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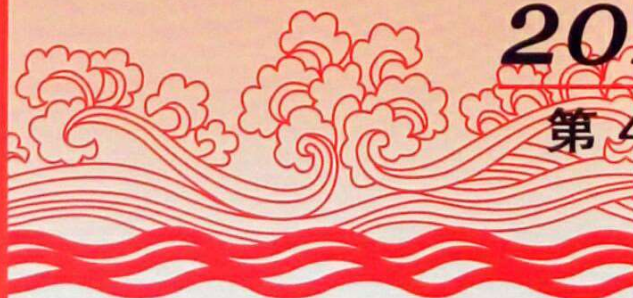
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## Key issues and developments on seismic safety evaluation of high concrete dams

ZHANG Chuhan, JIN Feng, WANG Jinting, XU Yanjie, PAN Jianwen

(*Department of Hydraulic Engineering, Tsinghua University, Beijing 100084, China*)

**Abstract:** The state-of-the-art developments on seismic safety evaluation of high concrete dams is reviewed, including: large-scale numerical simulation of seismic ground motion from source-media to dam canyons; nonlinear earthquake damage-cracking behavior of dam-reservoir-foundation systems; dynamic experimental tests and meso-scale simulation of concrete; and performance-based seismic safety risk evaluation of concrete dams. At the end, the development trends of earthquake-resistant of high concrete dams are concluded.

**Key words:** earthquake-resistant of high dams; ground motion; damage-cracking; meso-scale simulation; safety risk

(责任编辑: 王冰伟)

## Study on prediction of ungauged basins: A case study on the Tibetan Plateau

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**Abstract:** Simulation of hydrological processes in ungauged basins is one of the challenges for hydrologists because of the complexity of the rainfall-runoff process, spatial and temporal homogeneity of basin underlying surface and meteorological variables and the limited knowledge of hydrologists to the regulations of water cycle. In this paper, we review the studies on hydrological simulations in ungauged basins. First, the types of ungauged basins are classified; then, hydrological simulations under the situation of lack of rainfall and runoff observations are summarized. Finally, we focus on the hydrological simulations on the Tibetan Plateau, which is one of the most typical ungauged basins worldwide. Using the HIMS hydrologic modeling system, simulation capabilities of satellite products, instantaneous peak flow estimated based on daily streamflow, flood survey and parameter regionalization of hydrological models are investigated over the Tibetan Plateau. These studies illustrate the research advance of Predictions in Ungauged Basins (PUB).

**Key words:** ungauged basins; hydrological simulation; hydrological model; the Tibetan Plateau

(责任编辑: 王成丽)

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## Progress of water resources allocation during the past 30 years in China

WANG Hao, YOU Jinjun

(State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research, Beijing 100038, China)

**Abstract:** Water allocation is a key point in water resources management. The domestic achievement about water allocation study in past 30 years is summarized. Disciplines and relations in water allocation in new situation and prospect of this field is pointed out based on the analysis of water resources system simulation under framework of natural-artificial dualistic water cycle. Future focuses in study of water allocation are discussed. It is pointed out that water quantity, water quality and efficiency of water use should be taken as major factors and criteria of water allocation under multi-dimensional decision-making mechanism, and low-carbon mode is another tool to accelerate water from low-efficiency to high-efficiency fields.

**Key words:** water allocation; natural water cycle; social water cycle; high-efficiency; multi-dimensional regulation; low carbon mode

(责任编辑: 李琳)

# Development and practice of the operation mode of “Storing Clear Water and Discharging Muddy Flow” in sediment-laden rivers in China

HU Chunhong

(*China Institute of Water Resources and Hydropower, State Key Laboratory  
of Water Environment Simulation and Control, Beijing 100038*)

**Abstract:** Sediment deposition in a reservoir constructed in a sediment-laden river has a direct impact on the reservoir's lifespan and its comprehensive benefits of flood control, power generation, navigation and water supply. In 1970s the reservoir operation mode of 'Storing Clear Water and Discharging Muddy Flow' was put forward by Chinese scientists for coping with serious sedimentation problem in the Sanmenxia Reservoir, and further applied and developed in several key water control projects such as the Xiaolangdi Reservoir on the Yellow River and the Three Gorges Reservoir on the Yangtze River. This operation mode successfully solves the problem of the conflict between sedimentation and benefits of a reservoir on a sediment-laden river by reducing its sediment deposition and maintaining its effective storage capacity for long-term use. It gives full play to the comprehensive benefits of a reservoir and presents an effective new way to cope with reservoir sediment problem for a sediment-laden river. The operation mode of 'Storing Clear Water and Discharging Muddy Flow' will be constantly optimized and improved in practice along with the knowledge deepening on reservoir sediment problems. Base on the actual situation of changes on runoff and sediment loads of rivers, the paper puts forward suggestions on further optimizing operation mode for the Three Gorges Reservoir and Xiaolangdi Reservoir to ensure the projects' safety and comprehensive benefits and to provide scientific support for promoting development on the theory and technology of reservoir sedimentation.

