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目 次

“一带一路”中国大陆区水资源特征及支撑能力研究 …… 左其亭 韩春辉 马军霞 刘 静（631）

多孔连续介质渗透压力对变形应力影响的数值模拟方法探讨 …… 张国新（640）

作物生产水足迹量化方法与评价研究 …… 吴普特 孙世坤 王玉宝 李笑雷 赵西宁（651）

强余震对主震受损重力坝非线性动态响应的影响 …… 王高辉 卢文波 严 鹏 陈 明（661）

环境流理论进展述评 …… 董哲仁 张 晶 赵进勇（670）

黄土高塬沟壑区绿水对土地利用和气候变化的响应研究——以南小河沟流域为例 ……

…… 夏 露 宋孝玉 符 娜 李怀有 李垚林（678）

开裂混凝土有效导热系数研究：三维模拟与试验验证 …… 沈 雷 任青文 张林飞 韩 衍（689）

基于微观孔隙通道的饱和/非饱和土渗透系数模型及其应用 …… 陶高梁 孔令伟（702）

基于单线法试验的黄土增湿变形非线性模型研究 ……

…… 金松丽 邢义川 赵卫全 张爱军 郭敏霞（710）

澜沧江-湄公河流域跨境水量-水能-生态互馈关系模拟 … 于 洋 韩 宇 李栋楠 赵建世（720）

无压条件下微孔陶瓷灌水器入渗特性模拟 ……

…… 蔡耀辉 吴普特 张 林 朱德兰 赵 笑 冯 立（730）

晋西黄绵土坡面径流流态与输沙特征试验研究 …… 付兴涛（738）

低水头闸坝工程鱼道过鱼效果评价 …… 张艳艳 何贞俊 何 用 张金明 张 康（748）

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JOURNAL OF HYDRAULIC ENGINEERING

Vol . 48 No . 6, 2017

(Monthly)

CONTENTS

Water resources characteristics and supporting capacity for "the Belt and Road" in China mainland ····· ZUO Qiting HAN Chunhui MA Junxia LIU jing (631)

Study on numerical simulation method used in analyzing the effect of seepage pressure in continuous medium with pores on deformation and stress ····· ZHANG Guoxin (640)

Research on the quantification methods for water footprint of crop production····· WU Pute SUN Shikun WANG Yubao LI Xiaolei ZHAO Xining (651)

Effect of strong aftershocks on nonlinear dynamic response of mainshock-damaged concrete gravity dams ····· WANG Gaohui LU Wenbo YAN Peng CHEN Ming (661)

Comments upon progress of environmental flows assessments ····· DONG Zheren ZHANG Jing ZHAO Jinyong (670)

Impacts of land use change and climate variation on green water in the Loess Plateau Gully Region——A case study of Nanxiaohegou basin ····· XIA Lu SONG Xiaoyu FU Na LI Huaiyou LI Yaolin (678)

Study of effective thermal conductivity of cracked concrete: three-dimensional simulation and experimental validation ····· SHEN Lei REN Qingwen ZHANG Linfei HAN Yan (689)

A model for determining the permeability coefficient of saturated and unsaturated soils based on micro pore channel and its application ····· TAO Gaoliang KONG Lingwei (702)

Study on nonlinear constitutive model for loess moistening deformation based on single-line experiment method ····· JIN Songli XING Yichuan ZHAO Weiquan ZHANG Aijun GUO Minxia (710)

Simulation of transboundary water-hydropower-ecology nexus in Lancang-Mekong Basin ····· YU Yang HAN Yu LI Dongnan ZHAO Jianshi (720)

Simulation of infiltration characteristics of porous ceramic emitter under non-pressure condition ····· CAI Yaohui WU Pute ZHANG Lin ZHU Delan ZHAO Xiao FENG Li (730)

Characteristics of flow pattern and sediment transport processes on loessal soil slope in western Shanxi Province ····· FU Xingtao (738)

Analysis on the efficiency of fishway for the low-head gate dam ····· ZHANG Yanyan HE Zhenjun HE Yong ZHANG Jinming ZHANG Kang (748)

