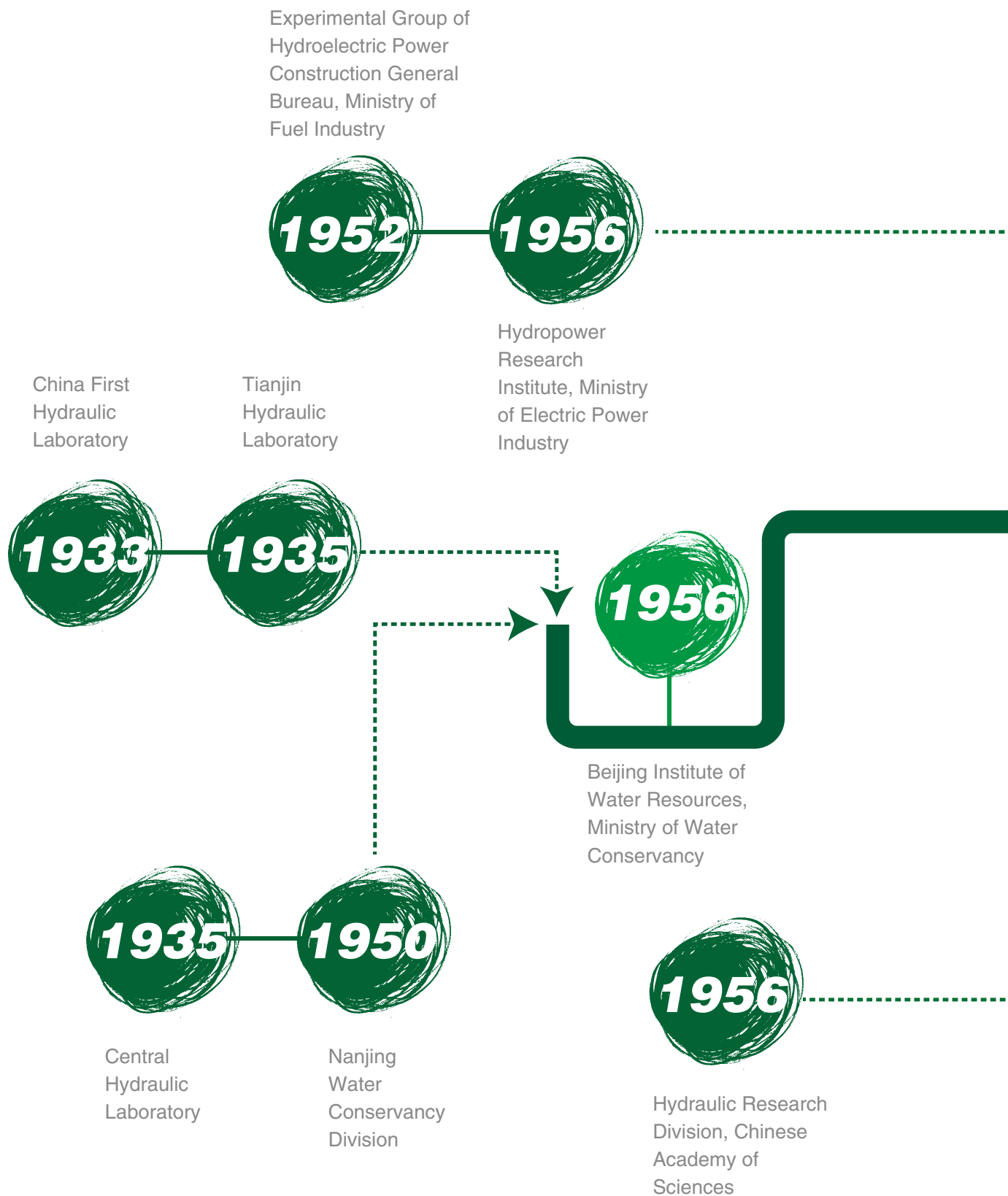
Annual Report 2016

CHINA INSTITUTE OF WATER RESOURCES AND
HYDROPOWER RESEARCH

In 2016, IWHR accomplished great breakthroughs in R&D, attaining overall progress in flood control and disaster mitigation, water resources management and eco-environment improvement, efficient irrigation, drinking water safety, intelligent water technology, as well as the construction, operation and management of key water projects. Newly-signed contracts in 2016 totaled to CNY 1.24 billion, among which about 9% are overseas research projects in electromechanical hydropower equipment, rubber and hinge dams, impounding safety of dam projects, flood control planning and policy consulting. Throughout the year, IWHR accomplished 466 reports, 577 papers, 46 monographs, 188 patents and 20 standards in addition to 33 main awards (including 2 national prizes).

Looking ahead into the year 2017, we will build on our existing efforts and hold the hands of our international partners more firmly on the joint adventure to the future. The ship of IWHR can never sail without the support and driving of all its international friends, to whom we would like to extend our heartfelt appreciation. Hope we could do more to better the future of water in China and the whole world!

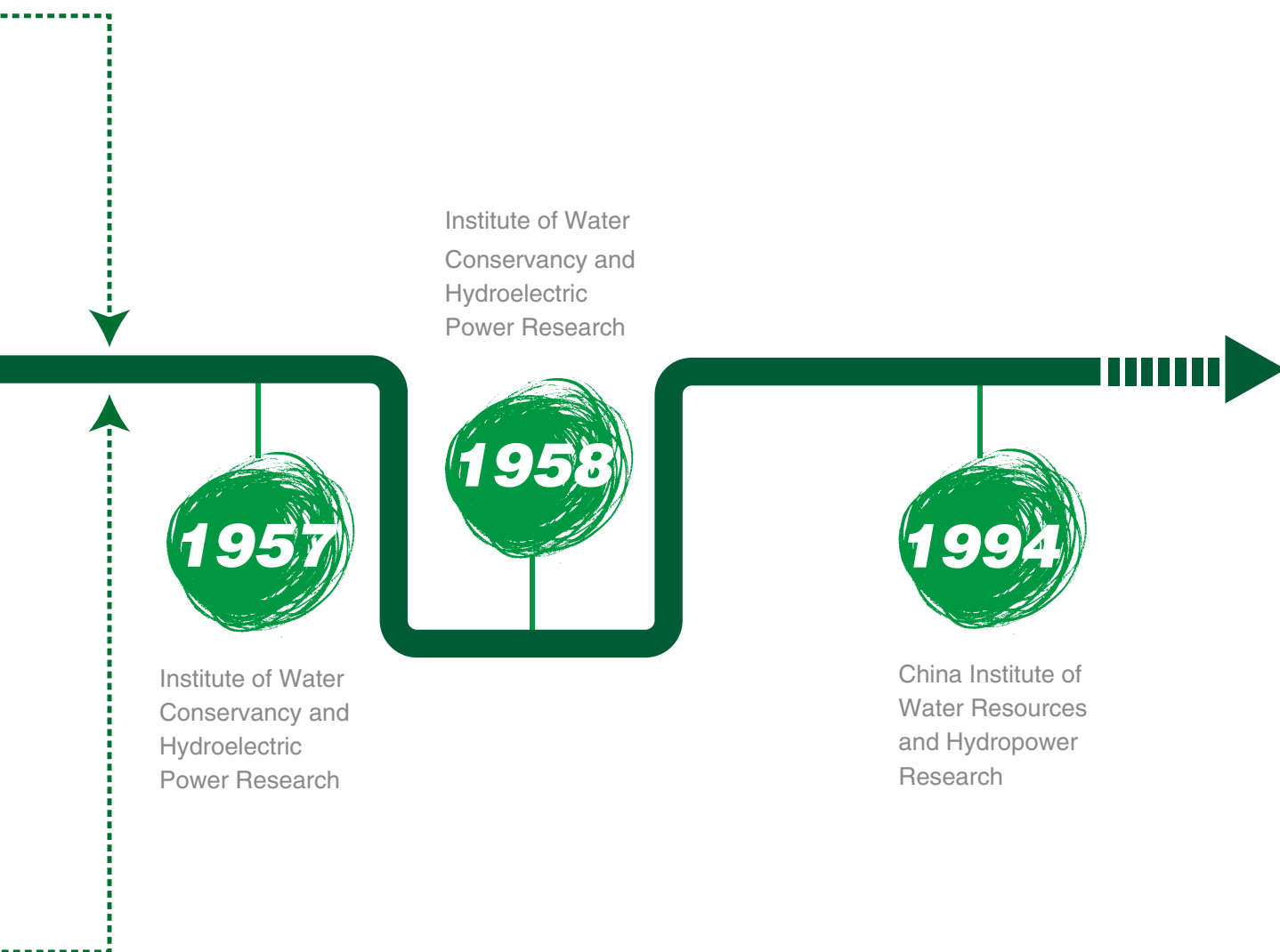




HISTORY

Annual Report
2016

CHINA INSTITUTE OF WATER RESOURCES AND
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Annual Report



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Harvesting © Shen Fujin



Vision and Strategy

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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

