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Separation Effect of Rainfal Data Based on Parameter Estimation Methods

Kim, Kyung Duk, Graduate Student, Dept. of Civil Engr., Yonsei Univ.
Bae, Deg Hyo, Senior Researcher, Industrial Technology Institute, College of Engr., Yonsei Univ.
Heo, Jun Haeng, Assistant Prof., Dept. of Civil Engr., College of Engr., Yonsei Univ.
Cho, Won Cheol, Prof., Dept. of Civil Engr., College of Engr., Yonsei Univ.

It is very important of select appropriate distributions for hudrological data in planning and designing hydraulic structures. Also, it is necessary to check whether the selected distribution reproduces the statistical characteristics of the real data. In this study, the parameters of the two-and three-parameter gamma, two-and three-parameter lognormal, Gumbel, two-and turee-parameter log-Gumbel, GEV, log-Pearson type III, two-and three-parameter Weibul, four-and five-parameter Wakeby distributions were estimated for the rainfall data of 22 sites in Korea with 7 different durations based on the methods of moments, probability weighted moments, and maximum likelihood. And the validity conditions were checked for the estimated parameters. The separation effect for each distribution was examined through 10,000 simulations using the estimated parameters. As results, the separation effect was the smallest: log-Pearson type III for moment method, log-Pearson type III and GEV for probability weighted moment method, and GEV for maximum likelihood method. However, it is large for the two-parameter distributions.

Pipe Network Analysis by Using Frontal Solution Method

Park, Jae Hong, Graduate Student, Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.
Han, Kun Yeun, Associate Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.

Steady state analysis of pressure and flow in water supply piping systems is a problem of great importance in hydraulic engineering. The basic equation consist of continuity equation and energy equation. The network equations are solved iterativey by using linear solution method. The

resulting linear simultanceous equations are solved by frontal method. Frontal method, which is suitable to sparse matrix, gathers only non-zero entries in coefficient matrix. The suggested methodology can analyze faster than the existing routines by using smaller computer memory. The model presented in this study shows accurate and efficient results for various piping systems.

Real-Time Flood Forecasting Using Rainfall-Runoff Model: Ⅱ. Application

Jeong, Dong Kug, Associate Prof., Dept. of Civil Engr., Hannam Univ.

The proposed flood forecasting system combines a flood routing model with a parameter estimation model. In the parameter estimation model system states and parameters are treated with the extended state-space formulation. The extended Kalman filter is adopted to estimate the states and parameters. A sensitivity analysis is used to investigate the relative significance of the parameters. Insensitive parameters are treated as constants and parameters that are mutually correlated are combined in a simplified form. The developed estimation methodology is applied to dam sites of the multi-purpose reservoirs in Korea. The forecasted hydrographs from the extended Kalman filter satisfactorily coincide with the observed. From the time sequence plots of estimated parameters, it is found that the storage coefficient is a almost constant, but exponent varies appreciably in time.

Analysis of Flood Flow Characteristics of the Han River using 1-Dimensional St. Venant Equations

Kim, Won, Researcher, Water Resources Engr. Division, Korea Institute of Construction Technolog.
Woo, Hyo Seop, Director, Water Resources Engr. Division, Korea Institute of Construction Technology
Kim, Yang Su, Senior Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Flood flow characteristics of the Han River(from Goan to Indo Bridge) are analyzed using 1-dimensional St. Venant equations. NETWORK, a finite difference model, is used to calculate each term(local acceleration term, convective acceleration term, pressure force term, gravity force term, and friction force tern) of the momentum equation and to analyze the flow characteristics. By the result of the study, as the general characteristics of flow in a channel that acceleration terms are very small and the other three terms are much greater is presented, three terms(pressure force term, gravity force term, friction force term) are to be main terms which decide the characteristics of flow. Specially in this region the acceleration term is noted so large that it cannot be ignored according to the shape of hydrogrph and the region.