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Water resources characteristics and supporting capacity for "the Belt and Road" in China mainland

ZUO Qiting[1,2], HAN Chunhui[1], MA Junxia[1], LIU jing[1]

(1. *School of Water Conservancy & Environment, Zhengzhou University, Zhengzhou* 450001, *China*;
2. *Center for Water Science Research, Zhengzhou University, Zhengzhou* 450001, *China*)

Abstract: Water resources conditions and supporting capacity are related to the smooth implementation of "the Belt and Road" which is one of the major national strategies in China mainland. Based on the understanding of "the Belt and Road" strategic layout that put forward by the Chinese government, and reference to many literatures, this paper delineates the main line and water resource areas of "the Belt and Road" in China mainland. The level of social and economic development, the conditions of water resources and the utilization are summarized in these areas. On this basis, we referenced the calculation method of development index and coordination degree of water resources are referenced to calculate the carrying index of water resources CC, which is used to quantitative analysis of the water resources supporting capacity before and after the implementation of "the Belt and Road". The results show that: (1) The main water resources areas of "the Belt and Road" involve in 12 provinces (municipalities and autonomous regions) and 61 subareas of the water resources regionalization III with a total area of 3,171,403.91km^2, where the water resources conditions and carrying indices are different in space. (2) In accordance with the current situation of water resources and the overall development trend, after the implementation of "the Belt and Road", the carrying index of water resources is trending downward, it is necessary to implement a series of regulatory measures. (3) Overall, the areas with poor water resources supporting capacity are mainly concentrated in the central region. According to the analysis results, the authors put forward the water resources regulatory measures that adapt to the development of "the Belt and Road", which provide technical support for improving the water resources supporting capacity of "the Belt and Road", and ensure the smooth implementation of the national "the Belt and Road" strategy.

Keywords: "the Belt and Road"; water resources characteristics; supporting capacity; the carrying index of water resources; regulatory measures

Study on numerical simulation method used in analyzing the effect of seepage pressure in continuous medium with pores on deformation and stress

ZHANG Guoxin

(*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: Seepage force and uplift pressure are often used to analyze seepage field's influence on deformation and stress, which is a simplified proximal algorithm ignored solid media's own deformation under pore pressure. For fine-granular medium like soil and sand, this self-deformation can be ignored, but for continuous medium with pores like concrete and rock with cracks, the neglect of pore pressure's effect on solid medium and overestimate of uplift pressure will misestimate the deformation and effective stress. From the perspective of stress-strain under pore pressure, regarding the pore pressure as initial strain (initial stress), the paper derives the finite element formula for seepage load (named "initial strain/stress" method). Comparing different results getting from different calculation methods, it shows that from the calculation using seepage force and uplift pressure as seepage load, the obtained deformation and effective stress appear too large error and sometimes are even wrong, while the "initial strain/stress" method can come to correct result of deformation and stress.

Keywords: continuous medium with pores; seepage field; pore pressure; initial strain; effective stress

Effect of strong aftershocks on nonlinear dynamic response of mainshock-damaged concrete gravity dams

WANG Gaohui[1, 2], LU Wenbo[1], YAN Peng[1], CHEN Ming[1]

(1. *State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan* 430072, *China*;
2. *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: Damages of earthquakes in the past indicate that a large mainshock usually triggers numerous aftershocks within a short period, and large aftershocks have a potential to cause additional damage to structures. A Concrete Damaged Plasticity (CDP) model including the strain hardening or softening behavior is presented for the concrete material. Moreover, the interaction between the impounded water and the dam-foundation system is taken into account by the Lagrangian formulation. The validity of the coupling model is verified. The effects of single mainshocks, single aftershocks and mainshock-aftershock seismic sequences on the accumulate damage of concrete gravity dams are presented. The impacts of strong aftershocks on nonlinear dynamic response behavior of the mainshock-damaged dam are discussed in terms of the damage, displacement, and damage dissipation energy. The results show that mainshock-aftershocks seismic sequences have a significant impact on the accumulated damage of the concrete gravity dam. It is necessary to raise the level of anti-seismic property for large dams, to which more attention should be paid in aseismic design of the dam.

