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为纪念中国水利水电科学研究院组建 60 周年，《水利学报》特约请中国水科院专家撰写综述性论文，集中总结各学科 60 年的发展脉络和最新业绩，突出具有标志性的创新成果。谨以此向中国水科院 60 华诞献礼，与广大专家学者交流分享。

60 年来，中国水科院围绕不同时期的国家需求，把研究水利科学的基本理论及水利水电建设的重大技术问题作为主要任务，一代代水科人牢记使命、攻坚克难，先后承担完成了一大批国家重大科技计划项目，承担了国内几乎所有重大水利水电工程关键技术问题的研究任务，解决了一系列重大水利水电科技问题和工程技术难题，为中国水利水电事业发展做出了应有的贡献。我院也因此人才辈出，先后拥有 12 位院士和一批高层次人才，现有 6 位院士领衔、近 1400 位专家学者组成的科研队伍，成为科技部“创新人才培养示范基地”。

60 年来，中国水科院坚持“突出重点学科、巩固优势学科、发展新兴学科、加强交叉学科”的学科发展思路，研究领域不断扩大、学科体系日益健全，从组建之初的 8 个专业，发展到今天的 18 个学科、93 个专业方向，覆盖水文水资源、水环境与水生态、防洪抗旱减灾、泥沙与水土保持、农村水利、牧区水利、水力学、岩土、抗震、结构材料、机电、自动化、遥感、信息化、水利史、新能源等领域，著写了一大批有重大影响的经典论文，为推动水利水电科技进步贡献了水科人的智慧和成果。

当前，深入贯彻习近平总书记关于“节水优先、空间均衡、系统治理、两手发力”的水利工作方针，解决好新老水问题，水利水电科技创新被寄予了更高的期待、也迎来了十分严峻的科技挑战。随着水资源短缺、水生态损害、水环境污染交互影响加深，水旱灾害依然多发频发，全球气候变化影响加剧，需要从更广、更深的层面加强重大水利科技问题研究；随着一大批大型水利工程在西部地区开工建设，十分复杂的地形地质条件与越来越高的工程建设安全保障要求，亟需攻克一系列复杂工程技术难题。广大水利水电科技工作者使命光荣、责任重大，唯有共同努力、加快创新，才能担当重任。

加快水利水电科技创新、建设水利水电科技强国，必须拥有在世界上起到主导和引领作用的水利水电科技期刊。中国水科院主办或承办了 8 种科技期刊，包括《水利学报》《中国水利水电科学研究院学报》《中国防汛抗旱》《泥沙研究》《水电站机电技术》《International Journal of Sediment Research》《International Soil and Water Conservation Research》《Journal of Ecohydraulics》等。长期以来，这些期刊在发布最新科研成果、引领学科发展、树立良好学风等方面发挥了十分重要的作用。其中《水利学报》一直秉承“创新求实、崇德戒躁、与时俱进、传播精华”的办刊理念，被评为“中国最具国际影响力学术期刊”，荣获“百强报刊”称号。面向新时代，充分发挥《水利学报》的平台优势、品牌特色和纽带作用，弘扬科学求实的学术风尚，营造民主和谐的学术氛围，推动水利前沿理论与技术研究，宣传水利科技研究成果，促进水利科技学科融合与创新，为中国创建世界一流水利水电科技期刊、建设世界水利水电科技强国而不懈努力，为实现中华民族伟大复兴的中国梦贡献应有的力量。

中国水利水电科学研究院院长



2018 年 10 月

Several key questions in the researches of runoff and sediment changes and trend predictions in the Yellow River

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Abstract: The condition of runoff and sediment in Yellow River has greatly changed since mid-1980s. Under the new circumstances, a clear understanding in process, characteristics and the key issues of runoff and sediment changes, is of great importance to focus the key scientific problems and support the ecological civilization constructions in the Yellow River Basin. In this study, the changing process and trend of runoff and sediment in the Yellow River Basin during the period of 1950–2016 were analyzed. Meanwhile, the previous predictions and causes of runoff and sediment were reviewed and analyzed. The results show that the runoff and sediment in the Yellow River declined sharply in recent years, with unsynchronized of magnitude. Both the time duration of runoff and the amount of runoff and sediment, which are good for sediment transport, were reduced. Changes of sediment concentration were synchronized with soil and water conservation engineering. In the previous researches, the soil conservation method, hydrologic method and the physical-based modelling method were adopted in the runoff and sediment predictions. Differences of predictions in different historical period were obvious. Insufficient recognition of mechanism, absence of evaluation technique, and uncertainty of prediction conditions, were the main causes. Under the new circumstances, in order to improve predictions in runoff and sediment in Yellow River, more scientific researches need to be strengthened, including the mechanism of runoff and sediment changes, group effect of the driving factor, the credibility evaluation of runoff and sediment predictions, and management strategy of the Yellow River.