Derivation of Sediment Concentration for the Computation of Total Sediment Discharge

Lee, Jong Seok, Instructor, Dept. of Civil Engr., Dankuk Univ.
Kim, Jin Kyoo, Prof., Dept. of Civil Engr., Seoul National Polytechnic Univ.
Cha, Young Kee, Prof., Dept. of Civil Engr., Dankuk Univ.

Quantitative computation of sediment discharge in alluvial channels is conducted by the determined method based on the incipient motion or the sediment transport concept. the derived formulation of sediment concentration in this study was developed in order to compute the total sediment discharge by a regression analysis method, one of the determined methods by the sediment transport concept. The used data set in derived formulation consists of the total 360 data including 135 and 225 measured data in natural channels and experimental channels, respectively. Also, the formulation by the multiple regression analysis was compoed of independent variables of flow depth, mean velocity, channel slope, Froude number and median diameter in bed materials.

Economic Feasibility Study on the Efficient Use of Advanced Water Treatment for Water Supply

Lee, Sang-Il, Assistant Prof., Dept. of Civil Engr., Dongkuk Univ.

Advanced water treatment for water supply is being introduced for the treatment of various organic materials which cannot be removed by conventional water treatment methods. While the development of advanced water treatment system appropriate to the domestic environment is essential, the study on the economic costs and the social impact is also of importance. In this paper, it is shown how to estimate the costs(capital and maintenance) for advanced water treatment facilities, especially those using ozone treatment combined with activated carbon process and membrane separation. Estimated costs were compared with the government budget. Also, a general relation between the system capacity and investment was derived. Four alternatives were considered from the aspect of the amount of water to be produced and the delivery system to the user. These alternatives were applied to the city of Pusan. It turned out that bottled water, produced only for drinking, has best economic advantages in having minimum system capacity without detriment to water quality.

A Comparative Study on Spatial and Temporal Line Interpolation of Characteristic Method

Paik, Joong Cheol, Graduate Student, Dept. of Civil Engr., Yonsei Univ.
Bae, Deg Hyo, Senior Researcher, Industrial Technology Institute, College of Engr., Yonsei Univ
Heo, Jun Haeng, Assistant Prof., Dept. of Civil Engr., College of Engr., Yonsei Univ.
Cho, Won Cheol, Prof., Dept. of Civil Engr., College of Engr., Yonsei Univ.

The subject research attempts to develop an new temporal interpolation scheme for the method of characteristics. The proposed three-point time-line Lagrange interpolation Reachback(3PR) method is a temporal quadratic interpolation scheme using the three grid points near the intersection between a characteristic line and a previous time-line. The accuracy of the 3PR method is compared with those of temporal and spatial interpolation schemes such as Reachback, Upwind, and quadratic spatial interpolation methods for two pure advection problems. The results show that on the aspects of the numerical damping and/or oscillation the temporall interpolation schemes are better than the spatial ones under the same interpolation order conditions. In addition, the proposed 3PR method improves the accuracy of Reachback method as well as it contains the merits of time-line interpolation schemes.

A Determination of Discharge Head of the Cherepnov Water Lifter with Siphon

Lee, Kwan Soo, Prof., Dept. of Civil Engr., College of Engr., Chunnam National Univ.
Rhee, Kyoung-Hoon, Assistant Prof., Dept. of Civil Engr., College of Engr., Chunnam National Univ.
Park, Sung Chun, Full-time Lecturer, Dept. of Environmental Engr., College of Engr., Dongshin Univ.
Jeong, Byoung Kyen, Assistant Prof., Dept. of Environmental Engr., Soonchun Industrial Technology College

This paper presents an experimental study on the discharge head of Cherepnov water lifter that was continuously operated with the aid of the siphon. The energy used by the Cherepnov water lifter is derived from the potential energy of the water itself. The lifter consists of three interconnected tanks and five pipes, one of which is open and two others are hermetically sealed. The effects of varying operating parameters such as the tank and pipe size, the ratio between head of discharge and drop height were analyzed. As a result, factors that can maximize the efficiency and increase the average delivery rate were indentified. When the ratio between head of discharge and drop height is about 0.5, the efficiency of Cherepnov water lifter is maximized. In order to design the efficient Cherepnov water lifter, the discharge head of the Cherepnov water lifter should be assigned to be twice as much as the drop height. The effect of tank size on the efficiency is less than 5%, while the effect of the pipe size is not negligible. The larger the pipe

size is, the more the efficiency increases.