Keywords: concrete gravity dam; aftershock; accumulated damage; dynamic response; mainshock-aftershock seismic sequences

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Research on the quantification methods for water footprint of crop production

WU Pute[1, 2, 3], SUN Shikun[1, 2], WANG Yubao[1, 2], LI Xiaolei[2], ZHAO Xining[2, 3]

(1. *Key Laboratory for Agricultural Soil and Water Engineering in Arid Area of Ministry of Education, Northwest A&F University, Yangling* 712100, *China*;
2. *Institute of Water Saving Agriculture in Arid regions of China in Northwest A&F University, Yangling* 712100, *China*;
3. *National Engineering Research Center for Water Saving Irrigation at Yangling, Yangling* 712100, *China*)

Abstract: Water use efficiency assessment is the key and base of agricultural water resources management. Water footprint provides a new evaluation index for water use evaluation in both rain-fed agriculture and irrigation agriculture. The quantification of crop water footprint is the precondition for the assessment of agricultural water use efficiency. This study evaluated the applicable range and characteristic of existing crop water footprint calculation method based on field crop evapotranspiration. Then the study put forward two kinds of calculation methods that based on regional water consumption and regional water use. Combined with the first calculation method, three calculation methods that suitable for different evaluation targets and application scopes were established. Taken mainland China as the research area, water footprint of wheat was quantified by using the above three different methods. The results show that three calculation methods have their respective applicable scope and scientific connotation. Method that based on field crop evapotranspiration can reflect the crop use efficiency at the field scale and agricultural climate resources endowment. Method that based on regional water consumption can reflect the water use efficiency at the regional scale, agricultural climate resources endowment and regional water consumption characteristics. Method that based on regional water withdraw can reflect the regional water use efficiency, irrigation system performance. Due to differences of the three calculation method, the method should be chosen based on the research scale and target to make the quantization and assessment of crop water footprint more scientific and reasonable.

Keywords: water footprint; quantification methods; water use process; water use efficiency

Comments upon progress of environmental flows assessments

DONG Zheren, ZHANG Jing, ZHAO Jinyong

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

Abstract: The development of environmental flow assessments methods were reviewed in this paper, from simple hydrological formulas to ecological limits of hydrological alteration (ELOHA). The major points of Environmental Flows were discussed, such as the difference between nature flow and regulated flow, hydrological alteration-ecological response relationships, thresholds of aquatic ecosystem and so on. The comments upon issue about environmental flows application were made, including concept of ecological water requirement, integrality and veracity of bibliographic citation in technique criterion, enhancement of models and software development, and adaptable management strategy.

Keywords: environmental flow; flow duration curve analysis; instream flow incremental methodology; ecological limits of hydrological alteration; nature flow paradigm

Impacts of land use change and climate variation on green water in the Loess Plateau Gully Region——A case study of Nanxiaohegou basin

XIA Lu[1], SONG Xiaoyu[1], FU Na[1], LI Huaiyou[2], LI Yaolin[2]

(1. *State Key Laboratory Base of Eco-hydraulic Engineering in Arid Area, Xi'an University of Technology, Xi'an* 710048, *China*;
2. *Xifeng Experiment Station of soil and water conservation, Yellow River conservancy committee, Xifeng* 745000, *China*)

