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Distinguish relations for the critical intitiation of non-homogeneous debris flow

SHU Anping[1], ZHANG Xin[1, 2], DUAN Guosheng[1], WANG Shu[1], SHI Zhe[3]

(1. *Key Lab. of Water and Sediment Sciences of MOE, Beijing Normal University, Beijing* 100875, *China*;

2. *Centre of International economics and Cooperation- Exchange of Ministry of water Resources, Beijing* 100053, *China*;

3. *Institute of Water and Soil Conservation, Changjiang Academy, Wuhan* 430000, *China*)

Abstract: As one of natural disasters, non-homogeneous debris flow is common in nature, occurring widely throughout the world in flood seasons especially in the southwest China. The formation mechanism of debris flow is highly concerned by scholars around the world. Studying the formation mechanism of debris flow and occurrence conditions is the basis for debris flow forecast and prevention. With 48 flume simulation experiments, the mechanism of debris flow and the quantitative relations of factors related to debris flow formation are revealed. According to sediment movement mechanics, Shields number is important to determine solid particle starting of debris flow. With the Shields number results classified by water quantity, vertical distribution of solid particle (non-homogeneous coefficient Ψ) and d_{50}, the Shields number shows positive relations with particle median diameter d_{50} and water discharge Q with analysis. The vertical distribution of solid particle reflects the non-homogeneous properties and the starting order of particles. When particles at the upper layer are much coarser than those at the lower layer, the Shields number is the largest. In the aspect of the particle shear stress, the critical expression of particle starting(the ratio of water shear stress to critical particle starting stress, if the calculation value of the discriminant is larger than 1.0, then particles start.) are preliminarily established separately based on the overall fitting formula and break fitting formula of Shields starting drag curve. Through verification with the field data from Jiangjia Gully, the critical expression of the particle initiation based on the overall fitting formula has a smaller deviation, having the better applicability. These results above is very significant for both preventing and reducing debris flow disasters.

Keywords: non-homogeneous debris flow; initiation processes; Shields number; critical expression of initiation

Prediction model for the thermal conductivity of concrete based on its composite structure

WANG Licheng, CHANG Ze, BAO Jiuwen

(*State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, Dalian* 116024, *China*)

Abstract: Temperature field analysis is one of the most important criteria for predicting the durability and service life of concrete structures, and thermal conductivity is commonly regarded as an important parameter to determine the time-dependent temperature field. With consideration of the non-homogeneous characteristic of the material composition, a mesoscale approach, in which concrete is described as a three-phase composite consisting of the coarse aggregate, hardened cement mortar matrix and the interfacial transition zone (ITZ) between them, is adopted to develop the thermal conductivity of the mortar and ITZ components with in concrete in terms of the composite model. Compared with the experimental results existed in the literature, effect of various factors, such as the water-cement ratio, volume fraction of aggregate, sand ratio, saturation degree and the interfacial thermal resistance, on the thermal conductivity was discussed. The results show that thermal conductivity of concrete increases with an increase of saturation and aggregate volume fraction, but decreases with the increase of water-cement ratio. The influence of water saturation degree on thermal conductivity is well presented by means of the proposed model taking into account the interfacial thermal resistance.

Keywords: concrete; composite materials; mesoscale; thermal conductivity; saturation degree

The discrete generalized Nash Model and its application in the river flood routing

YAN Baowei[1], YU Yu[1], GUO Shenglian[2], PAN Zeng[1]

(1. *School of Hydropower and Information Engineering, Huazhong University of Science and Technology, Wuhan* 430074, *China*;
2. *State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan* 430072, *China*)

Abstract: Based on the generalized Nash flow routing theory, the calculation formula was simplified by the definition of S-curve or detention storage curve. The discrete generalized Nash model (DGNM) for river flow routing was derived. The outflow downstream can be expressed by a linear combination of the inflows at the beginning and end of the current time, and the outflows of the current time and several times before. The weight coefficients of the linear combination were obtained by the defined S-curve or detention storage curve. The DGNM, with a clear physical concept, also has a statistical significance. Its structure is very simple and its form is more intuitive, which facilitates its popularization and application in practice. The case study also suggested that the DGNM has a good forecasting ability.