Keywords: mechanism of runoff and sediment change in Yellow River; group effect; trend prediction; assembly assessment; management strategy

The frontier research achievements on stochastic theory of sediment transport

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Abstract: Sediment motion has been widely and deeply studied for decades by combing the mechanics and probability theory. The latest research achievements have been introduced in this paper, which include patterns of sediment motions, mechanical analysis and statistical laws of individual sediment particle movement, transition probability and exchange intensities between four different states in bed layer, more formulas for sediment transport than the existing two, sediment incipient motion characteristics and incipient velocity study, the theoretical boundary condition at bed surface, one dimensional non-equilibrium sediment transport and the corresponding mathematical model, non-equilibrium sediment transport when the bed load exchanges with both the bed load and the suspended load, riverbed coarsening by scouring or exchanging between sediment in different moving states, and point-source, line-source, and degraded area-source dispersion for bedload. In addition, new achievements in other fields of sediment transport derived by stochastic theory were also given, such as the size distribution of carrying-sediment capacity and effective bed material, exchange between coarse and fine sediment, multi-value of the carrying-sediment capacity, and bottom tearing scouring under high sediment-laden condition in the Yellow River.

Keywords: sediment transport; stochastic theory; exchange intensity; transition probability; distribution function of probability

Review and prospect of progress in water environment and water ecology research

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Abstract: Water environment and ecology is a comprehensive science that studies the interaction between watershed activities and the water environment and water ecology evolution of the basin, providing basic theory and methods for the construction of water ecological civilization, with closely relation to the disciplines such as hydrology, hydraulics, ecology, environmental science and technology, and resource science and technology. The problems including water shortage, water ecological damage, and water environmental pollution, which have become increasingly serious since the 1980s, have significantly driven the formation of water environment and ecological disciplines. A brief review of the development of water environment and ecology is presented, and the main research achievements of the Department of Water Environment(DEW) in China Institute of Water Resources and Hydropower Research(IWHR) since 2010 are introduced as following aspects. (1) Water environment monitoring technology and standards. On the basis of the previous research achievement such as monitoring technologies for natural water quality and heavy metals, trace and ultra-trace toxic and harmful organic pollutants, new progress has been made in the development of water environment monitoring and analysis techniques and standards, reference materials for water environment monitoring, health risk assessment methods for water source, water pollution emergency warning and forecasting system, and new technologies and equipment for water environment monitoring. (2) The evolution mechanism and model of water environment and water ecological process in basin. A series of innovations have been achieved, including the evolution mechanism and effects of heavy metal pollutants in large reservoirs, the characteristics and driving mechanisms of migration and transformation of source waters, the variation of ecological and hydrological processes, the ecological response mechanism of rivers and lakes, and the water environment and ecological model of watershed. (3) Watershed water quality management and water pollution prevention technology. Water function zone water quality assessment guidelines, and watershed total maximum load control technology system are formed. The watershed comprehensive planning technology of water pollution control and the lake reservoir sediment pollution assessment and ecological dredging scheme development technology are proposed, and the biological slow water treatment technology and equipment are put forward. (4) River and lake health assessment and water ecological protection and restoration technology. The river and lake health assessment standards, the river-lake water system ecological connectivity technology, ecological flow determination technology, water quality and water quantity joint dispatching technology and water ecological restoration technology were formed. Finally, the scientific and technological needs of water environment and ecology in the new era are analyzed, and the future prospects of water environment research is proposed.