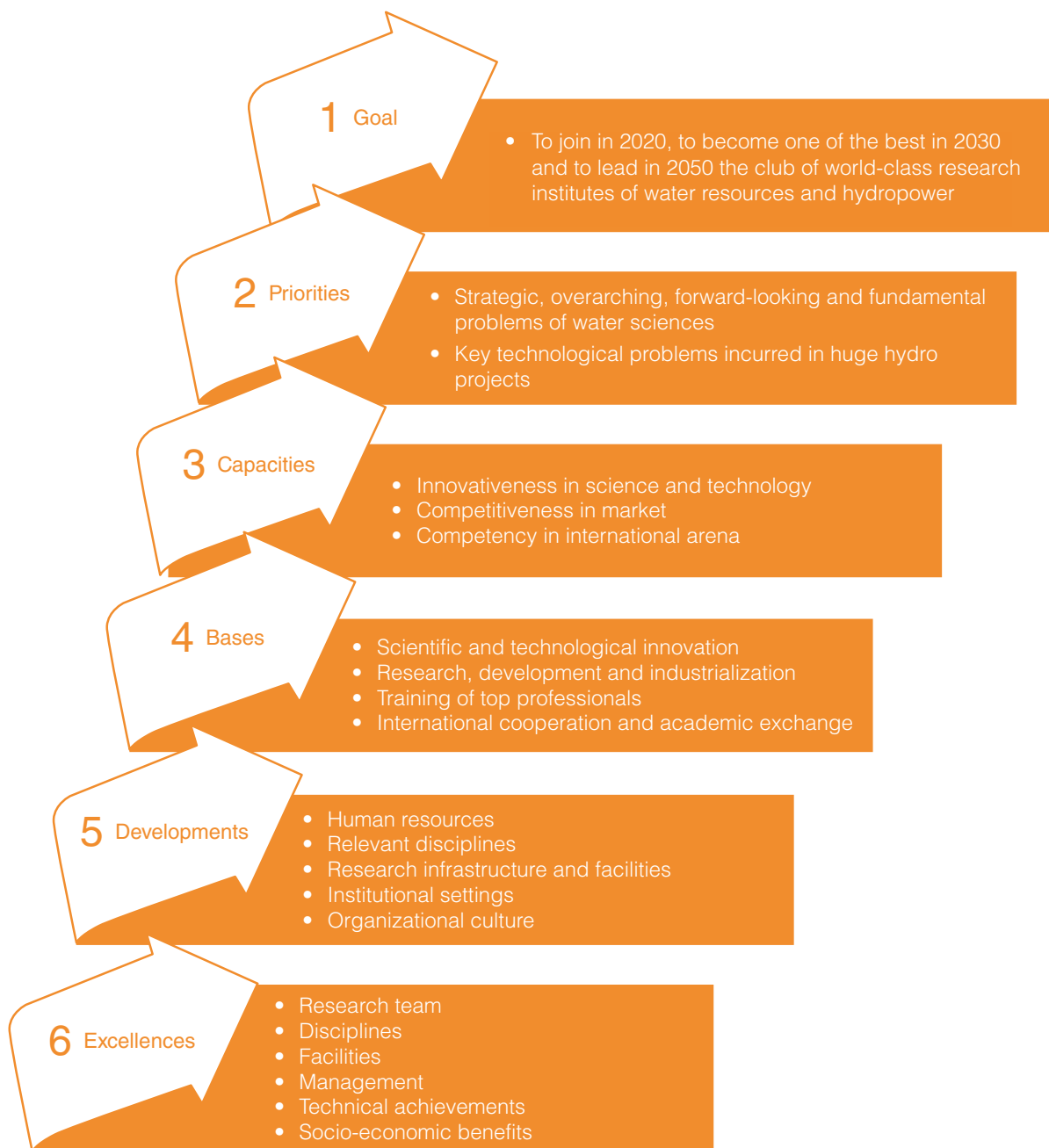
Innovation

Practicality

Devotion

Dedication

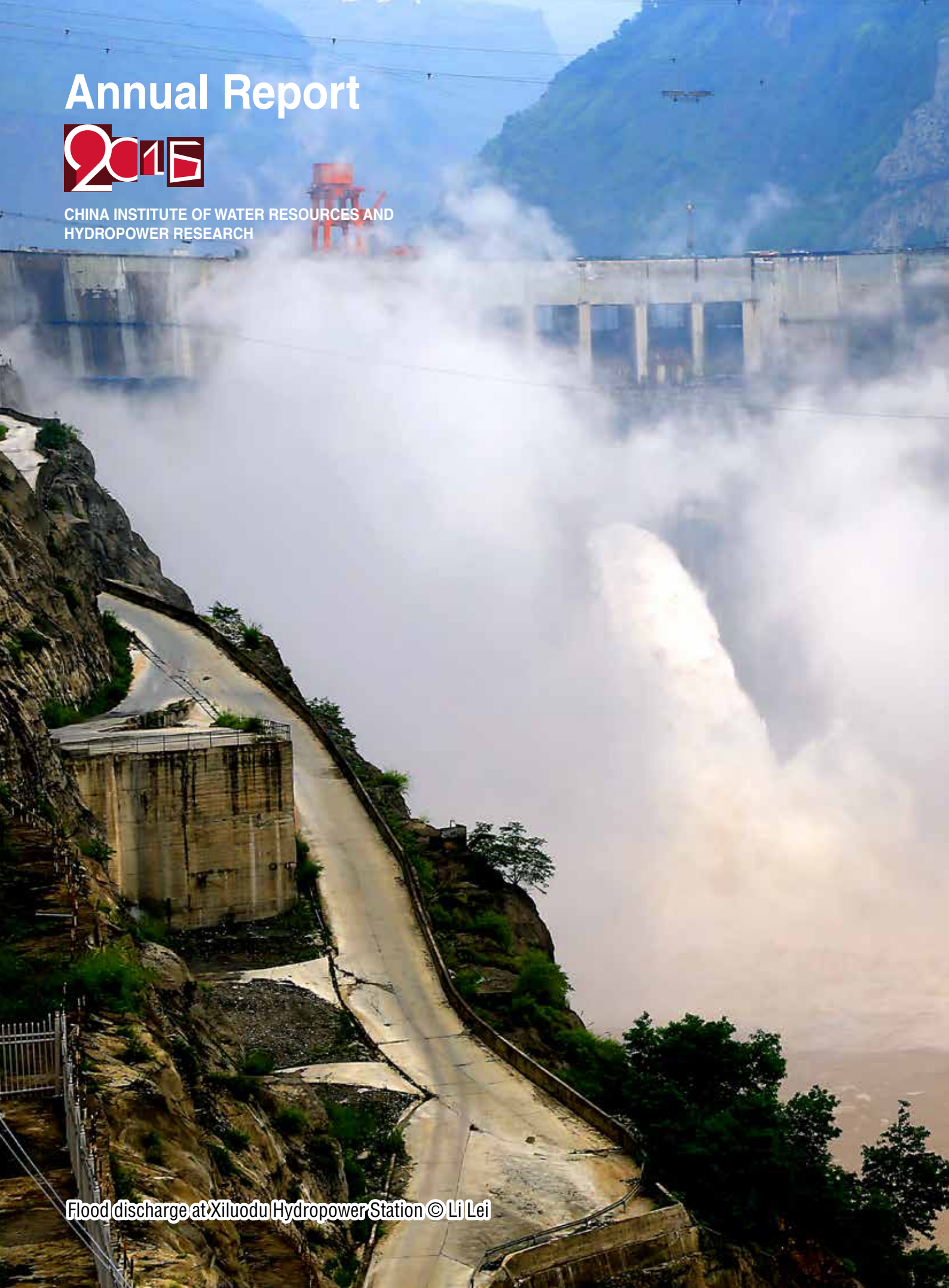
Strategy



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Flood discharge at Xiluodu Hydropower Station © Li Lei



Mission Achievement

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Research on the non-equilibrium transport of non-uniform suspended load

Han Qiwei Team

Keywords

Non-uniform, non-uniform suspended load, non-equilibrium transport, sediment exchange, exchange intensity

Theoretical System

- Sediment movement in rivers and scouring and deposition on river beds are exceptionally complicated, and its research as a discipline remains in the stage of development. Nevertheless, it's necessarily involved in the construction of water works, the building of flood control systems and the regulation of rivers and lakes and also associated with water environment and ecology. Therefore, studies on sediment movement must be brought to a new high and make major breakthroughs so as to meet the need of the new situation. Scientific problems involved include:
 - (1) Switching (exchange intensity) of sediment movement states (resting, rolling, saltating and suspending) on river beds and the ratio (probability) and change of each movement state;
 - (2) The state and movement of sediment are random because of the fluctuation of flow, size of sediment and the contingency of its position on river bed. On the other hand, the state and movement of sediment follow necessarily the law of mechanics in given conditions. Thus, the key is how to analyze their mechanisms and educe relevant laws combining the hydromechanics and random process; and
 - (3) To take the edge of research and promote disciplinary development, we must make source breakthroughs and innovations in basic theories so as to reform and develop the existing theories of sediment movement and river dynamics.
- Research Accomplishment -- a Theoretical System for Non-equilibrium Transport of Sediment
 - Breakthroughs in source studies of sediment movement theories
 - We have established conditions for the switching of the four movement states of sediment on river bed and 16 switching probabilities (Figure 1: 4*4 Switching Probability Matrix). We have obtained the distribution and mathematical expectation for the initiation time (when static sediment starts to move) of particles and the distribution and mathematical expectation for the single-step motion and one-off motion of the rolling, saltating and suspending of particles.
 - Based on the four states of sediment

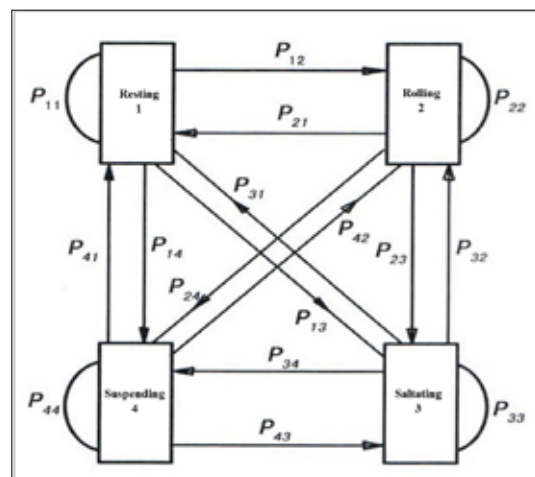


Diagram of Sediment Rolling, Saltating and Suspending

movement, we have established 12 degrees of exchange intensity (Table 1) -- the number of particles transitioning from a movement state to another per unit of river bed area and per unit of time, including the distribution and conditional expectation of particle volume.

- Building up the theoretical system for the non-equilibrium transport of suspended load based on the exchange intensity of sediment

- In line with the exchange intensity of sediment on river bed, we have established boundary conditions for the diffusion equation in theory, which are of extensive generality and are able to cover all existing relations. We have obtained the sediment-carrying capacity of non-uniform suspended load through the exchange between

suspended load and bed load. Being conform to massive observations, the system can cover established major formulas and while pointing out their theoretical defects. We have also proved the validity of theoretical basis of the one-dimensional equilibrium sediment transport equation (widely adopted) established by author in line with the boundary conditions. We can also provide the entire linear evolution of sediment concentration. Gradation of suspended load and bed load varies to sediment concentration.

- Proposing and exploring new fields of movement of suspended load
 - We have presented for the first time the concept of suspended height, and researched the relations between the distribution of sediment concentration and suspended height -- as drops from 2.0 to 0.001, suspended height will increase from 0.0666 to 1.000, which means the suspended height ranges from bottom to water surface. We have conducted in-depth studies on the gradation of sediment-carrying capacity and effective bed load under non-equilibrium transport conditions, which are a new part of the theoretical system of movement of non-uniform suspended load. Based on which we have also divided the incoming sediment into three parts, with the presentation of new concepts and a set of new formulas.
 - We are the first to have proved that wash load, bed load and total load have the same sediment-carrying capacity, which enable us to describe them with a uniform formula and also unify the law despite the size of particles. We have made breakthroughs in the research on the sediment-carrying capacity of suspended load, no longer having to separate the bed load from wash load in study. Thus, we provide a theoretical foundation for the total load-based mathematical models.
- Solving long-standing theoretical disputes and problems
 - We have derived for the first time the recovery saturation coefficient under equilibrium and non-equilibrium conditions, theoretically (Figure 2). As an important parameter in the non-equilibrium transport of sediment, this coefficient, on some levels, determines the scouring and deposition. The ambiguity of sediment-carrying capacity has been proposed since the 1950s. Many of the senior Chinese scholars agreed with it and gave conceptual interpretations. This study proves, theoretically, the ambiguity of sediment-carrying capacity under scouring and deposition conditions and presents a formula for it.
- We have analyzed six phenomena of bed coarsening and their mechanisms, derived a general formula for the coarsening (of bed load and suspended load) using the statistical theory of sediment

$$\left. \begin{aligned}
 \lambda_{12i} &= (\varepsilon_{1i} - \varepsilon_{20i})(1 - \beta_i) \frac{m_0 R_{1i} P_{1i}}{\pi D_i^2 t_{02i}} \\
 \lambda_{23i} &= \varepsilon_{20i} (1 - \beta_i) \frac{m_0 R_{1i} P_{1i}}{\pi D_i^2 t_{03i}} \\
 \lambda_{14i} &= \beta_i \frac{m_0 R_{1i} P_{1i}}{\pi D_i^2 t_{04i}} \\
 \lambda_{21i} &= (1 - \varepsilon_{0i})(1 - \varepsilon_{4i}) \bar{K}_{2i} \mu_{2i} U_{2i} \\
 \lambda_{23i} &= \varepsilon_{2i} (1 - \varepsilon_{4i}) \bar{K}_{2i} \mu_{2i} U_{2i} \\
 \lambda_{24i} &= \varepsilon_{4i} \bar{K}_{2i} \mu_{2i} U_{2i} \\
 \lambda_{31i} &= (1 - \varepsilon_{0i})(1 - \varepsilon_{4i}) \bar{K}_{3i} \mu_{3i} U_{3i} \\
 \lambda_{32i} &= (\varepsilon_{0i} - \varepsilon_{2i})(1 - \varepsilon_{4i}) \bar{K}_{3i} \mu_{3i} U_{3i} \\
 \lambda_{34i} &= \varepsilon_{4i} \bar{K}_{3i} \mu_{3i} U_{3i} \\
 \lambda_{41i} &= (1 - \varepsilon_{0i})(1 - \varepsilon_{4i}) \bar{K}_{4i} \mu_{4i} U_{4i} \\
 \lambda_{42i} &= (\varepsilon_{0i} - \varepsilon_{2i})(1 - \varepsilon_{4i}) \bar{K}_{4i} \mu_{4i} U_{4i} \\
 \lambda_{43i} &= \varepsilon_{2i} (1 - \varepsilon_{4i}) \bar{K}_{4i} \mu_{4i} U_{4i}
 \end{aligned} \right\} \text{Exchange Intensity} \quad (2-99)$$

exchange and in particular, took the lead in proposing the exchange coarsening (inc. bed load and suspended load) and proved that sandy bed coarsening is mainly caused by the scouring of suspended load.

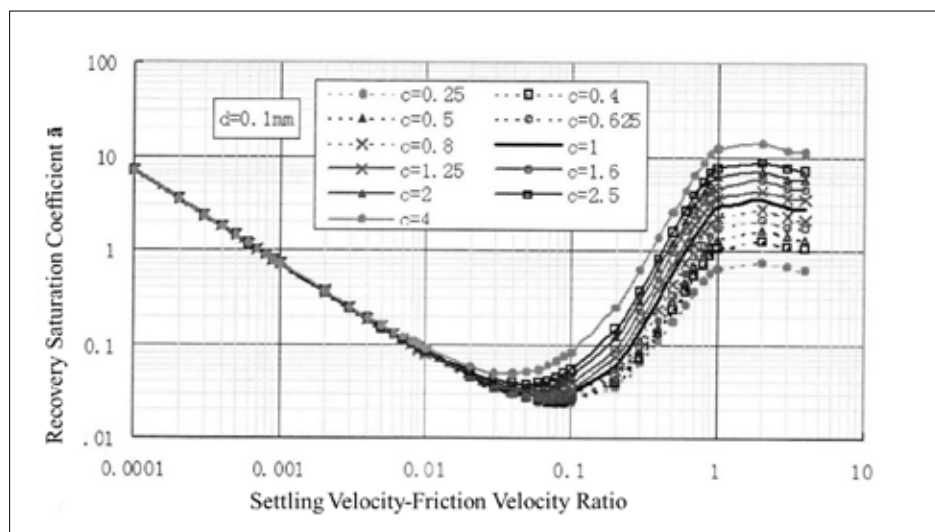
To sum up, long-term systematic in-depth studies have been conducted on the non-equilibrium transport of non-uniform suspended load and a theoretical system for non-equilibrium sediment transport has been built up according to the said statistical theories of sediment movement, especially the statistical theory of sediment exchange on river bed.

Methodology

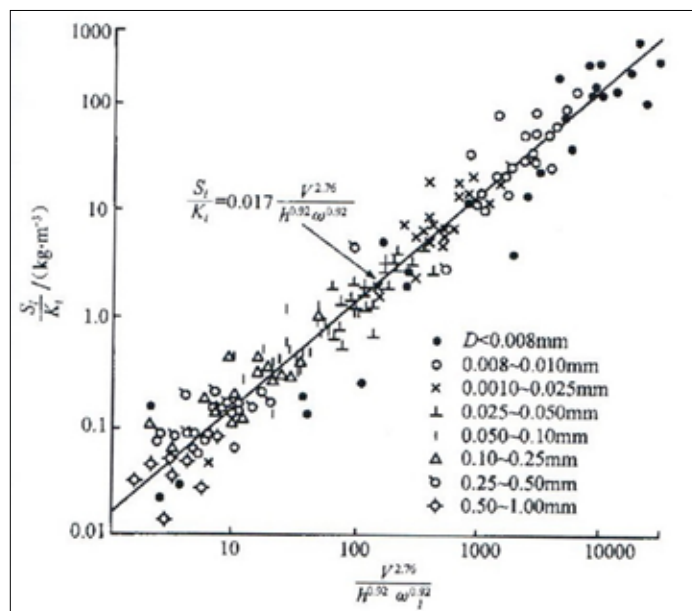
- A solid theoretical foundation. The aforementioned research is based on a major theoretical foundation of the “statistical theory of sediment movement” accomplished by the author. The achievement was introduced in the U.S. Encyclopedia of Fluid Mechanics with a dedicated chapter (Chap. 18, Vol. VI).
- This research is an interdisciplinary crossing fluid mechanics, probability theory (random process) and river dynamics.
- In this research, problems are studied in a well-planned and connected way, hence the research process are mutually reinforcing, which help us build a theoretical system instead of sole resolution of individual problems.
- Importance is attached to conditions for good achievements: sufficient practical experience, solid theoretical basis, in-depth studies, repeated meticulous considerations, dialectic research methods and necessary self-denial.

Application

- Items of boundary conditions of the suspended load diffusion equation and sediment scouring and deposition can be established, theoretically, according to the statistical law of bed exchange intensity (achievements (1)-(3)). Then, the formula of non-uniform sediment-carrying capacity and the distribution of suspended height can be obtained. Meanwhile, gradation of suspended load, bed



Relation between Recovery Saturation Coefficient (Grain Size $d = 0.1 \text{ mm}$) and Settling Velocity-Friction Velocity Ratio



Group-specific relation between Sediment Concentration and Hydraulic Factor of the Yangtze River Xinchang Hydrologic Station

load and sediment-carrying capacity can be acquired, which can cover and deepen almost all the existing problems about suspended load and help present some new fields of research.