Keywords: generalized Nash flow routing theory; discretization equations; river flood routing; detention storage flow; linear combination

Bed sediment entrainment function based on kinetic theory

JIA Baozhen[1], ZHANG Lei[2], LI Xiaonan[1], ZHONG Deyu[1, 3]

(1. *State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Beijing* 100084, *China*;
2. *State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research, Beijing* 100048, *China*;
3. *Joint-Sponsored State Key Laboratory of Plateau Ecology and Agriculture, Qinghai University, Xining* 810016, *China*)

Abstract: A large part of previously obtained entrainment functions were derived empirically due to the difficulties in relating microscopic motion of particles to their statistical properties. Presented in this paper is a new entrainment function derived on the basis of Kinetic Theory for sediment transport. The entrainment function for bed sediment is defined in terms of Kinetic Theory as a statistical ensemble average of the upward boundary flux of bed sediment in per unit area and per unit time picked up from bed into motion by lift, drag due to turbulence, gravity and other stochastic forces. The velocity distribution function involved in the entrainment function is determined by means of the kinetic equation for sediment-laden flows, as permits us to consider the variety of forces that affect the motion of bed sediments. The entrainment function is also calibrated, verified and compared with 80 runs of 3 different experiments, and furthermore, it is applied to serve as the boundary condition in modeling suspended sediment distribution in a pure erosion experiment. The results show that, the entrainment function is not only theoretically well-grounded, it has a satisfactory accuracy in predicting bed sediment entrainment rates as well. It shows that 87.2% of the calculated entrainment rates by the newly obtained entrainment function have a relative error falling into the range of [-0.5, 0.5], indicating it has a comparatively higher accuracy in comparison with other functions. The entrainment function applied as the bed boundary condition also works well in reproducing the pure erosion processes. The entrainment function derived in this paper has the advantage over other methods in that it helps to provide a new approach to statistically associate the dynamic processes of microscopic motion of particles to macroscopic features of sediment transport.

Keywords: entrainment function; Kinetic Theory; velocity distribution function; entrainment flux

Pier scour under influence of headcut erosion of sand pit

QI Meilan[1, 2], KUAI Yanrong[1]

(1. *School of Civil Engineering, Beijing Jiaotong University, Beijing* 100044, *China*;
2. *Beijing Key Laboratory of Structural Wind Engineering and Urban Wind Environment, Beijing* 100044, *China*)

Abstract: Considering the influence of retrogressive erosion on total scour at underwater structure, the study of scour evolution and prediction was conducted to provide a reference to the flood protection of structure. Based on the flume experiments, the evolution and influential factors of retrogressive and local scour were observed. In addition, a time-dependent calculation method was proposed for the coupling scour. The ratio of local scour with or without retrogressive erosion varies with the distance between the pier and sand pit in an up-convex shape curve, of which increase or decrease is related to the flow discharge and hydraulic drop at the pit. Furthermore, the contribution ratio of local scour and retrogressive scour to the total scour depend on distance between pier and sandpit, hydraulic drop and discharge. In a featured location, the rate of retrogressive erosion is instantly times larger than that of the local scour at pier. The coupling calculation method proposed in this paper is capable to predict the total scour depth at a pier including retrogressive erosion and local scour.

Keywords: pier coupling scour; sand pit; hydraulic drop; retrogressive scour; local scour

Field experiment and simulation of lateral and vertical water flow in multi-layer soil in hilly region of southern China

SHAO Dongguo, YANG Xia, XU Baoli, GU Wenquan

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

Abstract: With undulating conditions in hilly region of southern China, the mechanism of soil water transformation is complicated due to different soil textures between upstream and downstream fields as well as different layers within field. In order to reveal the influence of field different layers on soil water movement, field experiment was conducted in Tuanlin experimental irrigation station of Zhanghe irrigation district in Hubei province. Both water lateral infiltration through the cultivated horizon layer(CHL) and vertical infiltration through plow pan layer(PPL) under variable water table in field were monitored or estimated in the experiment. The processes were also simulated by a two-dimensional soil water movement model under variable water head using HYDRUS-2D, which show that the simulated results agree well with observed values. The results demonstrate that the PPL with compact structure in field, decreased deep percolation by retarding water vertical movement, but at the same time enhanced water lateral movement through the CHL. The average soil stable vertical infiltration rate through the PPL was 0.006cm/min, while the average soil stable lateral infiltration rate through the CHL was 0.05cm/min. Based on the analysis of soil water balance at the stage of steadily infiltration, the total percolation in experiment area accounted for 21.11% of the cumulative infiltration, 0.46% and 20.65% of which were attributed to the vertical percolation and lateral seepage, respectively, and the CHL contributed 81.06% to the lateral seepage. The study illustrates that the lateral seepage plays an important role in water losses so that it is very essential to control percolation especially lateral seepage for water-saving and drainage reduction in southern China.