A Study on the Index of Drought Warning and Emergency for the Municipal Water Supply Management

Cho, Hong-Je, Prof., Dept. of Civil Engr., Woolsan National Univ.

The goal of the present research was to suggest a simple, reiable, and easily evaulated index of drought that could be used to consider a counterplan for water supply management against water shortage for municipal and industrial uses in city area. The index of drought was calculated by the Phillips drought index technique. The Phillips drought index is based on exceedence probabilities of monthly precipitation but it can also utilize daily data in order to present drought information on a real-time basis when needed. The application of the suggested technique was tested to municipal water supply system and management of Ulsan city and Pohang city, and showed promising. The Phillips drought index technique could be used for any other city's drought contingency plan.

Preliminary Release Scheme by Flood Forecasting

Shim, Myung Pil, Prof., Dept. of Civil Engr., Inha Univ.
Lee, Jae Hyoung, Dept. of Civil Engr., Chunbuk National Univ.
Kwon, Oh Ig, Graduate Student, Dept. of Civil Engr., Inha Univ.

A preliminary release scheme(PRS) is suggested for the operating rules during flod period to deal with conflicts between flood control and water conservation purposes. PRS can be used to decide the optimum releases, based on the forecast of an oncoming flood and flow rate at the control point downstream when comparing the variable restricted water evel (VRWL) for flood control with the minimun required water ever (MRWL) for conservation use. The model is applied to Chungju and Daechung reservoirs through simulations of the technique. This study illustrates the procedure to decide the time size for preliminary releases. Also, effects of duration and magnitude of preliminary release are reviewed based on historical flood records. The simulation results indicate that the proposed PRS is effective for the managers to fine optimal operating policies during flood period. The proposed scheme can be used with main release scheme using real-time operation on hour-to-hour basis to decide the release for a flood.

Icing Loads on Fixed Cables : I. Laboratory Experiments

Yoon, B., Assistant Prof., Dept. of Civil Engr., College of Engr., Myongjee Univ.
Ettema, R., Iowa Institute of Hydraulic Research and College of Engr., Univ. of Iowa, USA

Presented herein are the results of a laboratory study on structural loads(icing weight and wind loads) associated with icing formation on rigidly fixed, circular power-transmission cables and cylinders. The experiments were carried out using movable wind tunnel under two different conditions : refrigerated and non-refrigerated conditions. Temporal evolution of icing loads were determined in the refrigerated laboratory and wind loads for icings at several stages of icing formation were measured in the non-refrigerated laboratory.

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Sediment Discharge Based on a Time-Integrated Point Sample

Jung, Kwan Sue, Senior Researcher, Korea Water Resources Corporation

A procedure for computing total suspended sediment load is presented based on a single point-integrated sample, a power velocity distribution, and Laursen's sediment concentration distribution equation. The procedure was tested with field data from the Rio Grande River. Computed concentrations agreed well with depth-integrated measurements corrected for unmeasured load using nominal values of β, κ, and w. Even better agreement was obtained when site-specific data were used to define the x and z exponents of the velocity and concentration distribution. The difference between total suspended oad computed using a single measurement and this procedure and conventional computations based on depthintegrated measurements is well within sampling error. There are major advantages in estimating total suspended load using a single time-integreated sus-pended-sediment point sample. Less field time is required; sampling costs are greatly reduced; and sampling can be more frequent and better timed to measure the changing sediment load. Single-point sampling makes automatic sampling procedures more feasible.