Abstract: The ecological environment of Loess Plateau gully area is fragile, and the water resources are very scarce. In this study, the typical small watershed gully area of the Loess Plateau—Nanxiaohegou basin was selected as the study area. The variation of green water in Nanxiaohegou was revealed based on land use and meteorological data, furthermore, response of green water to climate and land use change was analyzed. Besides, this paper made some researches quantifying the respective contribution of land use and climate changes to green water from 1954 to 2012. The results show that: (1) The mean annual green water of Nanxiaohegou basin is 443.2mm. According to the K-M statistical test, green water of Nanxiaohegou basin shows a decreasing trend, but the trend is not obvious. At the same time, according to the UF and UB curves of the position of the intersection, annual green water mutated around 1978. (2) Interannual variation of green water in different land use types is uneven, among which the green water in forest is the largest, grassland comes second and construction land is the least; the precipitation is a major limiting factor affecting green water in climate variation. (3) According to the results of scenario analysis, the contribution rate of climate and land use change to the annual green water reduction are 123.6% and -23.6%, while the results calculated by the separation of evaluation method are 137.7% and -37.7%. It indicates that the contribution of climate factors for green water change is more than that of the land use factors, while the increase of forest area is the reason for green water increase because of the land use change. The research provides a reasonable and effective theoretical basis for the restoration of regional ecological environment, regional water resources planning and management of the Loess Plateau.

Keywords: green water; land use; climate change; quantitative evaluation; Nanxiaohegou basin

Study of effective thermal conductivity of cracked concrete: three-dimensional simulation and experimental validation

SHEN Lei, REN Qingwen, ZHANG Linfei, HAN Yan

(*Hohai University*, *Nanjing* 210098, *China*)

Abstract: A mesoscopic numerical method is proposed to investigate the effective thermal conductivity (ETC) of both tensile and compressive cracked concrete, and this method is applied to obtain the quantitative relationships between tensile or compressive strain and ETC, respectively. The main conclusions are drawn as follows: (a) for tensile dominated failure, concrete ETC decreases by 23% during plastic stage whereas a very slight linear decrease is found at complete failure; (b) for compressive dominated failure, ETC decreases by 30% during earlier plastic stage, and then becomes steady afterwards. In the softening stage, ETC linearly decreases with the increase of compressive strain; (c) it is the interfacial thermal resistance induced by the micro-cracks between aggregates and mortar rather than the macro-cracks that play the dominant role in this phenomenon; (d) concrete ETC shows more anisotropy when cracks appear. Then an experimental validation of compressive cracked concrete's ETC vertical to cracks (C-ETCV) shows that C-ETCV decreases by 20% ~ 25% at earlier plastic stage and then becomes steady at later plastic stage. The numerical results obtained simulations are used to determine the interfacial thermal resistance factor in Wang model. A good agreement between the data from simulation, Wang model and experiment indicates the correctness of this study.

Keywords: cracked concrete; effective thermal conductivity; meso-scale simulation; experiment; Wang model

A model for determining the permeability coefficient of saturated and unsaturated soils based on micro pore channel and its application

TAO Gaoliang[1, 2], KONG Lingwei[2]

(1. *School of Civil, Architecture and Environmental Engineering, Hubei University of Technology, Wuhan* 430068, *China*;
2. *Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan* 430071, *China*)

Abstract: To reveal the influence mechanism of deformation on the saturated and unsaturated permeability and establish the corresponding prediction method from the micro perspective is of great significance for seepage analysis and hydro-mechanical coupling study of saturated and unsaturated soils. Using the fluid mechanics theory, the relation between the permeability coefficient and the equivalent pore-size of micro pore channel has been established. On this basis, by using the capillary theory, a new model was presented to determine the permeability coefficient of saturated and unsaturated soils from soil-water characteristic curve (SWCC), which was testified to be reasonable based on existing experimental data. Combining this model with prediction method of SWCCs of deformation soils, the saturated and unsaturated permeability coefficients of Wuhan deformation clay were predicted. The results show that the predictions of the saturated permeability coefficients are in good agreement with the experimental results, which decrease in orders of magnitude under compression deformation condition. In double logarithmic coordinate, unsaturated relative permeability coefficients decrease with the increase of matric suction for the suction stage greater than the air entry value, which has the approximately same slope for different initial void ratio and present as a "brush" profile. In condition of the same matric suction, the smaller initial void ratio is, the greater unsaturated relative permeability coefficient is. In the suction stage smaller than the air entry value, unsaturated permeability coefficient is approximately equal to the saturated permeability coefficient. In the suction stage greater than the air entry value, unsaturated permeability coefficient decrease with the increase of matric suction, which show the approximately coincident line in the condition of different initial void ratio.