Keywords: southern hilly region; multi-layer soil; soil water content; cumulative infiltration; lateral seepage; HYDRUS-2D

Development and application of flood disaster evacuation analysis system

DING Zhixiong[1, 2], LI Na[1, 2], WANG Jing[1, 2], CAO Daling[1, 2]

(1. *China Institute of Water Resources and Hydropower Research*, *Beijing* 100038, *China*;

2. *Research Center on Flood & Drought Disaster Reduction of the Ministry of Water Resources*, *Beijing* 100038, *China*)

Abstract: With the rapid development of social economy, the increasing density of residents and assets in the flood prone areas has enlarged the risk of flooding. In the context of global warming, extreme storms and typhoons bring greater threats to the residents and assets in flood prone areas. How to organize the residents to evacuate more effectively and orderly is an important means to reduce the casualties and damages. Taking a multi-disciplinary approach including hydrology, hydraulics, disaster prevention and geographic information science, the flood risk is analyzed based on flood simulation to identify the population and its spatial distribution in the flooded areas. The optimal matching method is developed for planning placement shelters. In addition, the optimal evacuation routes analysis model and traffic congestion analysis model is developed. These models are integrated on a GIS based platform to create a comprehensive simulation system which can perform flood evacuation analysis and real-time simulation. The Jingjiang flood diversion area is taken as a pilot study to develop a flood scenario simulation model and the real flood event of 1954 is used to simulate the process of flood diversion in this area. According the result of flood simulation, there are three hazard areas in Jingjiang flood diversion area, i.e. dangerous hard disaster area, deep water hard disaster area and flood light disaster area. The flood diversion scenario of 1954 is used to simulate and analyze the disaster evacuation based on the 2014 emergency response plan of Jingjiang flood diversion area. An optimized program of evacuation in batches is proposed base on the characters of simulated flood routing. The result shows that the models, methods and related system are useful, which can provide a solution for analyzing and optimizing the evacuation plan in flood diversion area.

Keywords: flood simulation; evacuation analysis; Jingjiang flood diversion area

Application and sensitivity analysis of geostatistical approach to groundwater pollution source identification

LONG Yuqiao[1, 2, 3], CUI Tingting[1, 2], LI Wei[1, 2], Wu Chunyong[1, 3], LI Yange[1]

(1. *Department of Hydrology and Water Resources, Nanjing Hydraulic Research Institute, Nanjing* 210029, *China*;
2. *State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Nanjing* 210098, *China*;
3. *Nanjing R&D Tech Group Co., Ltd., Nanjing* 210029, *China*)

Abstract: To identifying the groundwater pollution source, a geostatistical approach is applied on the groundwater pollution identification (PSI) in a 1D homogeneous aquifer. Numerical test is employed to analyze the impact of observation point configuration on the PSI and the sensitivity analysis of pollution concentration observation error and model parameters. It is found out that if concentration observation data could precisely describe the real concentration distribution at the observed time point, a nice identification of the pollution discharge process could be obtained. If the calculated pollution discharge process is similar with the real discharge process, the dimension of the observation error is between 10^{-6} and $10^{-3.5}$, the dispersion coefficient varies between −10 % and 5 %, and the actual mean velocity varies between ±2 %. In the numerical case, the geostatistical approach shows a good performance for identifying the contaminant release process. Comparing to the observation error of concentration, the influence of dispersion coefficient and actual mean velocity are more outstanding in this case.

Keywords: geostatistical; groundwater; pollution; identification; sensitivity

Bond degeneration of fully grouted GFRP bar in submerged soft rock in diversion of water from Changjiang River to Huaihe River

LI Guowei[1, 2], ZHENG Cheng[3], CHEN Shenggang[4], WU Jiantao[2],
CAO Xueshan[2], YUAN Junping[3],

(1. *Key Laboratory of Ministry of Education for Geomechanics and Embankment Engineering, Hohai University, Nanjing Jiangsu* 210098, *China*;
2. *Highway and Railway Research Institute, Hohai University, Nanjing, Jiangsu* 210098, *China*;
3. *Geotechnical Research Institute, Hohai University, Nanjing, Jiangsu* 210098, *China*;
4. *Anhui Investment Co Ltd, Hefei, Anhui* 230000, *China*)