**Key words:** sediment-laden rivers; reservoir operation mode; Storing Clear Water and Discharging Muddy Flow; long-term effective storage capacity

(责任编辑: 李福田)

## Perspective on water security issue of changing environment in China

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2. *The Research Institute for Water Security, Wuhan University, Wuhan 430072, China;*

3. *Hubei Provincial Collaborative Innovation center for Water Resources Security, Wuhan 430072, China*)

**Abstract:** Water security issue is not only an international hot topic, but also big challenges and problem of China on guaranteeing Chinese water security and realizing its sustainable development. This paper gives a definition of water security and addresses the important issue on new advantages of water security under a changing environment on both China and international, which includes water security assessment and new progresses of water security issue related to global change and its impact. It is emphasized on basic studies of hydrology and water resources related to climate change impact and water security issue, also interdisciplinary approach between natural sciences and social science, and water and the future of humanity. Some of suggestions and countermeasures are given as adaptive water management to changing environment.

**Key words:** water security; climate change; perspective; challenges; opportunity

(责任编辑: 韩 昆)

## Advances and assessment on design flood estimation methods

GUO Shenglian, LIU Zhangjun, XIONG Lihua

(*State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan 430072, China*)

**Abstract:** Design flood provides an important basis for determining the construction size and operation strategy of water conservancy project. A state art review of flood frequency analysis, including sampling method, distribution type, empirical frequency formula, parameter estimation method, design flood hydrograph, historical flood, regional flood frequency, PMP/PMF, seasonal design flood and design flood for cascade reservoirs are systematically summarized. The main research progress in recent three decades of China is emphasized and problem existing in the present study is discussed. The frontier and hot issues of design flood are briefly classified into four aspects, including multivariate design flood estimation, nonstationary flood frequency analysis, flood frequency analysis based on physical mechanism of hydrological processes and uncertainty analysis of design flood. Finally, the research emphasis and directions of design flood estimation in China are suggested.

**Key words:** design flood; flood frequency analysis; PMP/PMF; historical flood; multivariate probability distribution; nonstationarity; uncertainty

(责任编辑: 王成丽)



## Studies on cemented material dams and its application

JIA Jinsheng<sup>1</sup>, LIU Ning<sup>2</sup>, ZHENG Cuiying<sup>1</sup>, MA Fengling<sup>1</sup>, DU Zhenkun<sup>1</sup>, WANG Yang<sup>1</sup>

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**Abstract:** The concept of Cemented Material Dam (CMD) was proposed in 2009 and published in 2012. Chinese Technical guideline of CMD was issued in 2014. Take Cemented Sand, Gravel and Rock (CSGR) Dam as an example, studies on method of dam cross section design, material selection and mix ratio design, and quality control are introduced to explain the concept and principles of CMD. Lab test results on strength, impermeability, freeze thaw resistance and projects application of CSGR are introduced. Based on studies and practices, main principles of CMD were summarized. The applications indicated that the CMD could reduce construction cost by 10% ~ 20% and had higher safety to resist overtopping failure compared with embankment dam. It also has advantages of quick construction and environmental-friendly. CMD provides a new solution for small dam construction.

**Key words:** Cemented Material Dam; CSGR dam; CSR dam; dam design; material properties

(责任编辑: 王冰伟)

## New technology and innovation on flood discharge and energy dissipation of high dams in China

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**Abstract:** The waterpower construction in China has being got rapid development during the recent 60 years, especially in the 30 years after the reform and opening-up, many world-class giant water conservancy projects are constructed or under construction. To meet the urgent need of the project construction with advanced and safe flood discharge and energy dissipation scheme, the study of high speed flow and flood discharge and energy dissipation with high head and large discharge flowrate have reached the world leading level. Several important research results on flood discharge and energy dissipation with high head and large flood discharge are introduced in the paper, which include combined dissipater with flaring pier, slit-type bucket dissipater, inner dissipater, air entrainment and cavitation alleviation in high head spillway tunnels, and energy dissipation in plunge pool with high head arch dam.