Keywords: deformation clay; saturated and unsaturated permeability coefficient; micro pore channel; soil-water characteristic curve

Study on nonlinear constitutive model for loess moistening deformation based on single-line experiment method

JIN Songli[1], XING Yichuan[1], ZHAO Weiquan[1], ZHANG Aijun[2], GUO Minxia[2]

(1. *China institute of water resources and hydro-power research*, *Beijing* 100048, China;
2. *Northwest A&F university*, *Yangling* 712100, China)

Abstract: Loess moistening deformation, generally caused by surface water infiltration or the rise of underground water level, is a critical technical problem to be solved in geotechnical engineering. The existing constitutive model can be used to describe loess moistening deformation. However, it is still greatly different from the acting path of stress and water in actual foundation. This paper introduces the concept of humidification level to describe the moisture condition of soil. With stepped wetting tests on original loess, the correlations between soil moistening deformation and moisture condition during wetting process under the action of stress were analyzed, and the nonlinear constitutive model for loess moistening deformation has been established. The relationship curves of humidification level and the ratio between humidification deformation coefficient and collapsibility coefficient are used to reflect the sensitivity of loess moistening deformation. Besides, it also deals with the influence of vertical stress and properties of loess on the sensitivity of loess moistening deformation. The lateral deformation characteristics in humidifying process are analyzed by adopting humidification levels and lateral deformation relationship curves with different stress ratios.

Keywords: loess; moistening deformation; humidification level; constitutive model; sensitivity; lateral deformation

Simulation of transboundary water–hydropower–ecology nexus in Lancang–Mekong Basin

YU Yang[1], HAN Yu[2], LI Dongnan[1], ZHAO Jianshi[1]

(1. *State Key Laboratory of Hydroscience and Engineering, Department of Hydraulic Engineering, Tsinghua University, Beijing* 100084, *China*;
2. *College of Water Resources and Civil Engineering, China Agricultural University, Beijing* 100083, *China*)

Abstract: Lancang–Mekong River is an important international river in Asia, the interactions of its water–hydropower–ecology is a significant basis for the negotiations of riparian countries. This paper selects the annual power production of three hydropower stations on the Lancang River, which are located in the nearest to the boundary (i.e., the largest impact to downstream), to represent hydropower aspect. The defined ecological alteration coefficients are selected to represent hydrological aspect, while five downstream countries' agricultural water withdrawal from the mainstream are chosen as the representation of water supply aspect. In addition, hydropower generation and environmental flow are optimized by applying a GAMS model, as well as the downstream agricultural water withdrawal is simulated by employing the WEAP model. Thus, water–hydropower–ecology nexus among the five downstream countries is conducted. It is concluded that hydropower is competing with environmental flow but coordinating with agricultural water supply. Some differences are found among the interactions of water–hydropower–ecology nexus under different water withdrawal scenarios. Agricultural water supply is influenced by hydropower generation by different degree in different scenarios, and increasing hydropower generation in China has positive effects on the irrigation of downstream countries but negative impacts on environmental flow. Thus, basin scale regulation is needed.

Keywords: Lancang–Mekong River; agricultural water supply; hydropower; simulation

Simulation of infiltration characteristics of porous ceramic emitter under non-pressure condition

CAI Yaohui[1], WU Pute[1, 2, 3], ZHANG Lin[2, 3], ZHU Delan[1, 3], ZHAO Xiao[1], FENG Li[4]

(1. *College of Water Resources and Architectural Engineering, Northwest A&F University, Yangling* 712100, *China*;
2. *Institute of Soil and Water Conservation, Northwest A & F University, Yangling* 712100, *China*;
3. *Institute of Water-saving Agriculture in Arid Areas of China, Northwest A&F University, Yangling* 712100, *China*;
4. *Key Laboratory of Geo-hazards in Loess area, Xi'an Center of Geological Survey, Xi'an* 710054, *China*)