Abstract: Anchor reinforcements in diversion of water project from Changjiang River to Huaihe River are subjected to cyclic loading in slopes. Under cyclic loading, the bonding state of anchor reinforcement affects the stability of anchorage. The high strength, high durability and corrosion resistance allow Glass Fiber Reinforced Polymer (GFRP) a suitable alternative to replace steel bars. This study carried out a number of pulling experiments on GFRP bars embedded soft rock in field to analyse the anchor performance associated with varying anchoring effect and bond strength under cyclic loading. Test results show that the effective anchorage length of the GFRP bar in soft rock depends on bond strength between the grout and surrounding rock. The high degree of weathering and low strength of the surrounding rock resulted in a large effective length of anchor bar. The depth to which the bond degenerated as a result of cyclic load is less than the effective anchorage depth. Above the bond degeneration depth, friction is mobilized at bar–rock interface. Below this depth, bond force is mobilized. Bonding state would completely fail if it was damaged. Bond degeneration under the same cyclic load frequency decreased with depth. At the same depth, the bond degeneration increased with increasing frequency of cyclic load. The maximum pulling force resulted from the water level change is lower than the design load of anchor reinforcement, and hence the factor of safety of GFRP anchors is relatively safe. Submerged soft rock which is reinforced by GFRP bar has better durability and load stability.

Keywords: submerged soft rock; GFRP bar; cyclic load; bond degeneration; water level fluctuation

Pressure fluctuations characteristics and rotating stall propagation mechanism of a pump-turbine in pump mode

ZHANG Chunze[1, 2], XIA Linsheng[2], DIAO Wei[1, 2], ZHOU Jiayu[1]

(1. *Chongqing Southwest Water Transport Engineering Research Institute, Chongqing Jiaotong University, Chongqing* 400016, *China*;
2. *State Key Laboratory of Water Resources and Hydropower Engineering Science, Wuhan University, Wuhan* 430072, *China*)

Abstract: The pump-turbines have to be operated under off-design conditions to maintain the stability of the grid. The rotating stall usually occurs at part load in pump mode, which can cause severe pressure fluctuations and strong vibrations. To understand the pressure fluctuations and the stall cells propagation mechanism within turbine, the Scale adaptive simulation (SST-SAS) turbulence model and unsteady RANS approach were adopted to simulate a mode pump-turbine with different flow rate. The results show that the simulated characteristics curves are in good agreement with the experiment results. The rotating stall occurs in the region from 40% to 80% of the best efficiency point (BEP) flow rate. The stall cells rotating along the circumference and their rotating frequency is 3.3% ~ 8.1% of the runner rotating frequency. The propagation of the stall cells is driven by the growth and the decay of the stall cell. The pressure gradient between the stalled and un-stalled channels make the fluids flow from the stalled channel into the un-stalled channel through the gap between the corresponding guide vane and stay vane, which will increase the flow separations in the un-stalled channel. The growth of flow blockage in the un-stalled channel will make the inflow deviate toward the downstream channel and pressure decrease around the leading edge of the guide vane suction side. Further, the adverse pressure gradient between the leading and the trailing edges of the un-stalled guide vane is enhanced. Consequently, the flow blockage continues to grow until the vortices occupy the entire un-stalled channel.

Keywords: pump-turbine; rotating stall; pump mode; numerical simulation; pressure fluctuations

Experimental investigation on drag coefficient of rigid vegetation influenced by regular waves

CHEN Jie[1, 2, 3], HE Fei[1], JIANG Changbo[1, 2, 3], ZHAO Jing[1]

(1. *School of Hydraulic Engineering, Changsha University of Science & Technology, Changsha* 410114, *China*;
2. *Key Laboratory of Water Sediment Sciences and Water Disaster Prevention of Hunan Province, Changsha* 410114, *China*;
3. *International Research Center of Water Science & Environmental Engineering, Changsha University of Science & Technology, Changsha* 410114, *China*)

Abstract: The coastal erosion problems caused by wave scouring can be solved by vegetation efficiently due to their function of wave damping. The experiments of wave attenuation by rigid vegetation were conducted in the flume, in which the effects of roots, stems and canopies were considered. The drag coefficient was computed by the formula of Kobayashi and Dalrymple and its variation was investigated. It can be found that the wave damping simulated by the Kobayashi model is better than that of Dalrymple by comparing the drag coefficients between the two formulas. Root, stem and canopy affect on wave dissipation at varying degrees. The relationship between the drag coefficient and Keulegan-Carpenter number, Reynolds number, Ursell number and relative water depth depends on submergence ratio. Finally, to obtain the model of rigid vegetation composed of root, stem and canopy, the term of drag force derived from the dissipation of energy equation has been modified involving swaying motion of plants.