**Key words:** high head; large discharge flowrate; arch dam; flood discharge; energy dissipation; flaring pier; slit-type bucket; inner dissipater; plunge pool; air entrainment and cavitation alleviation

(责任编辑: 李福田)

## The state-of-the-art review in the theory research and its application of multi-reservoir system operation in China

WANG Bende, ZHOU Huicheng, LU Di  
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**Abstract:** Method and theory of multi-reservoir system operation are the hot research on the flood control and efficient utilization of water resources, which has drawn great attention from the engineering field due to its advantage of significantly increasing the benefits of flood control and water conservation without enlarging the scale of the reservoir. The operation of multi-reservoir system in China has been systematically studied since 1970s, and has achieved a great number of research findings. Based on the complex giant system structure, this paper reviews the state of the art in the theory research and its application of multi-reservoir system operation in China from following aspects: the available information, operation model construction and solution technique, decision-making evaluation, real-time operation system design and development, as well as administrative management. The urgent issues and the trend in the research of multi-reservoir system and engineering practices are also put forward to provide reference to the related research.

**Key words:** multi-reservoir system operation; available information; operation model; model solution technique; administrative management

(责任编辑: 王成丽)

## Development and applications of eco-hydrological models: past and future

XU Zongxue, ZHAO Jie

*(Key Laboratory of Water and Sediment Science, Ministry of Education;  
College of Water Sciences, Beijing Normal University, Beijing 100875, China)*

**Abstract:** Eco-hydrological model is not only an effective approach to investigate scientific issues in the field of eco-hydrology, but also a useful decision support tool in ecological system, environment and water resources management. This paper mainly focused on the hot topics in the fields of hydrology and ecology, then figured out and summarized the state-of-art, the major progresses, main issues and requirements for eco-hydrological models. The key strategy and technology used in the development of eco-hydrological models were also discussed. Finally, expectations on the future of eco-hydrological models were proposed.

**Key words:** eco-hydrological models; hydrological cycle; ecological processes; progress

(责任编辑: 王成丽)

## Applications of meso-scale analysis methods on the study of the physical/mechanical properties of concrete

DU Xiuli, JIN Liu

(The key laboratory of Urban Security and Disaster Engineering, Beijing University of Technology, Beijing 100124, China)

**Abstract:** Concrete is a typical pseudo-brittle composite material, whose physical and mechanical properties are determined by the two major ingredients involving coarse aggregates and hardened cement mortar, and the bonding effects of the two components. Accordingly, to describe the physical and mechanical properties of concrete, the micro-/meso-scale analysis methods should be employed. Herein, the applications of meso-scale analysis methods were illustrated and discussed on the studies of the static/dynamic mechanical properties and failure mechanism of concrete, the size effects of concrete materials and reinforced concrete members, and the stress corrosion of concrete under chloride environment (including the chloride diffusivity, and the fracture of cover concrete induced by corrosion-expansion of reinforcing bar). Finally, some suggestions were provided for future development and studies.

**Key words:** concrete; meso-scale analysis method; static and dynamic mechanical properties; size effect; chloride diffusivity; cover concrete fracture

(责任编辑: 祁 伟)

## Microirrigation in China: history, current situation and prospects

LI Jiusheng, LI Yanfeng, WANG Jun, WANG Zhen, ZHAO Weixia

*(State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin,*

*China Institute of Water Resources and Hydropower Research, Beijing 100038, China)*

**Abstract:** The commercial use of microirrigation in China has been more than 40 years since it was firstly introduced in 1970's. Through continuous demonstration, extension and technical innovations, almost all facilities and equipment for microirrigation installations, including emitters, infiltrators, injectors, regulators, pipelines and other ancillary devices, have been domestically industrialized. Extensive technical issues regarding design, operation and maintenance of microirrigation systems were studied. Many application modes for typical crops have been established in different regions through demonstrations and extensions. Microirrigation has become one of water-saving irrigation technologies used in China that is able to increase crop production. Chemigation that is benefit to crop production and environmental conservation is currently successfully and popularly used in microirrigation systems. These achievements have made microirrigation be becoming an important landmark of agricultural modernization in China. After reviewing the introduction, demonstration, extension and related research works, the possible further research topics are presented in this paper.