Abstract: In order to research the infiltration characteristics of porous ceramic emitter buried in soil, a flow model of porous ceramic emitter under non-pressure condition was constructed on the base of the principles of soil water dynamics and previous studies about water soil potential around the porous ceramic emitter. An indoor soil bin experiment was carried out to verify the accuracy of the model. The results indicate that the model presented in this paper could be used to simulate the flow phenomena of the porous ceramic emitter under non-pressure condition. The predictions of the model are consistent with the experimental data. When the working pressure is 0 m, the basic cause of soil water content change is the change of the emitter discharge change, which decreases gradually with the increase of water contents around the emitter. When the soil water content is saturated, the emitter discharge would be stopped. When the soil moisture is dissipated, the flow would recover from emitter again, and the discharge is approximately equal to soil evaporation capacity. Therefore, the emitter discharge would supply the soil water content in time. This paper provides a reference for the popularization and application of porous ceramic emitter.

Keywords: porous ceramic emitter; simulation; non-pressure condition; infiltration

Characteristics of flow pattern and sediment transport processes on loessal soil slope in western Shanxi Province

FU Xingtao

(*College of Water Resources Science and Engineering, Taiyuan University of Technology, Taiyuan* 030024, *China*)

Abstract: In order to investigate the characteristics of flow pattern and sediment transport processes on loessal soil slope, western Shanxi province, Reynolds number, Froude number, runoff volume, sediment yield and sediment transport rate under different rainfall intensities and slope lengths were measured and analyzed based on the laboratory simulated rainfall events. The results indicate that flow pattern is basically laminar flow and torrential flow on slope lengths 1–5 m under 30–125 mm/h rainfall intensities. The flow pattern has significant impact on runoff erosivity, and there is a good power function relationship between sediment yield and the Reynolds number. Runoff turbulence is stronger with increasing rainfall intensity and slope length, and the sediment transport rate increases with these two factors. However, increment of sediment transport rate with slope length extending from 3 m to 4 m are less than that from 2 m to 3 m and 4 m to 5 m when rainfall intensity greater than 60 mm/h. The relationship between sediment transport rate and runoff volume can be described using power function. The conclusions can provide scientific basis for the control of soil and water loss as well as the construction of soil and water conservation measures on loess plateau slope.

Keywords: Loessal soil; slope length; rainfall intensity; flow pattern; sediment transport rate; runoff volume

Analysis on the efficiency of fishway for the low-head gate dam

ZHANG Yanyan, HE Zhenjun, HE Yong, ZHANG Jinming, ZHANG Kang

(*Key Laboratory of the Pearl River Estuarine Dynamics and Associated Process Regulation, Ministry of Water Resources; Pearl River Hydraulic Research Institute, Pearl River Water Resources Commission, Guangzhou* 510611, *China*)

Abstract: The passing efficiency of the fishway for water plant dam in Liuxi River was evaluated by statistical analysis and comparing with other fishway based on the monitor data from August in 2015 to July in 2016. The main contents includes that identifying the fish species, analyzing the influence of season and upper water level variation to passage efficiency, and comparing the result with other fishway at home and abroad. During the period of monitoring, there were 1,043 fishes being captured, which belong to 39 species, 3 order, 10 families, and 37 genera. The main passage season of the fishway is from April to October. When the water temperature in the fishway varies from 20℃ to 35℃ and the upper water level varies from 32.6 to 33m, the fishway corresponding to its flow regime is effective. There are 39 species fish can find the entrance and pass over the fishway. Compared with other fishways at home and abroad, the water plant dam fishway can better perform its function, except for there is less numbers than others. The study results play an important role in ecological operation for Liuxi Reservoir and protection of fish resources. It also plays important role in demonstration and expansion fishway construction for other low-head gate dams in the Liuxi River and in the Pearl River Delta plains.

Keywords: Low-head gate dam; water plant dam fishway; passage efficiency; influence factor; statistical analysis