Surface Saturation Area-Subsurface Outflow-Soil Moisture Storage Reationship: Ⅱ. Dynamic Analysis

Lee, Do Hun, Assistant Prof., Dept. of Civil Engr., College of Engr., Kyonghee Univ.
Lee, Eun Tae, Prof., Dept. of Civil Engr., College of Engr., Kyonghee Univ.

The dynamic responses in the subsurface outflow, surface saturation area, soil moisture storage are established by numerical experiments with Richards eqution. In addition to this, the dynamical relationships between surface saturation area and subsurface outflow, and between surface saturation area and soil moisture storage are also determined by varying the hillslope shape, soil type, and boundary condition. The simulation resuts indicate that the dynamical relationships between surface saturation area and subsurface outflow, and between surface saturation area and soil moisture storage are approximated by the steady-state relationship. And the dynamic responses of subsurface outflow and surface saturation area are characterized by the double peaks although the rainfall pattern is a simple pulse input. As a resullt of numerical simulation, the physical mechanism for the occurrence of the double peaks is explained using the concept of variable source area.

A Study on Unsteady Flow Model Including Weir Flow Simulation

Jun, Kyung Soo, Assistant Prof., Dept. of Civil Engr., College of Engr., Seongkyoonkwan Univ.

One-dimensional unsteady flow model including weir flow simulation is studied. Applicabilities of both the single channel model with local treatment of the weir overflow, and the looped-network model are studied using a test problem. It is shown that various types of weir flows including reverse flows are successfully simulated. Flow discontinuity due to the high crese elevation can also be simulated. The reverse free-flowing overflow can be simulated by the single-channel model as well as by the looped-network model.

Design of Automatic Monitoring Network for the Water Quality Management of River Basin

Choi, Ji-Yong, Institute of Korea Environmental Technology Development
Park, Won-Kyu, Dept. of Civil Engr., Dongkuk Univ.
Lee, Sang-Il, Assistant Prof., Dept. of Civil Engr., Dongkuk Univ.

In designing automatic water quality monitoring networks for a river basin, determination of measurement locations and items is critical to the effectiveness of the total system. In this paper we studied how to decide these two design factors when a monitoring network is designed for

the purpose of water quality surveilance and emergency alarm. For measurement locations, candidate sites are chosen based on the intake amount for water supply and the point sources of contamination. Then, detailed locations are decided according to the contaminant flow distance. As for measurement items, characteristics and the accident history of water pollution in the basin must be taken into account. Considering economic aspects, we proposed a two-stage measurement plan: basic components for all locations and selective ones variable for different locations. Proposed methodology is demonstrated through a case study for Nak-dong River Basin.

Statistical Analysis of Water Quality in the Downstream of the Han River

Baek, Kyung Won, Technological Support Division, Korea Infrastructure Safety & Technology Corporation

Chung, Yong Tai, Assistant Prof., Dept. of Environmental Mgmt., Soonchun Technical College

Han, Kun Yeun, Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.

Song, Jai Woo, Prof., Dept. of Civil Engr., Hongik Univ.

The characteristics of water quality in the downstream of the Han River were analyzed by statistical techniques. Basic characteristics, areal and temporal variations, and correlations of water quality data were investigated. Monthly water quality data have been investigated systematically by exploring data analysis, including time series plot, summary statistics, distribution test, time dependence test, seasonality test and flow relatedness test. Results show that water quality data in this river have seasonality. And applicability of stochastic models such as Thomas-Fiering model and ARMA(1, 1) model was identified. From the examination of water quality data related to discharge, it was found that DO and SS are sensitive to water temperature rather than discharge, while BOD and COD are sensitive to discharge at dry seasons. Seasonal periodicities were identified in all water quality variables from the cross correlation analysis.

Icing Loads on Fixed Cables: Ⅱ. Determination of Proper Length Scale

Yoon, B., Assistant Prof. , Dept. of Civil Engr., College of Engr., Myongjee Univ.