**Key words:** microirrigation; comprehensive benefit; technical innovations; application modes

(责任编辑: 祁 伟)

## Temperature control and crack prevention of super-high arch dam

ZHANG Guoxin, LIU Youzhi, LIU Yi

(State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin,  
China Institute of Water Resources and Hydropower Research, Beijing 100038, China)

**Abstract:** Temperature control and crack prevention are very important for super high arch dam. In this study, recent researches and practical achievement are summarized, while issues such as the identification of anti-crack safety factor and the standard of temperature control, the optimization and selection of temperature control measures, and the construction quality control are discussed systematically. Suggestions are proposed as follows. (1)The anti-crack safety factor should take the value range from 1.8 to 2.0, and the standard for temperature difference should be kept under strict control, taking the uniform foundation temperature difference standard for the whole dam, and controlling the highest temperature by the sum of arch sealing temperature and the standard foundation temperature difference. (2)The “931” temperature control mode, namely “early protection, small temperature difference, and slow cooling”, “three-phase cooling” and “intelligent monitoring”, should be adopted for full-process temperature control. (3)Spatial temperature gradient should be controlled in four zones: “ungrouted zone, simultaneous cooling zone, transition zone, and weighted cover zone”, and the temperature process should be controlled in “three phases and multi-stages”. The temperature control and cooling in the middle phase is essential. (4)Quality of the whole construction process should be monitored with intelligent tools, and intelligent temperature control measures should be taken for necessary steps. These suggestions are aimed at providing references for the editing and amending of technical specifications related to super high arch dam.

**Key words:** super high arch dam; temperature control and crack prevention; simulation; intelligent monitoring

(责任编辑:王冰伟)

## Research advances from soil water dynamics to ecohydrology

YANG Dawen, CONG Zhentao, SHANG Songhao, NI Guangheng

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**Abstract:** Soil water dynamics has been a new research field in hydrology and water resources since the 1980s. Research progresses in soil water dynamics achieved in the past decades greatly promoted the advances of sciences and technologies in the fields of irrigation and drainage, hydrology and water resources in China. Based on the soil water dynamics, the mechanism and laws of the water–heat–solute transfer in the unsaturated zone were revealed and understood. The theory of water and heat transfer in the Soil Plant Atmosphere Continuum (SPAC) was developed in 1990s (so called SPAC theory). The field scale crop model was developed rapidly based on SPAC theory, and the crop models became the major tool for study the impacts of climate change on agricultural water management and food production in the 21st century. At the same time, a number of scientific and practical issues were raised, such as the water transfer crossing the field scale to regional scale, multi-scale efficiency of the agricultural water utilization, ecological and environmental impacts of water resources development and utilization and so on. To solve these urgent issues and challenges, a new cross discipline of hydrology and ecology has been proposed, it is ecohydrology. Ecohydrology is based on the dynamics of water–energy–substance cycle, focuses on the basic scientific question of the climate–vegetation–hydrology interaction, and aims to serve the regional water resources management and eco–environment assessment and management.

**Key words:** soil water dynamics; Soil Plant Atmosphere Continuum; water–energy–substance cycle; ecohydrology

(责任编辑: 祁 伟)



## Research progress on the key technologies of drought risk assessment and control

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4. Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographical Sciences and Natural Resource Research, Chinese Academy of Sciences, Beijing 100101, China)

**Abstract:** As the basis of drought risk management, drought risk assessment and control can reveal the elements interaction mechanism of drought risk system, which can provide scientific basis for drought risk prevention and control measures. In this paper, the key technologies and their problems of drought risk assessment and control such as basic concepts, recognition, assessment and control of drought disaster risk were systematically described, definitions of drought risk and drought risk system were put forward, three typical main methods of drought disaster risk assessment were summarized, the main contents of drought disaster risk control were briefly described, and the main development trend of these key technologies of drought risk assessment and control were discussed.

**Key words:** drought risk system; recognition of drought disaster risk; assessment of drought disaster risk; control of drought disaster risk; scenario simulation analysis; chain transfer

(责任编辑: 李琳)

## Discipline of ecohydraulics and the application to modeling and mitigating eco-environmental effects of hydraulic works

CHEN Qiuwen

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**Abstract:** Ecohydraulics is a cross-disciplinary subject of hydraulics, biology and ecology. It investigates the forcing mechanism of flow on aquatic ecosystem and the related hydraulic remediation measures for alleviating the forces. The subject focuses on two aspects: (1) the influences of hydraulic changes on the biogeochemical processes of biogenic elements and the consequent effects on habitat distribution, species structure and ecological service; and (2) the counterforce of ecosystem changes on hydrological and hydraulic regimes. This paper is intended to review the development frontiers, research challenges, engineering applications and future potentials of ecohydraulics, oriented to the modeling and mitigation of eco-environmental effects of hydraulic works.