- The theoretically obtained recovery saturation coefficient (achievement 13) can be widely applied, and can serve to explain the “more in, more out” mechanism of the Yellow River and ordinary non-equilibrium transport equations.
- The gradation of sediment-carrying capacity and the gradation of effective bed load proposed constitute an important part of the non-equilibrium sediment transport. They improved the system of non-equilibrium transport and have been applied to the mathematical model for the downstream channel of the Three Gorges Reservoir.
- Bed coarsening has been widely applied to the scouring of suspended load and bed load and their deposition. In particular, the exchange coarsening fully reflects the exchange of coarse particles from upstream reaches and fine particles in the local section. It has been applied to the research of the Yangtze River, the Hanjiang River and the Yellow River.
- The rule that wash load, bed load and total load have uniform sediment-carrying capacity, which has been applied widely to the mathematic models of sediment. The theory of the ambiguity of sediment-carrying capacity has been applied to the downstream Yellow River, Huaihe River and the middle and lower reaches of the Yangtze River after the construction of the Three Gorges Reservoir.

Monograph

- Non-equilibrium Transport of Non-uniform Suspended Load (Han Qiwei, Science Press)

Representative Researches

Research, popularization and application of Francis turbine hydraulic model series

PENG Zhongnian, CHEN Rui, TIAN Yajuan et al.

Background

The waterhead, flow, and other parameters of different hydropower stations vary widely, and “personalized” hydropower stations require a rich hydraulic turbine model library and a “tailored” hydraulic model research and development means. The huge demand for safe and efficient use of water resources promotes the continuous improvement in hydraulic design level of turbines. Old hydropower stations have an urgent need for efficiency improvement and capacity expansion, while a large number of hydropower equipment manufacturers in China have a pressing demand for technical support for hydraulic design of turbines.

Contents

- Carrying out the experimental study on internal flow observation of Francis turbines, and exploring internal flow and pressure pulsation law of Francis turbines so as to provide technical support for the research and development of giant turbines such as turbines for the Three Gorges Reservoir;
- Researching and developing full-flowpath hydraulic design software system of Francis turbines independently;
- Researching and developing Francis turbine hydraulic model to meet the need of Francis turbine power stations for construction, efficiency improvement and capacity expansion;
- Proposing the technical transformation solution of hydraulic turbines for hydropower stations and establishing a “tailored” personalized solution process;
- Promoting and applying the Francis turbine new technology; and
- Declaring national invention patents for aforementioned core technology.



Full-flowpath hydraulic model design software system of Francis turbines



Turbine model unit and model runner



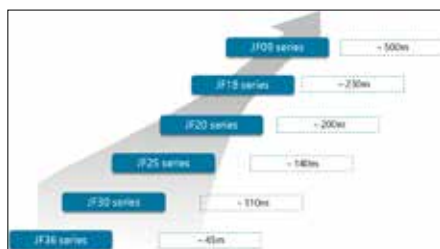
Turbine runner used in foreign hydropower stations

Achievements

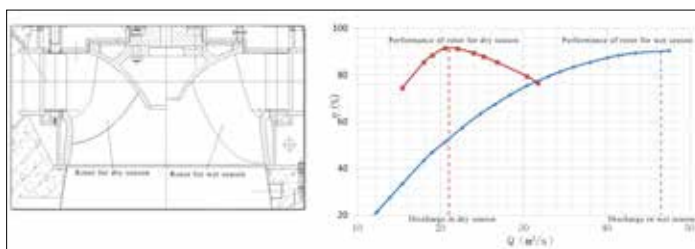
- The parametric design software system for full-flowpath hydraulic model of Francis turbines has been developed based on independently-innovated mathematical model, calculation formula, combination method and other core technologies, and has been constantly revised and improved according to high-precision turbine model test and internal flow observation results;
- The 17 series of hydraulic models developed by the above design system software cover all waterhead running range of Francis turbines. The optimal efficiency of the models is raised up to 93% or 94% for the first time in China, catching up with the international advanced level;
- The technical concept of “dry season runner” and “double runner configuration” of turbines has been created for the first time, the technical problem of operation difficulty of turbines due to large flow difference of runoff hydropower stations in wet season and dry season have been overcome, a relative increase of 30%-80% in turbine efficiency in dry season has been achieved, the hydraulic stability of hydropower units has been fundamentally solved, and two patents for inventions have been obtained;
- Six types of solutions for technological transformation of hydropower stations have been systematically summarized and a complete, scientific, efficient and reliable personalized solution process has been established, playing a leading role in efficiency improvement and capacity expansion of hydropower stations;
- For the first time, the internal flow of the runner was systematically observed and a comprehensive hill chart of Francis turbine model with various critical lines was drawn in 1995, promoting the development target and evaluation criteria for Francis turbines to a new height.

Application

- The results of the study on the internal flow regime and the hydraulic stability of Francis turbines deepen the industry's understanding of the hydraulic stability law of Francis turbines, and related content has been incorporated into the tender documents of large and medium-sized turbines.
- According to rough statistics, a total of more than 150 hydraulic models are developed according to the results; the products are listed as advanced and practical technologies of water conservancy for twice, and the results are introduced by 15 large-scale and influential turbine manufacturers in China, which illustrates that the results have promoted the industry's technological progress; the six categories of solutions for hydropower station technological transformation and personalized solution process have played a significant role in the project of efficiency improvements and capacity additions for hydropower stations organized by the Ministry of Finance and the Ministry of Water Resources.
- With excellent hydraulic performance, the Francis turbine hydraulic models of this research have stood out for several times in the fierce domestic and international hydropower market competition, and have been applied to 18 hydropower stations of 11 foreign countries and about 418 units in over 180 hydropower stations of more than 20 provinces, municipalities or autonomous regions in China. The total installed capacity is 4320MW, equivalent to the capacity of 6 giant units of the Three Gorges Project, and the performance indicators all meet or exceed expectations.
- The promotion and application of the achievements of this research has produced great social and economic benefits in that it brings annual power generation of approximately 850 million kWh which preliminarily equals to annual direct economic benefits of 255 million yuan, annual indirect economic benefits of 850 million yuan, and annual standard coal reduction of 270,000 tons, i.e. annual carbon dioxide emission reduction of 707,000 tons.



Waterhead coverage of Francis turbine hydraulic model series



“Dry season runner” and “double runner configuration” technology for Francis turbines

Study of key technology of water quality and water quantity combined regulation and emergency treatment of South-to-North Water Diversion Project

WANG Hao, JIANG Yunzhong, LEI Xiaohui

Background

The South-to-North Water Diversion project, a project with great investment and an important status, complex engineering conditions and operating conditions, harsh control conditions, high water quality requirement, involvement of multiple parties of interest, and has become one of the major water sources of most water-receiving cities after its operation. In the event of a sudden water pollution incident, the treatment will be extremely difficult, as in addition to possible interruption of water supply that may lead to water shortage in water-receiving areas, it may also produce incalculable economic losses, causing significant socioeconomic harm to surrounding towns. It is necessary to reduce the impact of the above risks on water quality by studying the scientific mode of water quantity and water quality combined regulation and the emergency treatment that adapts to the South-to-North Water Diversion Project.

With water quality safety protection as the core, this research uses emergency regulation and treatment of sudden water pollution incidents as a means to establish a set of technological system that guarantees water safety for the main canal of middle route of the South-to-North Water Diversion Project, providing direct technical support for the prevention and management of sudden water pollution incidents of inter-basin large-scale water diversion projects, and ensuring the realization of “transporting a canal of clean water to the north”.

Contents

- Water quantity and water quality coupling simulation technology for rivers, reservoirs, and canals;
- Pollution source risk assessment and water quality safety diagnosis technology;
- Water quality and water quantity rapid forecasting and traceability technology for water pollution incidents;
- Multi-objective dispatching and emergency regulation technology of water quality and water quantity;
- Emergency warning and emergency treatment technology of water pollution incidents; and
- Automated operating system for water quality and water quantity combined regulation.

Achievements

- A set of technical systems for emergency regulation of sudden water pollution incidents in long-distance water diversion projects has been established for the first time, which integrates “numerical simulation, evaluation and diagnosis, prediction and early warning, emergency regulation, and pollution treatment”;
- Water quantity and water quality multi-process coupling simulation model group, including one-dimensional model for canals under the control of sluice gates, two-dimensional model for lakes, and three-dimensional model for reservoirs, has been constructed based on the characteristics of large-scale water diversion projects. The accuracy and efficiency of the model group have been improved by parameter identification and parallel computation;



Water quality and water quantity combined regulation system platform for the first phase of the middle route of South-North Water Diversion Project

- A source identification model of sudden water pollutions based on coupled probability density function method has been constructed, successfully realizing the identification of the intensity, occurrence position and occurrence time of sudden pollution source in long-distance water diversion projects. In addition, the accuracy and efficiency of source identification has been greatly improved by introducing heuristic algorithms;
- To ensure water supply safety and control the proliferation of pollution groups, the determination methods of water lock closing duration and water lock draft depth, two of the key control indicators of emergency regulation, have been put forward to cope with soluble contaminants and floating contaminants respectively, and the emergency regulation models and preplans for water gate group of complex water diversion projects have been formed;
- Complete sets of technical systems, devices, materials and preplans for emergency treatment, which integrate pollution source control, pollutant proliferation, pollutant elimination and emergency waste disposal, have been put forward for sudden water pollution incidents in large-scale water diversion projects, and the intelligent generation model of emergency treatment has been developed;
- The automated operating platform for water quality and water quantity combined regulation in the main canal of middle route, the water source area of middle route, and the Jiangsu section of eastern route of the South-to-North Water Diversion Project has been developed, a comprehensive whole-process regulation of conventional water dispatching and sudden water pollution incidents has been achieved, and demonstration applications have been carried out.

Application

- This research forms 6 major categories of 15 key technologies of water quality and water quantity combined regulation and emergency treatment of the South-to-North Water Diversion project, develops 6 major categories of 21 products and devices including pollutant treatment device, treatment material, various types of databases, preplan, software platform and experimental platform, studies and prepares 5 standard specifications, including Multi-parameter Dimensionless Technical Specification for Water Quality Safety Evaluation and Diagnosis, and develops 2 automated operating systems for water quality and water quantity combined regulation.
- The technologies, products and devices developed by this research have been systemically applied to 2 demonstration projects of the research and have produced a fine effect; the automated operating system for water quality and water quantity combined regulation in the first phase of the middle route of South-North Water Diversion Project has been deployed in the dispatching center hall of the Construction and Administration Bureau of South-to-North Water Diversion Middle Route Project and the reservoir dispatching center of Hanjiang Water Resources & Hydropower Group, and has been widely used in the water pollution emergency regulation business for water source area of middle route of the South-to-North Water Diversion Project, and the conventional and emergency water quality and water quantity combined regulation business for the main canal of middle route of the South-to-North Water Diversion Project; this research has assisted the Office of the South-North Water Division Project Commission of the State Council and the Ministry of Water Resources in preparing a series of programs and plans for the South-North Water Division Project and provides a strong technical support for the trial operation and formal operation of the first phase project of the eastern route and middle route of the South-North Water Division Project.
- In addition, the achievements of this research cover closed water supply projects and open canal/river network water supply projects, and can be widely applied to many domestic water diversion projects such as the "Luanhe-Tianjin Water Diversion Project" and the "Yellow River-Qingdao Water Diversion Project".



Demonstration site of emergency regulation and treatment technology for sudden water pollution incidents

Sedimentation simulation and control techniques of the Three Georges Reservoir and downstream rivers

HU Chunhong, ZHANG Shuguang, LI Danxun, et al.

Background

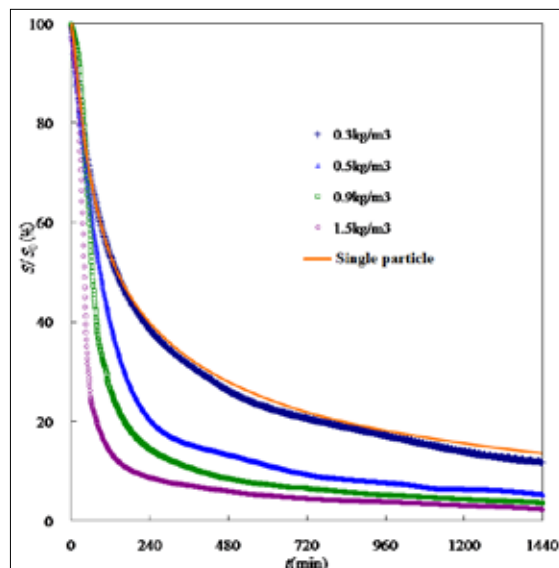
The Three Georges Reservoir has produced huge comprehensive benefits since it was put into use in 2003, yet there are still some problems to be solved. The sediment problem is one of the key technical problems affecting the safe operation of the Three Gorges project. To ensure the long-term safe operation and continuous comprehensive benefits of the Three Georges Reservoir and enhance the flood control safety and ecological security of basins, the National Key Technology R&D Program of the 12th Five-Year Plan Period carried out the research entitled "Sedimentation Simulation and Control Techniques of the Three Georges Reservoir and Downstream Rivers".

Contents

- Studying the influence of upstream cascade reservoirs on the change of water and sediment into the Three Gorges Reservoir;
- Studying key techniques of sediment simulation of the Three Gorges Reservoir and downstream rivers;
- Studying the evolution of the lower reaches of the Three Gorges Reservoir and its influence on downstream waterway;
- Studying the change of river-lake relations and its influence after the operation of the Three Gorges Reservoir;
- Sediment regulation and multi-objective optimal dispatching of the Three Gorges Reservoir.