Keywords: watershed; water environment; water ecology; water environmental monitoring; water environmental modeling; water functional zone; river and lake health

Reviews on temperature control and crack prevention of high concrete dam

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Abstract: Crack prevention is an important task for the construction of concrete dams. In this paper, the research progress of temperature control and crack prevention for high concrete dams is introduced from 5 aspects: simulation analysis, typical crack causes and crack prevention measures, intelligent temperature control and crack prevention of high arch dam and RCC dam. SapTis simulation software system, which can simulate 9 processes, three field coupling and three non-linear, is developed, and parallel calculation is developed for fine modeling and large scale computation. Analysis of the deck cracks, cleavage cracks, cracks in culvert, the downstream face crack in the typical parts of concrete dam, and the preventive measures is puts forward. The key points of temperature control for high arch dams and RCC gravity dams are given, and they include water cooling settings for high arch dams, emphasis on medium term cooling, strict control of cooling rate, and the measure of temperature difference control. The intelligent temperature control technology is an effective means to ensure the quality of the temperature control construction. It can effectively avoid all kinds of errors caused by artificial temperature control and improve the construction quality. In the end, the problems of high performance calculation, early age thermodynamic parameters and individual temperature control zoning standards, which are urgently needed in the future, are introduced.

Keyword: high concrete dam; temperature control and crack prevention; intelligent temperature control; simulation calculation

Advance and prospect in research on reservoir sediment control and functional restoration

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Abstract: Almost all the reservoirs in the world face the problem of sediment deposition, which has become an urgent technical problem to reduce the function, safety and comprehensive benefit of the reservoir. The long-term conservation and sustainable utilization of the reservoir and the effective restoration of the capacity of the deposition loss become an important way to solve the water shortage. This paper briefly introduces the basic research progress of reservoir deposition at home and abroad in recent years, discusses the reservoir sedimentation control and function recovery techniques from three aspects of incoming sediment reduction, hydrodynamic desilting and recovery of silt capacity. In future, it is necessary to study on the sediment movement process under the joint action of hydrodynamic and artificial measures, develop the techniques of volume recovery and sediment treatment and utilization of silt reservoir, establish reservoir function impact assessment model, and put forward reservoir functional recovery measures and strategies for different types of regions.

Keywords: reservoir; sediment control; functional restoration

Geotechnical centrifuge modelling based on LXJ-4-450 platform

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Abstract: Geotechnical centrifuge modelling is one of the most efficient physical modelling methods. Recently, with the development in hydraulic pressure, electronic control and sensing and testing technologies, the technique of geotechnical centrifuge modelling has been improved greatly. Correspondingly, its applications are also expanding. Based on the centrifugal modeling platform in IWHR, this paper presents the advances, including both the newly developed devices and the associated experimental results, in this area. The mechanisms of the pollutants migration through soil was examined using new design centrifuge apparatus. A device for the blasting modelling in centrifuge was developed to validate the scaling laws for shock wave and bubble pulse by underwater explosion. The mechanisms of overtopping of soil dams were explored using a custom-made device. Moreover, the liquefaction mechanism and earthquake wave propagation through saturated sand were investigated using the world's first horizontal-vertical centrifuge shaker. Besides, the technique of exerting large load force for centrifuge modelling based on hydraulic pressure system was developed. Finally, the new research platform of large geotechnical centrifuge at IWHR is introduced.

Keywords: geotechnical centrifuge modelling; physical model tests; experimental technique; dynamic; dam breach; pollution migration; blasting

The influence of wetland–ecosystem reconstruction on the avifauna diversity in the farming–pastoral zone of the loess plateau