Pokorny, M., Iowa Institute of Hydraulic Research and College of Engr., Univ. of Iowa, USA

Ettema, R., Iowa Institute of Hydraulic Research and College of Engr., Univ. of Iowa, USA

Attempts were made to determine a proper length scale representing characteristics of icing geometry. It was difficult to determine a single length scale especially for glaze icings because of their shape complexity. However, use of icing length, which is defined as the length of icing nor-

mal to the wind, as a characteristic length is suggested rather than the cylinder or cable diameter.

A Numerical Analysis of Thermal Discharge using k-l Turbulence Closure

Choi, Hung Sik, Assistant Prof., Dept. of Civil Engr., Sangjee Univ.

To evaluate the usage of k-l turbulence closure for the analysis of thermal discharge behavior, a two-dimensional depth-integrated numerical model is developed. The developed model is applied to a steady flow in an open channel with simpe geometry and the numerical results agree well with existing experimental data. The adequate simulation of recirculation, reattachment, and excess temperature rise at downstream of the outlet in the channel attributes to the correct calculation of turbulent eddy viscosity and diffusivity by k-l turbulence model. For an accurate prediction of thermal discharge behavior, the introduction of buoyancy production term, the modification of source/sink, and the correct input of turbulence constants of the k-l turbulence model are required.

Gate Operation Rule of Paldang Dam by Considering Discharge and Downstream Flow Pattern

Seo, Kyu Woo, Graduate Student, Dept. of Civil Engr., Yonsei Univ.
Lee, Jong Seol, Graduate Student, Dept. of Civil Engr., Yonsei Univ.
Heo, Jun Haeng, Assistant Prof. , Dept. of Civil Engr., College of Engr., Yonsei Univ.
Cho, Won Cheol, Prof., Dept. of Civil Engr., College of Engr., Yonsei Univ.

The existing gate operation rule of Paldang hydroelectric plant has been used since the construction of the dam in 1973 except partial modification due to the construction of Chungju multipurpose dam in 1985. The water level near the downstream of Paldang dam has been lowered about 3m because of the channel maintenance of Han River development project. Thus, the discharge estimation formula based on the submerged orifice type spillway has to be re-evaluated by considering various patterns of the gate operation rules and lowered channel bed. In this study, three types of gate openings were tested to select the proper gate operation rules through the hudraulic model test for various discharges and opening heights. Also. the numerical analysis has been performed to simulate the flow patterns of downstream. As a result, the gate operation rule, which opens 5gates each time from the left side, was selected as the proper gate operation rule of Paldang dam.

A Numerical Analysis of Buoyant Surface Jet with Turbulence Models

Choi, Han Ki, Associate Prof., Dept. of Civil Engr., Pusan Technical College
Keiji Nakatsuji, Prof., Dept. of Civil Engr., College of Engr., Osaka Univ., Japan

To investigate the hudrodynamic characteristics of the two-dimensional buoyant surface jet, the most important factors of the numerical analysis are the evaluation of the free surface and the turbulence transportation under the stratification. In present study, a numerical simulation model used with the semi-implicit method for pressure-inked equations(SIMPLE), the non-hydrostatic approximation and the algebraic stress model(ASM) is applied to investigate the vertical structure of inernal flow hydrodynamically. The ASM enables to take account of anisotropy of turbulence, the damping effects of the density interface, and the free surface on the turbulence structure accurately. The ASM tested produces better agreement than the k-ε model with measurements by Nakatsuji(1984) on the flow development and turbulence structure. Applicability of the ASM to a two-dimensional buoyant surface jet is examined through comparison with experimental data.

Characterization of Local Evapotranspiration Based on the Seasonal and Hydrometeorological Conditions

Rim, Chang Soo, Senior Researcher, Water Resources Research Institute, Korea Water Resources Corporation
Lee, Jong Tae, Prof., Dept. of Civil Engr., College of Engr., Kyongki Univ.
Yoon, Sei Eui, Prof., Dept. of Civil Engr., College of Engr., Kyongki Univ.