Achievements

- Theoretical research has made important innovations and reveals the law of sediment movement in the Three Gorges Reservoir;
- Mathematical model simulation technology has made a breakthrough, improving the simulation accuracy



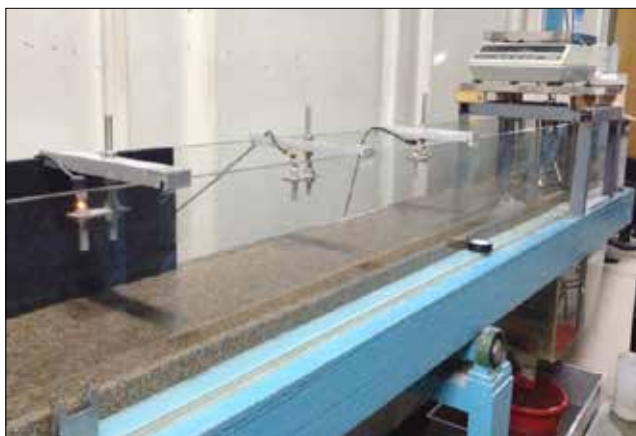
Sedimentation curves for different sediment concentrations in flocculation test of the Three Georges Reservoir

significantly;

- A new series of upstream incoming water and sediment of the Three Gorges Reservoir, which takes into account natural changes and the impact of human activities, has been put forward, providing basic conditions for research and application;
- The sediment regulation and optimal dispatching scheme of the Three Gorges Reservoir has been put forward, producing huge demonstration effect;
- A new technology of waterway regulation after the operation of the Three Gorges Reservoir and two types of new building structure for waterway regulation, namely permeable dam head and stepped dam head, have been developed, bringing remarkable engineering effect and ecological effect.

Application

- The sediment regulation and comprehensive optimization scheme of the Three Gorges Reservoir has been applied in the dispatching of the Three Gorges Reservoir;
- The ideas and new techniques of waterway regulation in the middle and lower reaches of the Yangtze River under the new water and sediment condition have been applied to multiple governance projects;
- The changes in the relationship between rivers and lakes, and relevant governance measures of Dongting lake and Poyang lake have been adopted in the planning and design;
- The sediment mathematical model has been promoted and applied;
- The new water and sediment series has been widely used as basic information.



Test on bed load sediment transport and secondary armoring rule of riverbed under the condition of clean water scouring downstream from the dam



Scouring and silting effect test of permeable dam head, one of the new structures for waterway regulation

Development and application of flood analysis software IFMS/IFMS URBAN

MA Jianmin, ZHANG Dawei, YU Haijun

Background

The research and development of highly applicable flood analysis software IFMS and IFMS URBAN, an important part of the flood risk map project of key areas across the country, is financed by national financial allocation according to the task arrangement of “The 2014 Implementation Plan for the Construction and Management (central level) of National Mountain Torrent Prevention and Control Project”. Since the completion of research and development, IFMS and IFMS URBAN software have been widely used in the flood risk map project of key areas across the country.

Contents

- Developing a two-dimensional GIS platform with independent intellectual property rights based on the DirectX display technology, which supports GPU acceleration for fast rendering;
- Realizing the simulation functions of one-dimensional large-scale river networks capable of simulating the dispatching of a variety of projects. The one-dimensional model uses the classic Preissmann format and the Godunov format that can calculate excessive flow;
- Realizing the shock capture function of the two-dimensional shallow water model. The 2D model computational engine uses a Godunov format based on unstructured grids, which not only simulates smooth classical solutions, but also deals with strong intermittent problems such as dam-break floods;
- Realizing the water flow simulation of urban pipe networks, and reconstructing the water flow model of pipe networks on the basis of internationally-renowned SWMM model to facilitate seamless integration with the system; and
- Realizing the mutual coupling function of one-dimensional, two-dimensional and pipe network models, effectively solving the flood analysis problems of various risk map projects.

Achievements

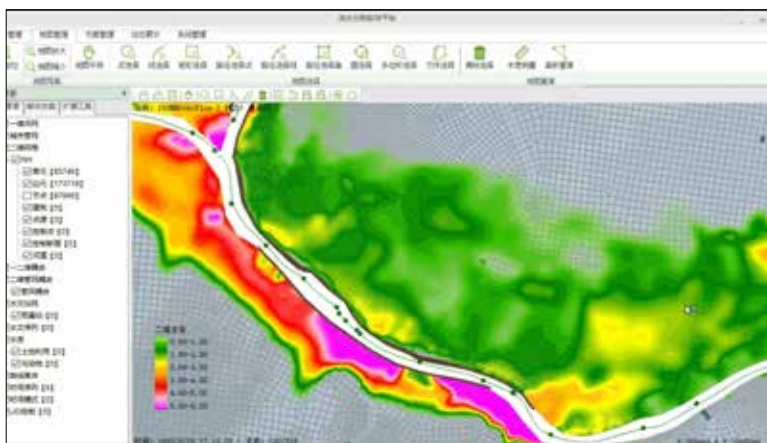
- The display and quick editing of large-data grids can be accelerated through the use of video card, the integrated display of remote sensing images and DEM with large-amount of data has been achieved, the management of flood analysis model elements has been implemented with object-oriented thinking, and the pre-processing, post-processing and simultaneous display of flood analysis model has been realized;
- The one-dimensional computing engine integrates the dispatching function of super-large river networks and hydraulic buildings, and is suitable for rapid flow simulation, slow flow simulation, and other complex strong intermittent simulation; the two-dimensional computing engine uses the porosity coefficient to simulate the influence of non-inundated area (such as houses), and realizes two-dimensional parallel computation;
- The software realizes the mutual coupling calculation function between multiple models, such as the lateral and forward coupling between the river network model and the two-dimensional model; it proposes a generalized one-dimensional channel based on two-dimensional grid and a new method for implementing one- and two-dimensional coupling calculations in local areas; and it realizes the vertical coupling function between the pipe network model and the two-dimensional mode;
- The flood analysis software includes an unstructured grid split tool which has a powerful function to split triangular and quadrilateral unstructured grids rapidly, and adopts Looping algorithm for non-structural quadrilateral grid splitting of any complex geometric boundaries.

Application

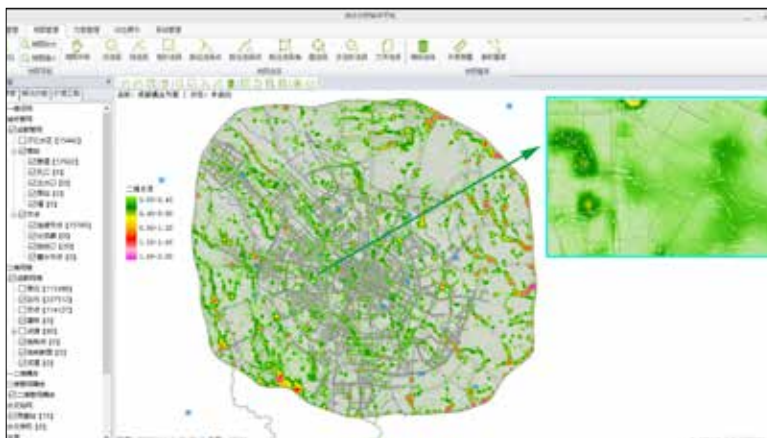
The system has been put into application by many institutions, has been applied in flood risk map preparation projects of many regions including Hunan, Xinjiang, Sichuan, Hebei, Shandong, Shanxi, and Inner Mongolia, and thus has a broad prospect for promotion and application.



Analysis and calculation of floods in Hunan Lanni Lake Large Circle Flood Protection Area by IFMS



Simulation of the flood of South River in Qionglai, Chengdu, Sichuan using the one-dimensional and two-dimensional coupling functions of IFMS



Central city flood risk map of Chengdu, Sichuan

Basic theory and key technologies of water ecological protection compensation for the headwaters

WANG Jianhua, RUAN Benqing, WANG Hao, et al.

Background

The Opinions of the General Office of the State Council on Improving the Compensation Mechanism for Ecological Protection, which was issued in April 2016, enunciates that “comprehensively carry out ecological protection compensation in the headwaters”. Considering that water constantly flows and recycles, protection and compensation of water ecology differ from that of terrestrial ecology in terms of means and methods, especially in terms of the externality of upstream-downstream conduction. Although there has already been a consensus on the effects of water ecological compensation on watershed ecological environment protection, due to the complexity of theoretical technology and practical operations, there is no domestic precedent of inter-provincial ecological protection compensation prior to the implementation of this project.

Contents

- On the basis of previous studies concerning physical basis of water ecological compensation, ecological effects, economic basis and sociological ethics, a binary compensation theory of “man-earth compensation and man-man compensation” is proposed and a four-level compensation standard system covering investment cost (minimum), water public services (basic), loss of development opportunity (complete) and increment of downstream benefits (maximum) is built;
- Typical headwater areas are selected to carry out water ecological protection mechanism and effect monitoring test, and large-scale ecological hydrological simulation models of headwater areas is established; the equalized representation index system of basic water public services and input accounting method are established; the development opportunity loss of headwater areas is evaluated through applying the system dynamics model; water ecological protection and direct economic benefits accounting are carried out, and the specific measurement method of four-level compensation standard is formed;
- The aforementioned theoretical techniques are applied to Xin'anjiang river basin and Sanjiangyuan (tri-headwaters) area of Qinghai Province, respectively. A compensation and assessment mechanism that is line with actual regional situation is put forward, systematically supporting the implementation of the nation's

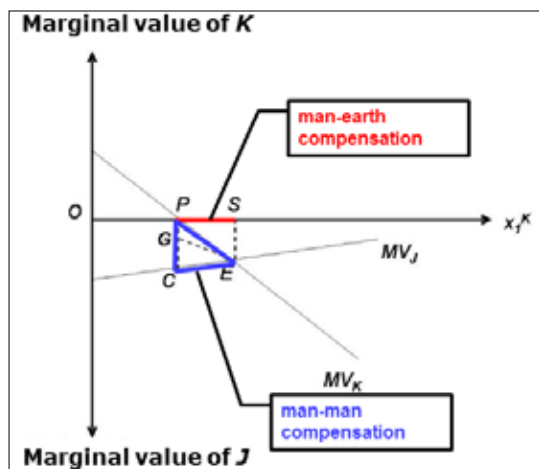
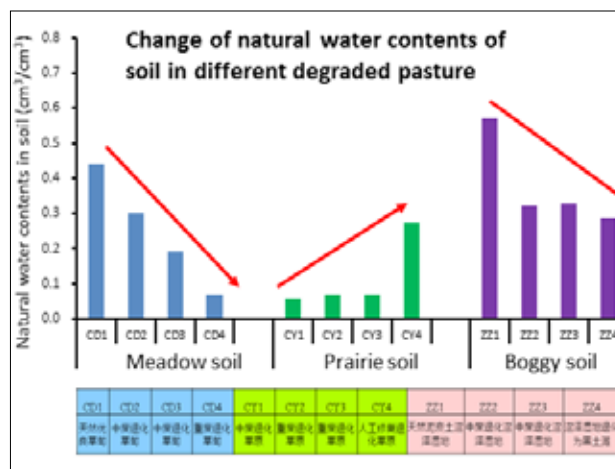


Diagram of the externality of water ecology protection in headwater areas and its impact analysis



Organic matter content and water content of different degraded grasslands

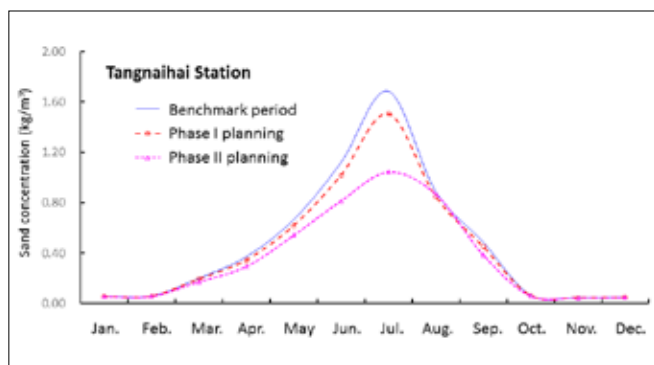
first inter-provincial water ecological compensation pilot program in Xin'anjiang, and the formulation and management system reform of phase II planning of ecological protection in Sanjiangyuan area.

Achievements

- The innovative binary compensation theory of “man-earth compensation and man-man compensation” is proposed for water ecological protection in the headwater areas, which realizes the scientific deconstruction of the mechanism and connotation of the watershed ecological protection compensation;
- Integrated eco-hydrological process simulation technology in headwater areas is developed, which provides quantitative tools for ecological protection measures planning, water conservation, runoff regulation, soil conservation and sediment reduction, water quality improvement and other aspects of evaluation;
- The four-level “minimum-basic-complete-maximum” compensation standard system of water ecological protection, which has a physical mechanism, and its calculation method have been innovatively established, representing the realization of hierarchical measurement of currency amount for water ecological compensation;
- The framework of water ecological protection compensation mechanism for headwater areas, which includes multiple compensation and binary assessment, is developed, advancing the establishment of watershed water ecological protection compensation system.

Application

The achievements comprehensively support the first and so far the sole officially-implemented inter-provincial headwater ecological compensation project in China (Xin'anjiang), the annual compensation standard of which reaches 500 million yuan. Through 3 years of implementation, the water quality of provincial boundary section has stabilized and reached grade II water standard; the permanganate index, ammonia and nitrogen concentration, and total phosphorus concentration of the Qiandao Lake have dropped by 19%, 54% and 28% respectively as compared to levels prior to the pilot project; and the eutrophication index of the Lake has dropped below 30. The achievements have been adopted by the Planning of Qinghai Sanjiangyuan Ecological Protection and Construction Phase II Project, supporting the planning to shift from a focus on traditional land ecological protection to equal emphasis on land ecological protection and water ecological protection. Suggestions brought by the research have promoted the establishment of Sanjiangyuan National Reserve, as approved by the State Council. The main achievements are used for reference in ecological compensation policies formulated by the National Development and Reform Commission and the Ministry of Water Resources, and are applied in ecological protection planning and policy design of headwater areas in Chengde (the headwaters supporting Beijing-Tianjin-Hebei) and Guyuan (the headwater of Jing River).



Sediment reduction effect of ecological protection of Tangnaihai hydrostation



Diagram of the co-built, shared and dependent areas of water ecological protection compensation in Sanjiangyuan area

Development of SK one-component polyurea and its application in hydraulic and hydropower projects

SUN Zhiheng, XIA Shifa, XU Yao, et al.