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Abstract: In order to objectively evaluate the impact of the wetland ecosystem changes on water–bird diversity in ecologically fragile zones, the water–bird diversity before and after the restoration and reconstruction of the wetland ecosystem in Yulin of the northern Shaanxi was systematically studied by line–transect–sampling in 2017 and 2018. The results show that there are 106 species of water–birds in the area, belonging to 55 genera of 20 families of 9 orders, accounts for 88% and 40.0% of the total number of water–birds in Shaanxi Province and the whole China respectively, which includes 2 species of Grade I, 11 species of Grade II listed as the State Key Protected Wildlife and 14 species of Provincial Key Protected Wildlife respectively, and 1 and 7 kinds of water–birds listed as Grade I and Grade II protected names in the CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention). The IUCN (International Union for Conservation of Nature) Red List Ranks of the VN (Vulnerable), NT (Near Threatened) and LC (Least Concern) species are 3, 4 and 96 species respectively. There are 90 species of water–birds entered into "A list of terrestrial wild animals that are beneficial to the state or have important economic and scientific research value"(for shortened as national "three values" in China's list). The water–birds from the palaeartic, widespread and oriental species account for 65%, 25% and 10% respectively. The region is dominated by passage migrant and summer visitor birds, which account for 58% and 34% respectively, there are fewer populations of vagrant visitor, winter visitor and resident birds, and there are large differences in avian residential types between different regions in the south and north. The water–birds are given priority to with the desert birds in the Mongolian Plateau, the water–birds from Charadriiformes, Anseriformes, Ciconiiformes and Gruiformes accounts for 45%, 25%, 10% and 9% respectively, and which number did significantly increase in recent years compared with that before wetland restoration and reconstruction. But the water–birds from Podicipediformes, Pelecaniformes, Phoenicopteriformes, Falconiformes and Coraciiformes are less proportion, which quantity doesn't change much. With the function restored of wetland ecosystem, the ceaseless improvement of regional environmental quality and people's consciousness of protecting birds, and the global climate warming, the desert birds and loess birds gradually spread out, which makes scope of bird species and quantity increased year by year. There were 232 species of birds recorded in the zone before 2010, up to 280 in 2017, and 18 new species found of water–birds are recorded in the zone. The study provides a fundamental basis for the protection of the largest breeding area (Hongjiannao wetland) and breeding population of relict gulls in the world, and migration routes of Chinese birds.

Keywords: water–birds; diversity; response; wetland restoration and reconstruction; farming–pastoral zone of the Loess Plateau

Research progress on reservoir induced earthquake

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Abstract: The reservoir induced earthquake is not only a difficult problem for academic circles to tackle, but also a focal issue that attracts the attention of the society. In this paper, the relationship between reservoir induced earthquake and dam height, reservoir capacity, lithology and seismicity background is preliminarily analyzed by collecting seismic examples of reservoir induced earthquakes at home and abroad. The characteristics, origin classification, reservoir water function and prediction method of reservoir induced earthquakes are comprehensively expounded. The methods and problems of reservoir induced seismicity and spectral characteristics are summarized. The development history of reservoir induced seismological monitoring and the latest digital monitoring technology are introduced. The key points and the technical measures for reservoir induced seismicity in the future are put forward. The paper provides a reference for further study of the mechanism of reservoir induced earthquakes.

Keywords: reservoir induced earthquake; seismic spectrum; earthquake source

Key techniques of flash flood disaster prevention in China

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Abstract: In view of natural-social dual stress factors and the existing key technical problems in preventing flash flood disasters in China, this paper illustrates the general idea, technical system and defense modes of flash flood disaster prevention on the basis of innovative theories and studies of rainstorm flood pattern in small basins, analysis and calculation method, monitoring and early warning technologies in flood disasters mitigation in China. Technological breakthroughs and innovative achievements have been made in the characteristics of underlying surface and the rainfall-runoff generation in small watershed, rainstorm flood distribution patterns in ungauged basins, and pilot rainfall-runoff distribution model and distributed model in ungauged basins, early warning index system and risk assessment theory, real-time flash flood disaster forecast and early warning technologies in small watershed, and the national early-warning system.

Keywords: flash flood disasters; flash flood disaster investigation and assessment; monitoring and early warning platform; risk zoning and regionalization; community-based prevention

Development and prospect of hydropower project with asphalt concrete impervious elements in China

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Abstract: Hot issues in the modern construction of hydropower project with asphalt concrete impervious elements in China have been reviewed and commented in this paper, which began in 1995 with the commencement of Tianhuangping Project using the western mechanization technology. Since then, the flow-off defects of asphalt facing at high temperature, pervasive before 1990s in China, has been prevented by means of a new mix design method with higher mixing index. Low temperature cracking of asphalt facing at extremely low temperature has also been avoided with the aid of special developed bitumen modified by SBS polymer. At present, new topics have been discussed and under studied, such as the aging of asphalt facing and the repair method, the evaluating method of water damage and the application of acid aggregate to the asphalt concrete, hydraulic fracturing of asphalt core wall, etc, which will deepen the comprehension of the nature of hydraulic asphalt concrete.