Keywords: rigid vegetation; drag coefficient; wave attenuation model; submergence ratio

Seismic subsidence fragility analysis of high CRFDs based on MSA

PANG Rui[1], KONG Xianjing[1, 2], ZOU Degao[1, 2], XU Bin[1, 2]

(1. *School of Hydraulic Engineering, Dalian University of Technology, Dalian* 116024, *China*;
2. *State Key Laboratory of Coastal & Offshore Engineering, Dalian University of Technology, Dalian* 116024, *China*)

Abstract: MSA is a fragility analysis method which is recently proposed and in view of discrete intensity factor, provides an effective approach for structural safety evaluation. However, this method is less applied in the field of earth-rockfill dams engineering. In this paper, crest settlement ratio is selected as the performance evaluation index in view of HCRFD, the seismic subsidence damage of HCRFDs was suggested dividing in mild, moderate and severe damage three standards. Considering the uncertainty of earthquake, fragility analysis is carried out with MSA, and the fragility curves and probability corresponding different damage grades are acquired, which can provide criterion and reference for the dam evaluation under the strong earthquake. In addition, seismic fragility analysis results of different stripe numbers show that decreasing the number of horizontal stripe appropriately has little influence on the result of fragility, thus it is conducive to the reduction of calculation conditions.

Keywords: high CRFDs; seismic subsidence deformation; fragility analysis; MSA method; damage grades

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Study on the design of joint sealing material and failure mechanism of adhesive layer under water pressure and deformation

LI Bingqi[1], ZHANG Yuchi[1], LI Zeyang[2], LIU Xiaonan[3]

(1. *China Institute of Water Resources and Hydropower Research, Beijing* 100038, *China*;
2. *Mathematics, The University of Manchester, Manchester*, M13 9PL, *United Kingdom*;
3. *Beijing University of Chemical Technology, Beijing* 100029, *China*)

Abstract: The damage and leakage of contraction joint in hydraulic structure will impact the safety of the structure. In this work, the authorsintroduce Cohesive Zone Model (CZM) into Finite Element Model (FEM) to simulate the damage process of joint sealing material under water pressure and deformation based on the tunnel across Yellow River on middle route of the South-north Water Transfer Project. We compare the results from simulation analysis with the strain-pressure curve from indoor pump-in test, and propose the fracture energy of CZM which fitted to bonding layer of joint sealing material. Furthermore, the impact of the width of contraction joint and the depth of joint sealing material on ability of resist to water pressure are discussed, which prove the validity of parameters. We also analyze the relation among contraction joint deformation, width of contraction joint, depth of joint sealing material and carrying capacity under the situation that the system bearing deformation and water pressure. The results provide theoretical foundation for physical mechanics design of joint sealing material and guidance for structure design of contraction joint.

Keywords: CZM; interfacial debonding; reverse water pressure; FEM; contraction joint; joint sealing material; failure mechanism

Experimental research on Manning's roughness coefficient of an open channel with aquatic vegetation

ZHENG Shuang, WU Yihong, Baiyinbaoligao, MU Xiangpeng

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

Abstract: Aquatic vegetation is an important part of the river ecosystem, but the presence of them increases the flow resistance and reduces the flood capacity. Thus, to carry out the research on Manning's roughness coefficient in vegetated channel has important guiding significance for the comprehensive management of river ecosystem. Based on a series of flume experiments with vegetated open-channel flow and dimensional analysis theory, the plant upright degree, the relative submerged height and the relative planting density of vegetation effects on the channel roughness are analyzed in this paper. And a universal equivalent Manning's roughness empirical formula is deduced which is applicable to the open channel with submerged aquatic vegetation. The formula is $n_V = n_0\left(1+\alpha_i \sqrt[4]{N}\left(e^{\delta_i \frac{h_{\omega}}{h}}-1\right)\right)$, $\delta_i = \gamma_i Fr^{\omega_i}$. In which, α_i, δ_i, γ_i, ω_i are the parameters for different plant species (i) and growth parameters , and they need to be determined by hydraulic experiments or field observations of specific aquatic plants.

Keywords: aquatic vegetation; plant upright degree; relative submerged height; relative planting density; equivalent Manning's roughness coefficient