Background

Common damages to hydraulic concrete structures include cracks, seepage, freeze-thaw erosion, frost heaving, scouring, cavitation erosion and carbonization that affect the structural safety and seepage-proofing safety of structures. The most direct and effective solution is to paint protective coatings of a proper thickness on the surface of concrete. Polyurea is highly resistive against scouring, abrasion, seepage, freezing and corrosion. It's divided into one-component polyurea and bi-component polyurea. Usage of the latter is limited at hydraulic and hydropower projects because it's only applicable to the overflow surface of concrete with a flow rate smaller than 5m/s, as limited by the size of spraying equipment. To overcome the said drawbacks, the project group developed the high-performance SK one-component polyurea with flexible techniques and reliable quality of construction that can be used directly without blending and is widely applicable.

Contents

- Performing molecular design and formula design of SK one-component polyurea, working out a material prescription for its application to hydraulic and hydropower projects based on experiments, and developing manufacturing techniques;
- Conducting systematic tests on the performance of SK one-component polyurea materials, presenting main technical indexes for SK one-component polyurea according to the hydraulic structures' positions where it's applied and their running conditions, and developing specific interface agent; and
- Developing spraying equipment specific to SK one-component polyurea suitable for various kinds of hydraulic structures, and working out corresponding construction processes and quality control methods.

Achievements

- SK one-component polyurea products for "anti-seepage" and "anti-scouring" uses are developed respectively, and supporting techniques of manufacturing, and realized their large-scale production are designed;
- Series of interface agent applicable to steel plates, rubber sheets and EPDM boards, concrete and other base materials are developed, which ensures the reliable bonding between SK one-component polyurea coatings and basal planes;
- Main indexes of SK one-component polyurea for anti-seepage and anti-scouring uses are put forward respectively according to the environment and running conditions of hydraulic structures, which meets the engineering requirements in water-level-varying areas, high-velocity flow areas, severe cold areas and other rugged surroundings; and
- Spraying equipment specific to SK one-component polyurea according to the characteristics of hydraulic and



Basic structure of SK one-component polyurea coating

hydropower projects are developed, and a complete set of construction processes and quality control methods for the spraying and blade coating of SK one-component polyurea are put forward.

Application

The achievements have been applied to hundreds of hydraulic and hydropower projects in multiple sectors such as surface seepage-proofing, freeze-thaw resistance and durative protection of concrete dams, surface seepage-proofing of contraction joints of concrete structures, surface seepage-proofing of sockets of water pipes, anti-scouring protection of flood-releasing structures, treatment of concrete cracks, and durability protection and roughness reduction of water conveyance structures. In total, over 500 tons of SK one-component polyurea have been applied. Technical Regulations for the Construction of Polyurea Coatings at Hydraulic and Hydropower Projects, whose formulation was organized by the project team, has been promulgated, and the achievement has been included into the 2015 Catalogue for Guiding the Key Promotion of Advanced Operative Hydraulic Techniques of the Ministry of Water Resources, laying a solid foundation for wider application.



PCCP socket seepage treatment on the Beijing section of the middle route of the south-to-north water diversion project



Seepage and freeze-thaw resistance of Longtan Reservoir, Ningxia



Anti-scouring protection of overflow surface of Baishan Hydropower Station, Jilin



Seepage proofing, freeze-thawing proofing and roughness reduction of Yumenkou Aqueduct, Shanxi



Surface scouring proofing and freeze-thaw proofing of Lijiaxia spillway, Qinghai



Surface flexible sealing of concrete panels at Jilintai, Xinjiang

Research on the evolution mechanism of water environmental quality and security countermeasures of aquatic ecosystem of the Three Gorges Reservoir

WANG Yuchun, GAO Bo, HU Mingming, et al.

Background

The success of the Three Gorges Project is highly contingent on high-quality water and soundness ecological services functions in the Three Gorges Reservoir (TGR), which is also the key issue for comprehensive ecological environmental protection and construction of the basin of the Yangtze River. Nevertheless as a newly man-made giant lake, it is relatively scarce of scientific cognition about the evolution process and main problems of aquatic ecological environment of the TGR, which water yield and hydrologic processes are heavily disturbed by artificial regulation and impoundment. Therefore, scientific issues of great significance arise from basin environment science and basin ecology. Starting with the eutrophication of tributaries of the Three Gorges Reservoir, focusing on the integrated concept of interaction between mainstream and tributary, and centering on such disciplinary problems as hydrodynamic forces, water quality factors and aquatic organisms of the reservoir, this research construct a dynamic ecological model applicable to the ecological safety assessment of reservoirs and the multi-objective optimal scheduling of hydro-projects, providing scientific basis for the decision-making management of the ecological civilization of basins and the sustainable development of large-scale hydraulic projects.

Contents

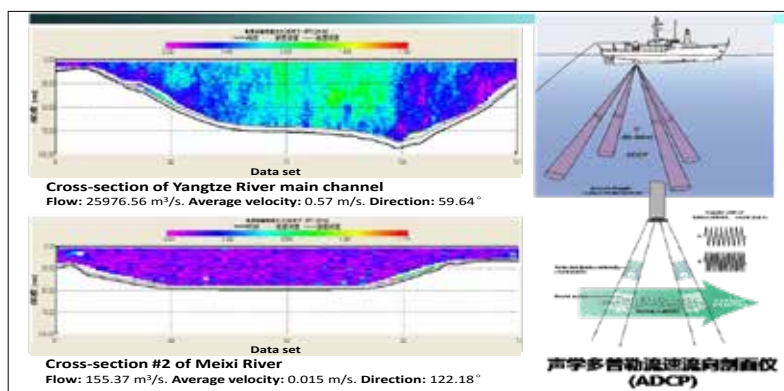
- Drawing the water quality change pattern of the Three Gorges Reservoir and causal analysis;
- Performing “hydrodynamic force-water quality factors-phytoplankton” combined eco-dynamic analysis and simulation study;
- Conducting sedimentary chemical research of the Three Gorges Reservoir to assess the latent ecological risks of heavy metal pollution;
- Conducting carbon cycling research to acquire data about greenhouse gas release flux of key waters and support the assessment on the green energy characteristics;
- Establishing an indicator system and methods for ecological safety assessment.

Achievements

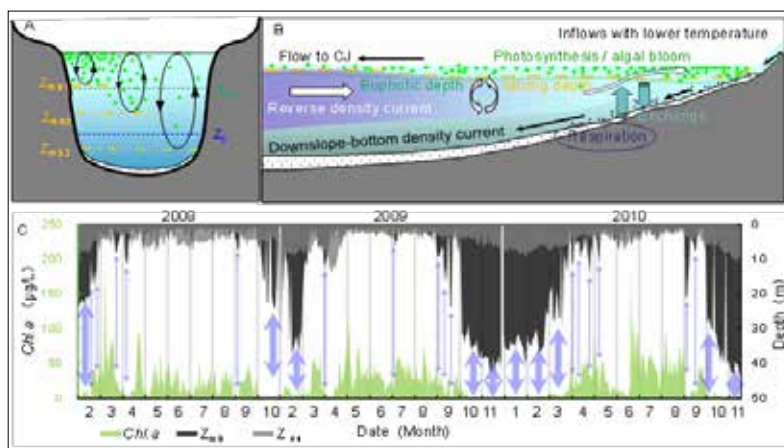
- After the Three Gorges reservoir is impounded, the trunk stream works effectively in self-purification and its water quality maintains good, but water quality of tributaries gets degraded, as indicated by analysis of long-sequence water environmental monitoring data;
- Causes for the ecological evolution and eutrophication of the Three Gorges Reservoir are suggested. The trunk stream retains, in general, the ecological characteristics of a “river” while tributary waters are “sensitive waters” prone to algae bloom. A major reason for the spatial-temporal disparities in eutrophication is the “dissimilated development” of trunk and tributary ecosystems;
- According to the assessment, the Three Gorges Reservoir is confronted with risks of heavy metal pollution, and the “dissimilated development” of trunk and tributary ecosystems leads to the ecological risks in different degrees;
- We have analyzed sources of pollution to the Three Gorges Reservoir. The incoming pollution load is mainly from the upper reaches, and pollutants from tributaries may impose great influence on local waters;
- An ecological safety assessment methodology of the Three Gorges Reservoir based on the P-S-R (pressure-state-response) frame model is established, and countermeasures and suggestions for the ecological security countermeasures are provided.

Application

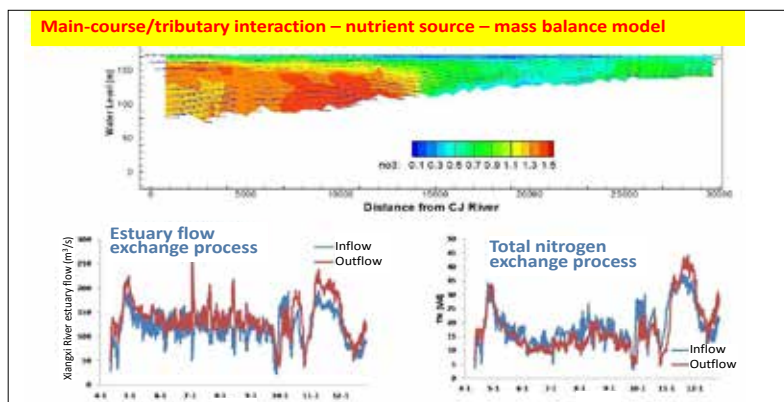
Monitoring data and research results have been adopted by the Bulletin on the Ecological and Environmental Monitoring Results of the Three Gorges Project. In the meantime, the research results have provided fundamental basis for environmental quality and environmental problem diagnosis of the reservoir area to the formulation of the Three Gorges Follow-up Work Plan and the Thirteenth Five-Year Plan for Eco-environmental Construction and Environmental Protection of Chongqing Municipality and direct technical support to the integrated management of water environment protection of the Three Gorges Reservoir. Positive benefits of this research project have been obtained.



In-situ Eco-environmental Monitoring (Flow Regime Measurement) of the Three Gorges Reservoir



Variation Features of Water Mass Mixing Layer of the Three Gorges Reservoir



Mass Balance Model

Monitoring technology and information system development of rural water supply safety management and monitoring

YANG Jifu, LI Bin, LI Xiaoqin, et al.

Background

Construction of rural drinking water safety projects has flourished across China since 2005; by 2010, 525,000 rural centralized water supply projects are built up. Another 225,000 centralized water supply projects can be expected and rural drinking water safety challenges will be solved basically, according to the Twelfth Five-Year Plan for National Rural Drinking Safety Projects. Nevertheless, such issues remain as built projects do not sustain for long, water supply quality registers a low rate of standard compliance and rural needs for safe water supply are not met, due to tremendous task of construction and outdated project management approach and skills. As a result, management and monitoring technologies and information systems for rural safe water supply are urgently needed to ensure that already built and new projects can work normally and yield the maximum benefit.

Contents

- Developing rural drinking water supply information management systems at provincial and county levels and enabling access to national rural drinking water information system;
- Developing software for the optimal design of water supply networks to minimize the sum of pipeline investment and operation cost; developing a new type of swing check valves and pressure reducing valves and the automatic flow and pressure monitoring and warning system for pipelines;
- Developing water quality risk assessment technology and system for rural centralized water supply so as to get hold of water quality risks in time and identify and detect particular pollutants rapidly;
- Establishing a systematic indicator system for rural safe water supply assessment and sustainable management pattern of water supply projects to promote and facilitate the scientific planning and professional management of rural water supply projects.

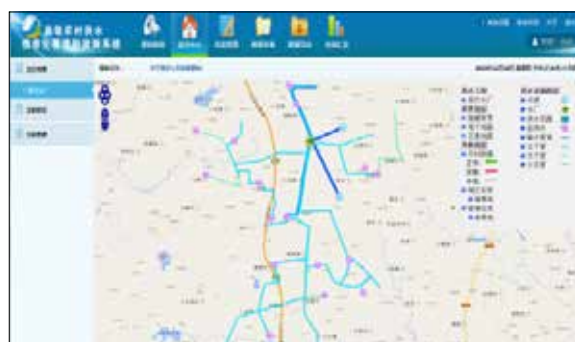
Achievements

- A regional information management and monitoring systems for rural water supply, including rural water supply information management system at provincial level, rural water supply information management and monitoring system at county level and rural water supply data and information processing software are developed;
- An optimal design software system for rural water supply pipelines centering on GIS technology, hydraulic computation module and optimal design module, and safe regulation technologies and devices for water supply networks are designed and developed;
- A water quality risk management system and a water quality risk management database specific to rural centralized water supply are developed; and rapid pollutant identification technology based on HPLC (high performance liquid chromatography) and other technologies for assessing health risks of water supply quality are developed; and
- An assessment indicator system for rural safe water supply in a moderately prosperous society, including 6 I-class indicators and 12 II-class indicators is designed, and 5 sustainable management patterns for rural water supply projects according to the national conditions of China are presented.

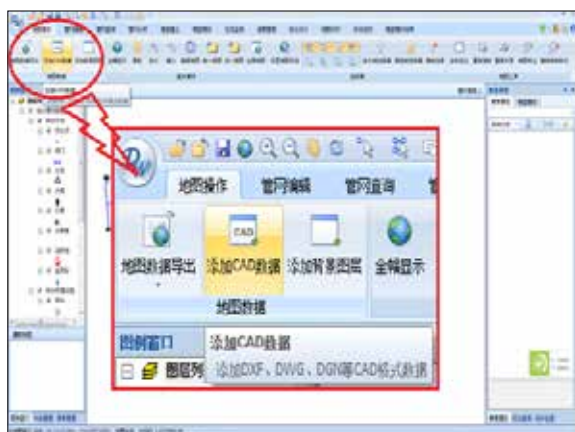
Application

Achievements of the research have been applied to the construction and management of rural water supply projects.

- The information management systems at provincial and county levels are applied to Shandong, Anhui, Qinghai and etc.;
- The optimal design of pipelines and safe regulation technologies are applied to 8 projects in 7 counties of Chongqing and Shandong;
- The water quality risk assessment and management system specific to water supply is applied to 1,324 projects in 5 counties of Beijing, Guangxi and etc.;
- The assessment indicator system for rural safe water supply and the sustainable management pattern of water supply projects are recognized by the Department of Irrigation, Drainage and Rural Water Supply, Ministry of Water Resources and applied to the 13th five-year plan for rural drinking water safety consolidation and improvement projects across China and in such provinces as Liaoning and Hebei, as well as industrial management;
- The technical regulations for operational management and technical guidelines for maintenance of water supply projects are applied to 7 projects in 4 counties of Liaoning, Chongqing and other regions. These achievements have benefited more than 2 million people directly with an economic output of 468 million RMB and more than 100 million people indirectly with a more remarkable socioeconomic yield.