Keywords: asphalt concrete; asphalt impervious facing; asphalt core wall; hydraulic fracturing; low temperature crack; aging; acid aggregate; flow-off of asphalt facing

Smart water grid project: the engine driving China's water management modernization strategy

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Abstract: The paper takes a review of water conservancy development in China in three stages since the founding of the modern China in 1949, and demonstrates that the smart water grid(SWG) project is an integrated carrier driving the implementation of China's water management modernization strategy. After a systemic analysis of the dual structure of current water grid system in China, namely the natural and the artificial, water flow and water basis, the ecological environment and the social-economy, the paper puts forward that SWG is a network amalgam of physical, information and management flow of water, and that SWG is featured by Security, Measurability, Accessibility, Resource-optimization and Technological-innovation, supporting the connectivity of water flow, information flow and business flow. The paper explains the key techniques for constructing a physical network of water that include quasi-nature ecological treatment of rivers and lakes, planning of water infrastructure network, safe and friendly construction of large water engineering under complex conditions; the key techniques for constructing a water information network that include intelligent sensing and multi-source 3D monitoring, multi-source water information integration and data-mining, and multi-scale forecast and prediction; and the key techniques for a water management network that include empirical-based water resources optimized allocation, multi-objective comprehensive scheduling of complex water resources systems, and nonlinear, intelligent control of water engineering project clusters. In its final analysis, the paper proposes the direction of Chinese SWG project construction in the future.

Keywords: water management modernization; smart water grid; integration carrier; smart feature

**Advances of evapotranspiration research based
on the Penman approach and complementary principle**

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Abstract: The Penman approach and complementary principle are the two main theories and methods on evapotranspiration estimation. This paper reviews the development of these two approaches, compares their differences in concepts and methods, and discusses the possibility and prospect of integrating them. The Penman approach emphasizes the processes at the land surface, and corresponding researches focus on the spatial pattern across various scales and the transpiration mechanisms controlled by plant physiological and ecological behaviours. The complementary principle emphasizes the processes in the atmosphere, and corresponding researches evolve from linear complementary relationship to the generalized complementary principle based on nonlinear functions. The Penman approach and complementary principle should be integrated for completely comprehending the evapotranspiration process, and raising the level of evapotranspiration research.

Keywords: evapotranspiration; Penman approach; complementary principle

**Analysis of the maximum dam body flood discharge in large high arch dam:
case study in Baihetan Hydropower Station**

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Abstract: The scale of spillway has great influence on the safety of dam body for high arch dam during flood discharge, which is one of the key technical parameters in the hydraulic design of high arch dam project. According to the results of hydraulic model test for Baihetan hydropower station and the technical reference that the maximum impact pressure on water cushion pond floor should be less than 15.0×9.8 kPa, the maximum dam body flood discharge is given quantitatively, and compared to the others of the same kind project from the unit of water cushion pond water energy dissipation. The test results show that there is a significant correlation between the maximum dam body flood discharge and the maximum impact pressure on water cushion pond floor. In the case of surface outlet operation condition, with the increase of the dam body discharge flow, the maximum impact pressure on water cushion pond floor increases in the form of a power function, and increase obviously. In the case of surface and deep outlet joint operation condition, the maximum impact pressure on water cushion pond floor mainly depends on the discharge flow ratio of surface outlets to deep outlets, basically in a linear relationship.

Keywords: water cushion pond of high arch dam; the biggest impact pressure; surface outlet; deep outlet; discharge flow

Multi-dimension health assessment and diagnosis of hydropower unit based on big data

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Abstract: At present, there are some problems in the safe and efficient operation of hydropower units, such as inaccurate health assessment, fewer fault samples, inadequate fault knowledge, lack of safe and efficient operation guidelines for large units, etc. The healthy data of hydropower unit test, on-line monitoring and operation and maintenance are analyzed. The characteristic parameters that represent the running status of the unit are proposed. The coupling relationship between characteristic parameters and the unit operating condition parameters is revealed. The multi-dimensional health assessment and performance degradation prediction theory of hydropower unit based on healthy samples is established. The zoning guideline for safe and stable operation of large-scale units is proposed. Based on the established model and criteria, a remote hydropower unit monitoring and diagnosis system platform is established. It provides important technical support for ensuring the safe, stable and efficient operation of hydropower unit.

Keywords: health samples; hydropower unit; intelligent assessment; running zone; safe and efficient