**Key words:** Ecohydraulics; hydraulic works; eco-environmental effects; modeling and assessment; mitigation measures

(责任编辑: 韩 昆)

## **Review and frontier scientific issues of hydraulic control for long distance water diversion**

YANG Kailin

*(State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin,  
China Institute of Water Resources and Hydropower Research, Beijing 100038, China)*

**Abstract:** The hydraulic control for the long distance water diversion is a new interdisciplinary theory, mainly related to the water hammer in pipeline, unsteady flows in open channels, canal ice engineering, pipeline leak detection, uncertainty of hydraulic parameters and system identification as well as 3D simulation and so on. In this paper, the review and the main problems of the hydraulic control related the subjects are summarized, and then, from the practical point of view, put forward some of the frontier scientific issues to be solved.

**Key words:** water diversion; hydraulic control; review; frontier scientific issue; 3D simulation

(责任编辑: 李福田)

## Advance of hydrographic remote sensing with time

LI Jiren

(China Institute of Water Resources and Hydropower Research, Beijing 100038, China)

**Abstract:** This paper reviews the development history of applied research and application of hydrographic remote sensing with the development of water conservancy, describes the important role played by remote sensing technology in the fields of monitoring and assessment for flood and waterlogging, drought and geographic disaster related to water, flood forecasting, precipitation prediction, soil moisture and evapotranspiration estimation, monitoring of surface water body and ground water storage variation, water environmental monitoring, surface water and ecosystem protection, soil erosion estimation, investigation of irrigable land area, variation monitoring of river course and river delta, especially the role played in professional work of water sector. It analyses the development orientation for applied research of hydrographic remote sensing. It is pointed out that the application requirement must be the driver for the development of hydrographic remote sensing, and the target is the realization of providing service to professional work. The popularization and application is the only way for the development of hydrographic remote sensing.

**Key words:** remote sensing technology; hydrographic remote sensing; advance with times; popularization and application

(责任编辑: 韩 昆)

**A review on the mechanism and its controlling methods  
of the algal blooms in the tributaries of Three Gorges Reservoir**

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**Abstract:** Since the initial impounding of the Three Gorges Reservoir (TGR) in 2003, the problems of algal bloom in some tributaries have been attracting much attention, and many research works have been done by some scientists and research institutes. In this paper, the condition of the water environment and algal blooms is firstly introduced, the hydrodynamics and its effects on the ecosystem are analyzed, research progress of the mechanism of the algal blooms and its controlling method is reviewed, and the future research aspects are discussed. The review of new findings includes that (1) a bidirectional density currents (BDCs) could be a common flow pattern in the tributaries of the TGR, which are caused by the density difference related to the water temperature and the silt concentration, in which water temperature is the dominant factor; (2) under the BDCs, the thermal stratification in the tributary bays present a “double mixolimnion-thermocline” pattern near the estuary and a “half U-shape” pattern near the backwater end, and the nutrients in the tributary bays are mainly from the mainstream through water intrusions; (3) the trigger of the algal blooms depends on the relationship between the mixing depth ( $Z_m$ ) and euphotic depth ( $Z_{eu}$ ), but not on the flow velocities directly; (4) the tide-type ecological operation method of TGR could effectively control the algal bloom through affecting the stratified density current. The further study should focus on how to predict the algal bloom accurately using some new theory and methods, and to develop a multiple-objective optimal operation of the cascade reservoirs in the whole Yangtze River upstream area.

**Key words:** Three Gorges Reservoir; mechanism of algal bloom; bidirectional density currents; nutrients; ecological regulation

(责任编辑: 韩 昆)

**60 years' perspective of the diaphragm wall technology for seepage control,  
Part I: construction method and workmanship**

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**Abstracts:** Diaphragm walls are in common use to provide seepage control for dams and dikes. China imported this technology since 1958 and has seen great advancement in the areas of construction equipment, wall stabilizing slurry design, joint connection workmanship and drilling technology in difficult conditions. In particular, the in-depth study and wide application of plastic concrete have enabled the accomplishment of many outstanding projects. This paper gives a comprehensive review on the key technology of these areas during the past 60 years. The highlights include: (1) the CZF serial percussion and inversely cycling drilling machine; (2) the joint pipe method for providing continuous seepage proof between the consecutive wall blocks; (3) the new slurry design that provides stable drilling walls; (4) methods tackling heavily leaking and large rock fragmented alluvium; (5) technology of plastic concrete diaphragm walls.

**Key words:** diaphragm walls; the joint pipe method; the new slurry design; plastic concrete

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