Rural Water Supply Information Management & Monitoring System at County Level



Optimal Design Software for Water Supply Pipelines



Water Quality Risk Management Information System for Water Supply

Study on optimization of adjustment and control of low-radioactive liquid emission from inland nuclear power plants based on environmental bearing capacity

Ji Ping, CHEN Xiaoli, ZHANG Haiwen, et al.

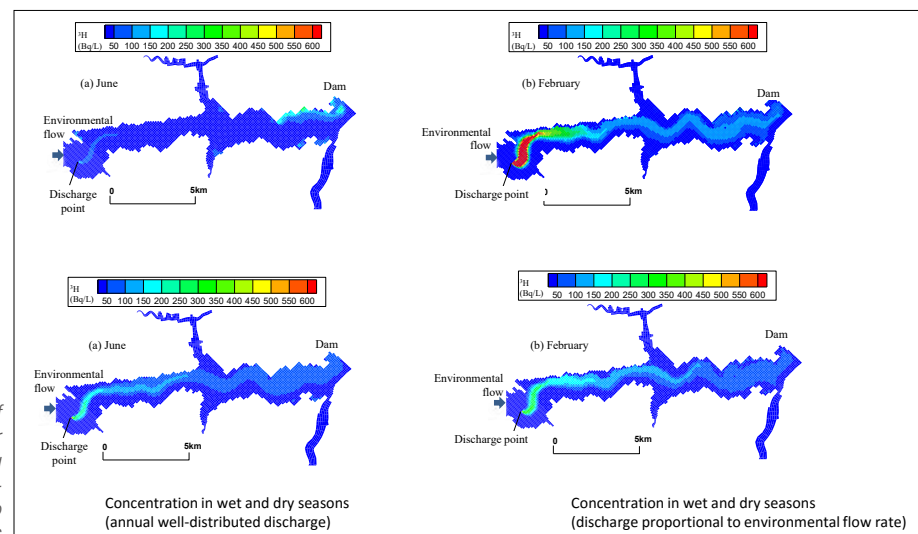
Background

To protect the environment and realize sustainable development, nuclear power will be a priority of energy development and inland development of nuclear power will be an inevitable trend. Inland nuclear power plants have to recharge water from and discharge emissions to nearby water sources which has a quite limited environmental bearing capacity. Besides, problems of drinking water and irrigation water are involved, so the compatibility between low-radioactive liquid emissions and the environment is a critical factor restricting nuclear power construction. Inland nuclear power plants are confronted with numerous new problems in the discharge of low-radioactive liquid, with regard to the hydrologic conditions assessment during site selection, discharge mode of low-radioactive liquid and water impact assessment. Thus, we're pressed for conducting systematic and in-depth scientific studies on the low-radioactive liquid discharge mode and its impact on water environment so as to realize the safe, harmonious and healthy development of inland nuclear power plants and water environment.

Contents

- Investigating low-radioactive liquid discharge standards and key indicators at home and abroad and researching present hydrologic conditions of existing inland nuclear power plants, and performing studies on controlling hydrologic conditions;
- Researching in a systematic manner the relations between the distribution pattern and its change rule of low-radioactive liquid and characteristic hydrological parameters, and studying the methods for rapid evaluation of diluting ability of waters during site selection of inland nuclear power plants;
- Researching the optimization of low-radioactive emission processes of inland nuclear power plants according to the uneven incoming flows of receiving waters; and
- Researching the optimization of outlets positioning and outfall patterns to solve the initial dilution problem related to the small flow of low-radioactive liquid.

Optimized operation of inland nuclear power plants by equaling annual emission of low-radioactive liquid to river flows

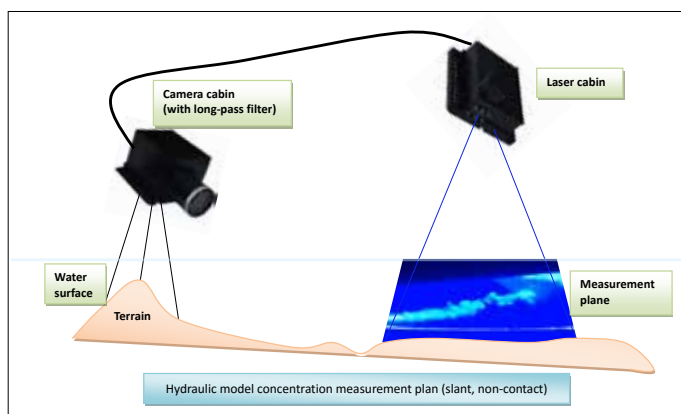


Achievements

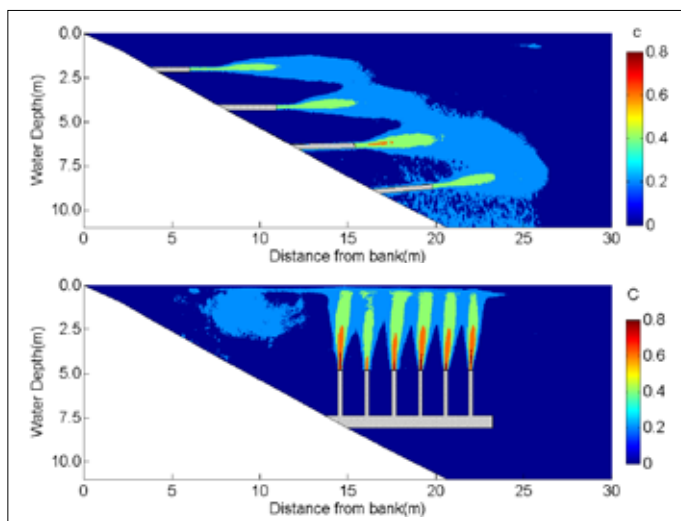
- An innovative idea has been put forward taking hydrologic processes as a controlling condition for assessing the impact of low-radioactive liquid emission, representing a new method for objectively assessing the compatibility between inland nuclear power plant construction and water environment;
- A selective discharge mode has been proposed utilizing the most of the dynamic dilution capacity of waters, establishing the outfall pattern and positioning scheme of diffusers in favor of rapid mixing and dilution in near field and thereby, providing a key technology for the temporal and spatial regulation of waste liquid concentration in receiving waters;
- A method has been put forward for the rapid assessment of the low-radioactive liquid dilution capacity of receiving waters and thereby providing a key technical support for the scientific layout and site selection assessment of inland nuclear power plants; and
- Concentration measurement technology have been developed based on the high-frame-rate and wide-range PLIF model test, presenting a fine mathematic model analogy procedure coupling the near field and far field, which have been proved a success in engineering application.

Application

The achievement has been applied to site selection and early verification of China's inland nuclear power plants. It marks a great exploration in the dynamic control of low-radioactive liquid which is promised broad prospects of application.



*PLIF Concentration
Measurement System*



*PLIF-based
Diffuser Emission
Concentration Test*

Key technology of hydropower simulation training based on virtual reality and its systematic integration

WANG Dekuan, ZHANG Weijun, WANG Guiping, et al.

Background

Along with the rapid development of hydropower arises the shortage of hydropower maintenance and management staff. In the meantime, as growing attention is paid to the work place safety and scientific management of hydropower plants, which requires trainings and evaluation of the professional and administrative staff. The conventional training, combining written document and isotropic physical prototypes, shows a poor effect due to limited quantity of prototypes, types of equipment, training field and environment. With in-depth studies of hydropower equipment simulation models, intelligent examination and scoring, graphical modeling and three-dimensional virtual reality, we have designed and developed a three-dimensional virtual reality simulation training system based on the physical characteristics of equipment. Capable of reproducing the field environment vividly, and simulating all operations and phenomena of running hydropower plants such as in-situ operation, monitoring system operation and fault handling, the system can enhance trainees' perceptual intuition, improve the efficiency and effect of training and evaluation, cultivate a large number of maintenance and management staff for the hydropower industry and guarantee the safe and economical operation of hydropower plants.

Contents

- Designing the frame of the simulation platform system;
- Designing and developing the simulation modeling language SimuLog;
- Designing and developing software for trainees' stations and instructors' stations;
- Researching and developing the intelligent examination and scoring system;
- Developing the virtual reality platform for hydropower simulation and building the three-dimensional model of hydropower equipment;
- Researching and developing the graphical simulation modeling platform and researching the mathematical model of hydropower equipment; and
- Integrating complete simulation system projects.



Simu3D Image

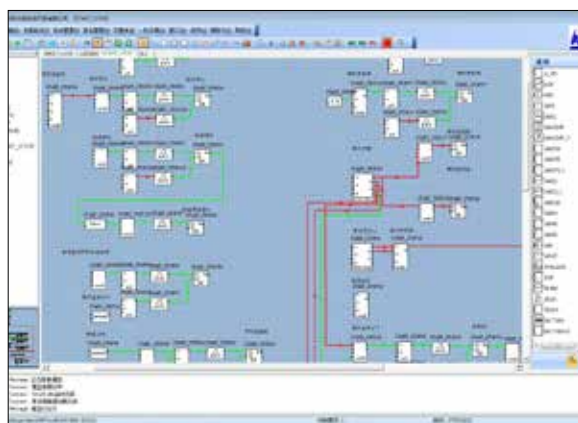
Achievements

- A training simulation system has been established consisting of four modules respectively for simulation monitoring, training examination, management and evaluation, visualization modeling and virtual reality;
- The design of this system has been integrated with that of the monitoring system, enabling the sharing of simulation and monitoring data;
- SimuLog, a descriptive language for simulation model, has been developed on our own ;
- Models have been built according to the physical characteristics of equipment, forming the library of hydropower electromechanical equipment models;
- An intelligent examination and scoring system has been developed in addition to a complete training and evaluation system covering “teaching, learning, training, examination and evaluation”;
- A graphical modeling platform has been developed using the object-oriented graph-visualization modeling technology;
- Simultaneous operation of multiple simulation models on the same hardware platform has been realized to support the parallel simulation of several hydropower plants on one platform; and
- A three-dimensional simulation engine has been developed independently to establish the three-dimensional interactive virtual reality of hydropower plants.

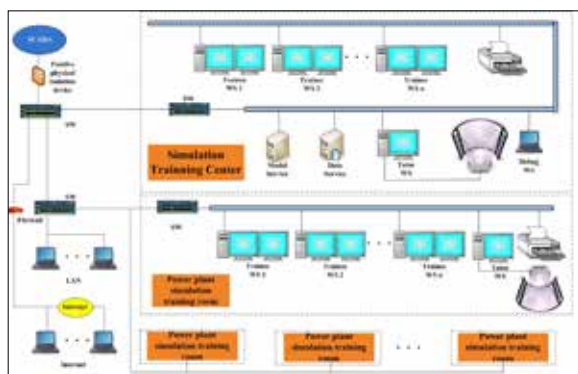
Application

The hydropower simulation training system has already been applied to Baishan Hydropower Plant, Three Gorges, Pubugou and Xiluodu, and some other projects during the process of development.

A virtual-reality-based three-dimensional simulation platform has been developed and put into operation based on the simulation project of Changsha Electric Power Technical College (State Grid Electric Power Training Center Hunan), and has been further applied to Ankang Hydropower Plant and Huadian Stung RusseiChrum Hydro-electric Project in Cambodia.



*SimuStudio Graphical
Modeling Platform*



*Hardware Structure of
Large-scale Simulation
Training System*

Best Papers



in Journal of IWHR

Geotechnical problems under low confining stress conditions

YANG Yusheng, LIU Qiwang, WEN Yanfeng, et al.

Abstract: Geotechnical problems under low confining pressure conditions were summarized, including the future development of lunar resources, deformation and stability of geotechnical structures in shallow soil, liquefaction of foundation soils, interpretation and application of laboratory and in-situ tests. In previous study, attention was paid only to the properties of soil-rock materials under high confining stress, and in applications the parameters of soil-rock materials under low confining stress were assigned in the same way as under medium to high confining stress; while the reliability of this parameter selection method was disputable, because the properties of soil-rock materials are seriously dependent on the stress. Therefore, recommendations for studying on the static and dynamic engineering properties of soil-rock materials and establishing constitutive models applicable to soils-rock materials under low confining stress were made to provide scientific basis for design criteria selection of the soil-rock materials and corresponding parameters selection method in numerical simulation.

Key words: low confining stress; geotechnical engineering problems; engineering properties of soil-rock materials

Study on landslide early warning of Mayanpo slope at Xiangjiaba hydropower station

JIANG Long, WANG Xiaogang, GE Huaiguang, et al.

Abstract: Most of hydropower stations are built in the mountain valley region with complex geological conditions, and so it is inevitable to involve some engineering geological problems of high slope stability in building a variety of high dams. This paper has systematically studied stability and early warning of high engineering slope in depth, and established the early-warning model and the health diagnosis system. The results show that: 1) displacement deformation increases with time and decreases with increasing depth. The change rules of performance are deformation rapidly increases in the early, and slowly increases in the medium, and becomes gradually stable in the later. 2) through stability analysis of Mayanpo slope by strength reduction FEM, the stability coefficient before treatment and after are 1.05 and 1.72. 3) using boundary displacement method, the early warning of slope landslide are analyzed with equivalent plastic strain region through as a criterion. The early-warning monitoring system of slope are established, which based on double controlling indicators of displacement deformation amount and safety factor.

Key words: Xiangjiaba Hydropower Station; Mayanpo slope; slope stability; landslide early warning; three-dimensional numerical model



A strength reduction dynamic FEM including the seismic input mechanism

WANG Can, ZHANG Boyan, LI Deyu

Abstract: In order to study the safety of slope stability during earthquakes and seismic wave propagation in slope media, on the basis of strength reduction theory, this paper introduces a slope seismic dynamic explicit finite element method including unlimited foundation radiation damping effect and proposes some corresponding slope instability criteria. This paper also develops the related coding computer programs that seamlessly match the corresponding ANSYS/LS-DYNA software. Moreover, some classical calculating examples show the correctness of strength reduction theory and instability criterion and display the utility of the nonreflecting boundaries used in ANSYS/LS-DYNA. In addition, with some examples of actual slope engineering analyzing, the results that show the proposed method is feasible in slope stability analysis. This paper provides an available method for future studies of slope stability during earthquakes.

Key words: slope; strength reduction; ground motion input; instability criterion; foundation radiation damping

Discussion on the ecological protection pattern for plateau rivers – with "two rivers" ecological protection as examples

CHEN Xingru, CHEN Wenxue, Baiyinbaoligao, WANG Xiuying

Abstract: The process of urbanization intensifying in recent years makes urban river face up huge pressures. Comparing with plain rivers, plateau rivers have unique water dynamic, geological features and ecological features. The earthquake took place in Jiegu Town, Yushu State, Qinghai Province on Apr. 14, 2010. Based on the investigation and analysis on the current situation, the problems are found out. According to the reconstruction thought of native and Qinghai Province, ecological environment protection and water culture reconstruction pattern are put forward on the basis of flood control and drain flood, which can support safe and comfortable foundation for ecological society development and human living. Combining ecological hydraulics and engineering hydraulics, the fishes are taken as protection goal to determine the plane modality and transection modes according to the characteristics of Zhaxike River and Batang River. The riverfronts are classified, and the three lines of waterfront are defined according to 'The General Plan for the Reconstruction after earthquake in Jiegu Town'. Some constructive suggestions on river management are proposed, which have great significance to sustainable development of Zhaxike River and Batang River, and also have important value for the management and protection for other basins.

Key words: plateau river; ecological protection; Yushu State; Jiegu Town

Seismic response analysis of sluice structure-soil system with deep soil deposit

DI Qingshuang, HU Xiao, XING Yichuan, ZENG Di

Abstract: Dynamic analysis method is needed for high seismic demand of sluice structures. Usually, sluice structures were commonly built on the soil layer with deep deposit. For the reason of complexity of such problems and engineering practices, the equivalent linear method was adopted in the dynamic response analysis of sluice structure-soil deposit system. On the statistic equivalent concept, the nonlinearity of soil material was addressed with linear solution method, so the problem was simplified. Concluding from a sluice structure analysis, that (1) comparing to the normal elastic solution, rational results can be obtained by equivalent linear method which considering nonlinearity of foundation soil, (2) the response of upper frame was bigger than the sluice pier, which need much more concern in the structure design, (3) when considering deep deposit soil layers, the effects of seismic inputs with long periods should be more concerned, (4) equivalent linear method take considering nonlinearity of soils by statistical equivalent method, with many engineering test data and experiences, it also convenient to expand to true nonlinear material model method.

Key words: sluice structure; soil-structure interaction; deep soil deposit; dynamic soil model; equivalent linear method

Water resources collaborative allocation model and ultra long-term scheme in megalopolis

LI Liqin, WEI Chuanjiang, XIE Xinmin, WU Xueyi

Abstract: In terms of the new situation and problems caused by the rapid development of megalopolis, exploring the water resources collaborative allocation model and ultra-long-term water allocation scheme are the solutions for the sustainable use of water resources for megalopolis. We choose Chang-Ji megalopolis as the case study. A multi-dimensional and multi-objective model was established to optimize water resources allocation for the megalopolis. This paper compared the results of long-term monthly water resources regulations under different schemes and proposed an ultra-long-term water resources allocation layout and water construction distribution of Chang-Ji megalopolis in 2050. The model with multi-dimensional and multi-objective functions provides a feasible approach to optimizing the overall layout of water resources allocation and offers fundamental support to guarantee a reliable water supply during the rapid urbanization.

Key words: megalopolis; water resources collaborative allocation; Chang-Ji megalopolis



in Journal of Hydraulic Engineering

Study on conceptualization method of deformation pattern and horizontal breakage of face slab of concrete faced rockfill dam

DENG Gang, WANG Xiaogang, WEN Yanfeng, et al.

Abstract: The deformation behavior of face slab of concrete faced rockfill dam (CFRD) in the cross section and its conceptualization method was studied. The relationship between deformation behavior of face slab and stress along slope direction in face slab, and the generation mechanism of stress along slope direction in face slab was explored. The effect of the external factor including time and reservoir water level on slab stress along slope direction was also discovered. It is found that the drag effect of dam deformation on face slab along slope direction is the main reason of the stress along slope direction in face slab. The case of Sanbanxi CFRD was employed to investigate the mechanism of horizontal breakage of face slab of CFRD. The results show that the rather big creep deformation of dam embankment and the displacement of face slab along slope direction due to dam deformation is the main source which lead to rather high stress along slope direction in face slab. The regional bending deflection of face slab due to reservoir water pressure, the effect of embankment settlement on stress of the first stage face slab, high horizontal stress of face slab due to special terrain, and the existing bending deflection of face slab due to slope deficiency increases stress along slope direction in face slab and eventually result in the face slab breakage in construction joint of the first and the second stage face slab, which has local structural defect.

Key words: Concrete faced rockfill dam (CFRD); deformation pattern of face slab; conceptualization method; extrusion failure; creep deformation; bending deflection



Study on temperature recovery after arch sealing of super high arch dams and its influence

ZHANG Guoxin, ZHOU Qiuqing

Abstract: The phenomena of temperature recovery exist widely in super high arch dams. In order to clearly understand the cause, range, process and influence, temperature changes after arch sealing of some typical arch dams are summarized. The temperature recovery models are built through data fitting and simulation methods, taking the age of concrete with the stop time of cooling water as its starting point. As an example, Xiaowan arch dam is analyzed with the built model. The results show that : (1) the main cause of temperature recovery is concrete hydration heat; (2) The temperature rise obviously in the later period of Xiaowan arch dam, generally 6-12 °C, up to the maximum value with about 4-7 years and back to the quasi-stable temperature with about 40 year; (3) The temperature load considering temperature recovery is different from the design load, with a higher average temperature and a smaller difference between upstream and downstream temperatures; (4) The whole dam has upstream deformation increment in consideration of the temperature recovery and all the stress is affected. There is tension stress increment in the dam toe and compression increment in the dam heel. Surface cracks may appear in the future because that the temperature difference is bigger than the design.

Key words: super high arch dam; temperature recovery; adiabatic temperature rise; temperature load; working performance

Hydrologic control criteria framework in the United States and its referential significance to China

WANG Hong, DING Liuqian, CHENG Xiaotao, LI Na

Abstract: Hydrologic control criteria framework is important for building sponge cities. This research investigated evolution of urban storm water management practices in the US, and the present trends in developing hydrologic control criteria framework for urban stormwater management. Consequently, a general concept of hydrologic control criteria framework is proposed; including volume-based control which emphasizes on maintaining infiltration, controlling water quality and avoiding river channel erosion; and peak discharge-based control which targets on flood reduction. Furthermore, the present status of hydrologic control criteria development in China was surveyed. Based on the results, this study recommends that in order to formulate appropriate hydrologic control criteria framework, more research should be conducted, database should be built at local level and data sharing should be achieved. Moreover, inter-agency coordination should be enforced. This study provides reference value to China's ongoing Sponge City construction.

Key words: Sponge City construction; Green stormwater Infrastructure; Urban stormwater Management; Urban Hydrology; Hydrological control criteria; Low impact development

Annual Report



CHINA INSTITUTE OF WATER RESOURCES AND
HYDROPOWER RESEARCH





Management Achievement

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Highlights of 2016

1

IWHR won two 2nd prizes of 2016 National Science and Technology Progress Award with its researches in structural safety of high concrete dams and hydraulic control of long-distance water transfer project.

2

Dr. Li Jiusheng (Department of Irrigation and Drainage) won ICID WatSave Award 2016 for his research on Innovation and Extension of Sprinkler and Micro Irrigation Technologies in China.

3

IWHR's Key Research Base for Water Heritage Protection and Research was approved, the first ever in water resources sector that is certified by China's State Administration of Cultural Heritage.

4

IWHR passed the review for National Civilized Organization and National Civilized Organization of Water Resources conducted by China's Ministry of Water Resources.

5

IWHR launched its pre-2020 "Five Human Resources Initiative" that offers supports to different tiers of its staff from the new-comers to innovative research teams and high-caliber overseas talents.

6

Dr. Wang Jianhua (Department of Water Resources) won the National Science Fund for Distinguished Young Scholars. He also became a state-sponsored expert (The 10,000-person Program) together with his colleague from the same department Dr. Yan Denghua, two of four such experts in water resources sector.

7

Prof. Ding Kunlun, ICID Vice President, was elected Chair of ICID Permanent Committee for Technical Activities (PCTA) and became a member of ICID Management Board. Prof. Liu Guangquan, IRTCES Deputy Director, was elected Secretary General of WASER.

8

IWHR is the lead organizer of 7 national key water-related research projects for 2016 (CNY 180 million), ranking sixth among all research institutes in China and top of the water resources sector.

9

IWHR jointly launched the Journal of Ecohydraulics with IAHR.

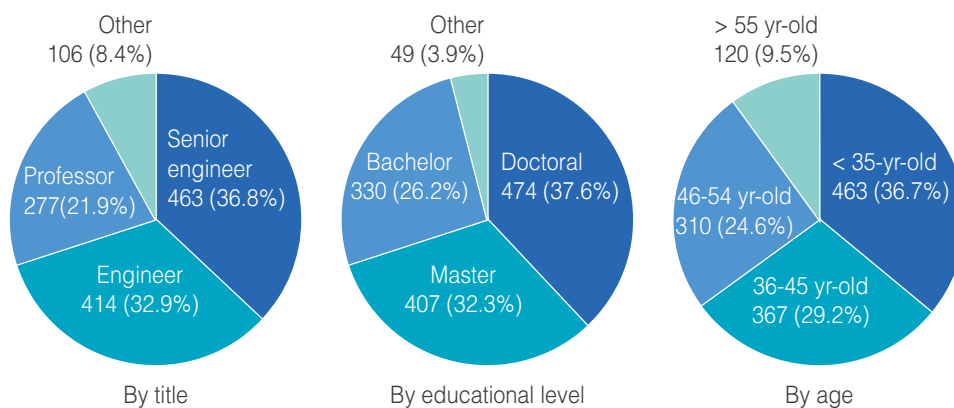
10

The SCI Impact Factor of International Journal of Sediment Research has been rising for 3 consecutive years to 1.388, and is one of the "academic journal with the greatest international influence in China."

Statistics

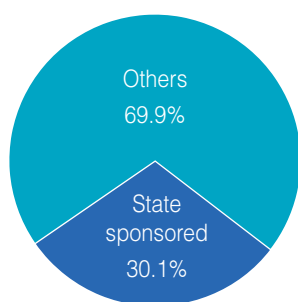
Human Resources

By the end of 2016, IWHR has 1260 technical professionals.

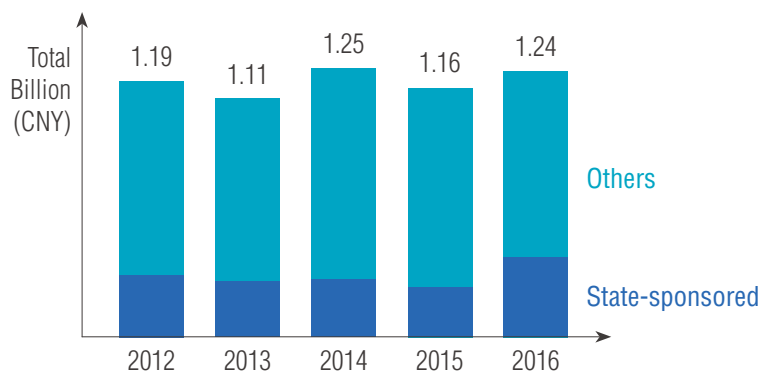


Research Contracts

Research contracts signed in 2016: CNY 1.24 billion in value.



- National: 75.5%
- Ministry of Water Resources: 22.6%
- Other ministries: 1.1%
- Local governments: 0.8%



Awards

In 2016, two completed research programs are granted state-level prize and 31 on provincial or ministerial level.

Type	Amount	Grade
State level	2	Second prize (2)
Provincial or ministerial level	31	Special prize (1)
		First prize (13)
		Second prize (13)
		Third prize (4)

Some of the prized research programs:

- Research and practice on key technology for structural safety for high concrete dams
- Theory and key technology of hydraulic control for long-distance water conveyance projects
- Research and practice on key technology for large-scale pumped storage power station construction in China
- Key technology for meteorological and hydrological forecasting in changing environment
- Research on the water and sediment evolution mechanism and regulation in the multi-scale watershed of the Yellow River
- Research and application of watertight structure of sealing coated flexible cover plate for concrete panels
- Characteristics and key technology application of low-heat portland cement concrete in hydroelectric engineering
- Simulation of radionuclides and temperature drainage processes in coastal nuclear power projects and optimization of hydraulic discharge outlets
- Research on limited irrigation technology in Yanghuang Extension Area of Arid Zone in central Ningxia
- Crack mechanism and control technology of hydraulic mass concrete
- Multi-objective stereo regulation system and practice of water resources in Huaibei Plain
- Research and application of key technology for energy saving and stable operation of large irrigation and drainage pumping stations
- Key technology and adaptation countermeasures for water cycle simulation and prediction in Huang-Huai-Hai River Basin under climate change
- Research and application of key technology for hydroelectric ecological environment protection in Yalong River Basin
- Research and application of key technology for high-quality and rapid construction of ultra-300m high arch dam concrete
- Key technology for pressure fluctuation control and energy saving of high flow double-suction centrifugal pumps and its application
- Research on "water-ecology-economy" security guarantee in west Liaohe River Plain
- Research and application of high precision and large flow metering standard device and key technology
- National flood risk mapping and integration management technology and application
- Construction and application of basic information base of water resources and geographic space
- Hydrological effects of forest vegetation and forest-water coordination management technology in arid and water-deficient areas in northwest China
- Research and application of key technology for three redlines of water resources in Guangxi
- Evaluation method and key technology for anti-seismic safety for high concrete dams
- Fine deployment of soil and water conservation forests and micro-terrain near natural afforestation technology and demonstration in semi-arid loess areas
-

Intellectual Properties

IWHR obtains 188 patents in 2016 (including 77 inventions and 111 utility models), participates in the editing of 24 technical codes, and also publishes 46 books and 577 papers.

	Patents		Technical codes		Books	Papers
	Inventions	Utility models	Chief-edited	Co-edited		
Amount	77	111	15	9	46	577

Journals



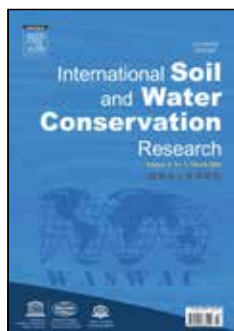
Journal of Hydraulic Engineering



Journal of China Institute of Water Resources and Hydropower Research



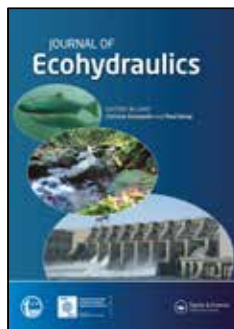
International Journal of Sediment Research



International Soil and Water Conservation Research



China Flood and Drought Management



Journal of Ecohydraulics

International Cooperation

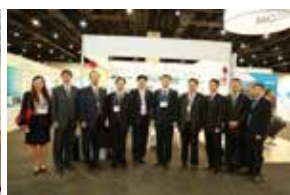
International Exchange



University of Washington delegation visits IWHR to promote communication among students



13th IWHR-KICT Joint Seminar held in Korea featuring innovations in seminar organizing



Attending the 84th ICOLD Annual Meeting held in Johannesburg, South Africa



Attending the 2nd World Irrigation Forum and the 67th ICID International Executive Council Meeting in Chiang Mai, Thailand



IWHR and IAHR jointly launch the Journal of Ecohydraulics that embodies the varied research undertaken in ecohydraulics



IWHR young scholars in a visit to Cornell University



Experts visiting Shatou Gate on Nanxi River to share advanced experience in river protection and restoration



Representing GWP China to sign an MOU with other GWP chapters in Asia to establish a mechanism of cooperation



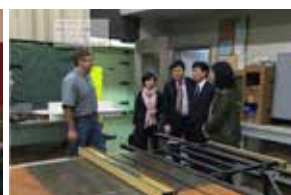
China-Germany collaborated research on automatic monitoring of green-house gas



Dr. Li Jiusheng winning ICID WatSave Award 2016 for his innovative research in sprinkler and micro irrigation



Attending 2016 IAHR Council Meeting held right before the 20th IAHR-APD Congress in Colombo, Sri Lanka



Visiting IIHR and University of Iowa on the global initiative based on Generalised Flood Decision Support System (FLOODSS)



Discussion with Royal Irrigation Department of Thailand on cooperation of hydraulic elevator dam



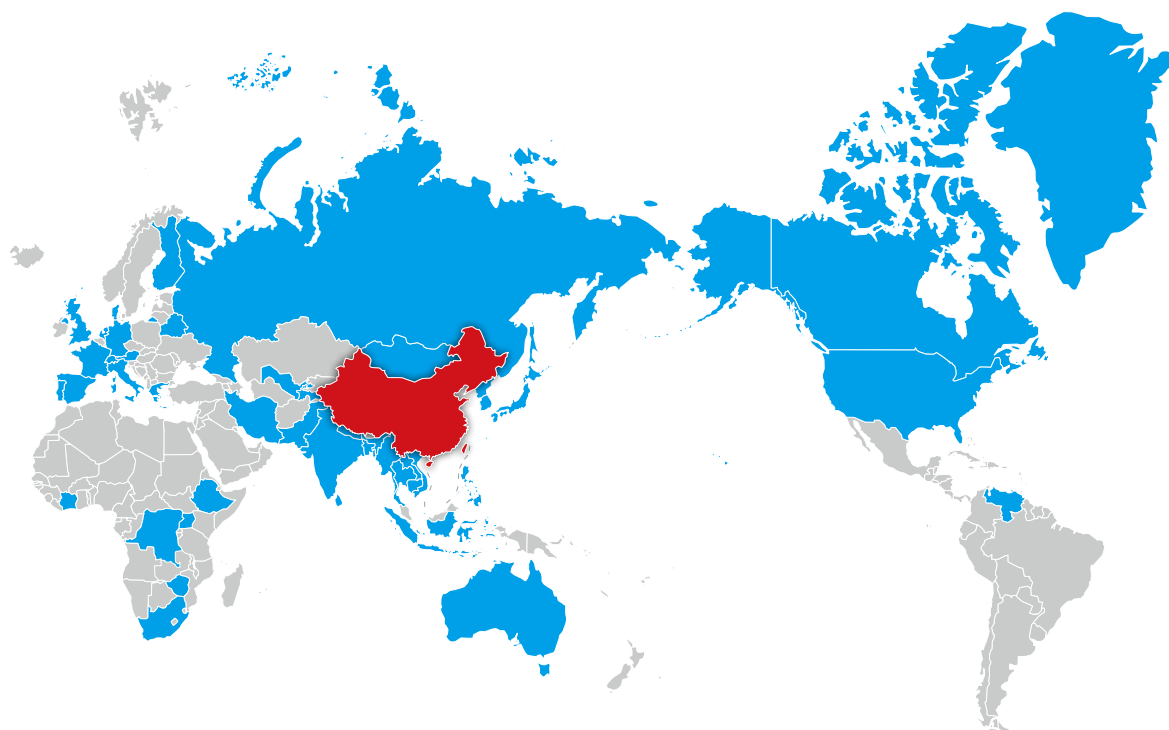
Visiting Vienna-based University of Natural Resources and Life Sciences on slope stability



Partnership with Cooperative Agreements



2016 IWHR Global Footprints



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Appendix

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Organizational Structure

President and Vice Presidents

Commissions

- Academic Commission
- Board of Academic Degree Assessment
- Board of Professional Title 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

Research Departments

- Department of Water Resources
- Research Center on Flood and Drought Disaster Reduction (*including the Remote Sensing Technology Application Research Center and the Department of Water Resources History*)
- Department of Water Environment
- Department of Irrigation and Drainage
- Earthquake Engineering Research Center
- Department of Geotechnical Engineering
- Department of Structures and Materials
- Department of Sediment Research
- Department of Hydraulics
- Research Center for Sustainable Hydropower Development
- Department of Water Resources for Pastoral Areas

Division of Comprehensive Business

- Section of Postgraduate Education
- Standardization Research Center
- Information Center

Enterprises

- Beijing IWHR Corporation
- Beijing IWHR Technology Co., Ltd.
- Beijing IWHR-KHL Co., Ltd.
- Tianjin Institute of Hydroelectric and Power Research
- Beijing Zhongshui Runke Certification 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)
- 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 (incl. the Remote Sensing Technology Application Research Center and the Department of Water Resources History)

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, application of remote sensing and other high-technologies, water resources history and water culture.

Department of Water Environment

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 analysis method of earthquake engineering; the arch dam and gravity dam seismic research; dynamic test of structures and equipment; monitoring and forecasting of reservoir earthquake; anti-earthquake analysis and safety assessment of electrical and nuclear power equipment.

Department of Geotechnical Engineering

Property study of geotechnical materials; behavior simulation, 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 projects; 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 projects; 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 control 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 resettlement policies of hydropower projects.

Department of Water Resources for Pastoral Areas

Water resources and water environment for pastoral areas; water-efficiency irrigation 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.



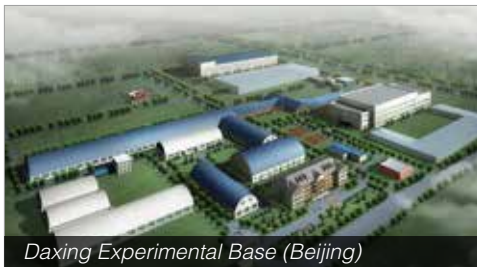
Scientific Research Bases



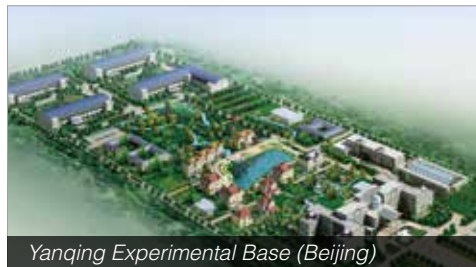
Technology Innovation Base (South, Beijing)



Technology Innovation Base (North, Beijing)



Daxing Experimental Base (Beijing)



Yanqing Experimental Base (Beijing)



Base of Water Resources for Pastoral Areas (Inner Mongolia)

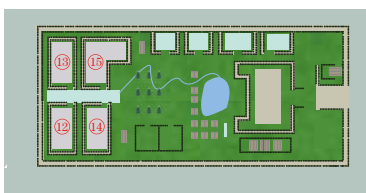


Tianjin Institute of Hydroelectric and Power Research (Tianjin)

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



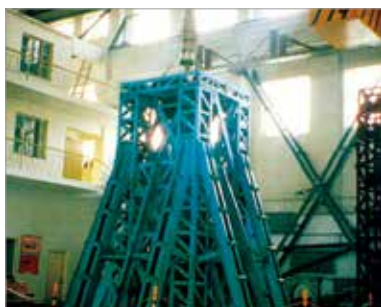
Vacuum tank (vacuum percentage 98.7%; flow discharge 1.0 m³/s)



Universal test stand of advanced hydraulic machinery model



LXJ-4-450g-t 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





Scope of business

- Consulting, design and equipment development of safety monitoring and automation system
- Foundation anti-seepage, reinforcement and treatment
- Inspection, diagnosis and assessment of project health
- Hydraulic Elevator Dam and Rubber Dam: R & D, manufacturing, installation, engineering contract, technical consulting; Water Sector: irrigation, drinkable water safety, water supply and drainage, and pump station; at the same time, we self-operate and agent the import and export of varied goods and technology, etc.
- General contracting (EPC) of overseas hydropower projects
- Complete set of electromechanical equipment and technical services in hydropower station
- Vibration testing, dynamic response simulation and safety assessment of hydraulic turbine and powerhouse

Representative products/projects



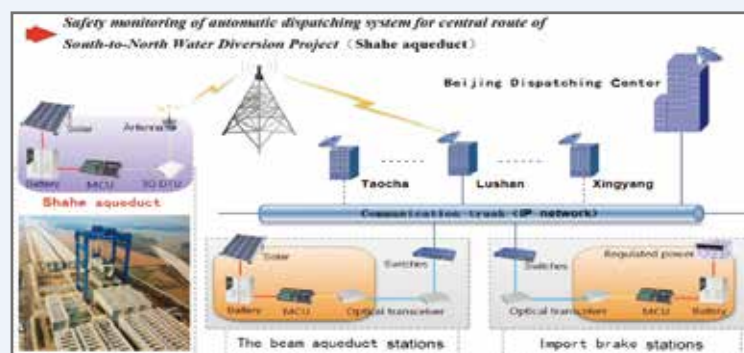
Leakage plugging project for Daping Hydropower Station in Yunnan Province



Hydraulic Elevator Dam in Dunhua, Jilin Province



Rubber Dam in Myanmar



Safety monitoring of automatic dispatching system for central route of South-to-North Water Diversion Project



Scope of business

- Study, design, development & turnkey of SCADA&system of simulation for hydropower stations, windfarms, solar power stations, projects of water diversion & irrigation, etc.
- Electro-machinery engineering technology for hydropower stations
- Experimental study of prototype, condition monitoring of hydropower generating units
- Study & integration of automation system of water regime forecasting and dispatching for hydropower stations & river basin
- Study, development & turnkey of management system of information for water utilities
- Design & manufacture of hydro turbine governors & auxiliaries

Representative products/projects

- EPC of electro-machinery equipment for hydropower projects, Bac Binh, Bayramhacili, etc.
- H9000 system of supervision & control for hydropower stations, Three Gorges, Xiluodu, etc.
- OTS2000 3D simulator for operator training for hydropower stations, Xiluodu, etc.
- HR9000 automation system for water regime forecasting & water dispatching, Ertan, etc.
- DVG2000 governors for hydropower stations, Tishrin, Fengtan, Zexi, etc.
- Experimental research of hydro-turbine models, Three Gorges, Xiluodu, Xiangjiaba, etc.
- Diagnostics of hydropower generating units, Three Gorges, etc.



H9000 system of supervision & control, condition monitoring system, experimental study of hydro-turbine model for Three Gorges Project



EPC of generating units for Bac Binh Hydropower Station



Radar water level gauge for Ertan hydropower station



Spillway of Bayramhacili Hydropower Station



Scope of business

- Research, development, manufacturing and integral construction of waterstop materials
- Research, development and manufacturing of hydraulic concrete and macromolecular materials
- Inspection, safety assessment and technical consulting of hydraulic structures
- Repair and reinforcement of hydraulic structures
- Research, development, manufacturing and construction of hydraulic bituminous concrete materials

Representative products/projects

GB waterstop materials have been applied in more than 100 hydropower stations in and outside China, including Shuibuya Hydropower Station. Our company has conducted optimization of concrete mixing and performance test for over 100 hydropower stations, including the Three Gorges Project. We have also completed the inspection, safety assessment, repair and reinforcement of a large number of hydraulic structures, as well as the construction of bituminous concrete face for the upper reservoirs of many pumped-storage power plants.



Construction of bituminous concrete face for the upper reservoir of Hohhot Pumped-Storage Power Plant in Inner Mongolia



Surface waterstop construction for the concrete face of Liyuan Hydropower Station in Yunnan Province



Inspection and safety assessment for the central route of South-to-North Water Diversion Project



Optimization of concrete mix and performance test for Xiluodu Hydropower Station

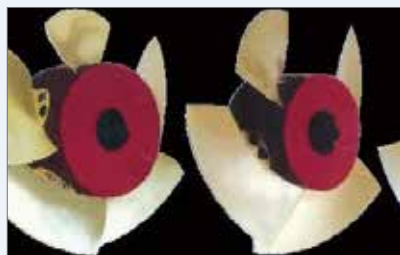
Scope of business

- Efficient hydraulic-model of hydraulic machinery (pump) technology
- Automatic component (device) manufacturing technology
- Integrated control system technology
- Smart grid device
- Power transmission and distribution equipment
- Debugging and installation guidance and transportation of the products we offered



Sponsor the journal of Electro-Mechanical Technology for Hydropower Station

Representative products/projects



Efficient hydraulic-model of pump



Axial pump



Energy-saving rollover flap valve



Mobile hydraulic driven pump unit



Water circulation pump for high Temperature and Pressure



Salt chemical circulation pump



Double micro-computer (PLC) static excitation system for synchronous generator



Filter reactor



Harmonic control system



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