Meteorological and soil water content data measured from semiarid watersheds of Lucky Hills and Kendall during the summer rainy and winter periods were used to study the interrelationships between the controlling variables of the evapotranspiration, and to evaluate the effects of variables on daily actual evapotranspiration(ET) extimation. Simple and multiple linear regression(MLR) analyses were employed to evaluate the order of importance of the meteorological and soil water factors involved. The information gained was used for MLR model development. The available energy and vapor pressure deficit were found to be the important variables to estimate actual ET(AET) for both periods and at both watersheds. Therefore, the important variables of evaportanspiration process in these semiarid watersheds appear to be simply the components of energy term in available energy and aerodynamic term in vapor pressure deficit of Penman potential evapotranspiration(PET) equation.

Development of a Simple In-Situ Data Logger

Yeo, Woon Kwang, Prof., Dept. of Civil-Environmental Engr., Myongjee Univ.
Yoon, Byung Man, Prof., Dept. of Civil-Environmental Engr., Myongjee Univ.
Lee, Jong Kook, Completed courses for Ph. D. degree in Ohio State Univ.

There have been easily found a number of examples that miseading or unreasonable measuring data set of physical variables are often produced in the field and the laboratory. The primary reason is that the specific requirements of civil engineers are initially disregarded in designing the experimental apparatus. It results from a lack of mutual understanding and co-operation between the user group and the maker. Therefore, their fundamental knowledge and apprehension become indispensible in order to obtain measuring data with high confidence and good quality. In this study it is shortly explained the basic structure and the operation system of the experimental equipments commonly used at the present. A Simple measuring set is developed which is quied easy for a general civil engineer to design and operate without any other specialty of mostly electricity/electronics. Based upon this requirement, one of data logger named PPDL8 is newly designed by making use of the parallel port in the personal computer, consisting of multi-channels able to measure 8 different point values simultaneously. It can also use many valuable sub-programs existing in PC because the user makes his own programs necessary for measurement, by himself. Of all things, it has a great advantage to increase the appicability of field measurements much larger when adopting the notebook computer to operate with small battery only. In addition this study gives, in fact, the excellent agreements of in-situ field variables by showing their measuring results of temperature, distance and turbidity.

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An Examination of Sediment Discharge Computation Errors Related to Imprecise Factors

Jung, Kwan Sue, Jung, Kwan Sue, Senior Researcher, Korea Water Resources Corporation

This study investigates the magnitude of errors that can be expected in integrating sediment concentration in a vertical, based on a single-point measurement, because of errors in input data. Potential error sources, including sampler location, water surface elevation, bed elevation, fall velocity β, value κ, and value were comparatively examined using data from a special study on the Rio Grande Conveyance channel in New Mexico. It is concluded that simple forms of equations for the vertical distribution of velocity and sediment concentration are sufficiently accurate to compute average sediment concentration based on a single-point field sample of sus-

pended sediment. The most uncertain point in the computation is related to the Rouse number z in the equation for the vertical concentration distribution of suspended sediment.

An Experimental Study of Backwater Effects Caused by Piers in the Covered Reach of Urban Streams

Yoon, Yong Nam, Prof., Dept. of Civil-Environmental Engr., Korea Univ.
Ahn, Jae Hyun, Water Resources Division, Doosan Engr. Corporation
Kim, Jin Kwan, Water Resources Division, Korea Engineering Consultant Group

The hydraulics of flow within the covered reach of urban streams is very complicated due to the accumulation and interference effect of eddies around the multiple piers supporting the covering slab. An extensive experimental study is done to quantitatively estimate the backwater rise effect caused by various arrays of multiple piers. The factors governing the backwater rise are found out to be the contraction ratio due to the piers, Froude number of the flow, longitudinal pier spacing, and the length of the covered reach. For a single section of lateral pier arrays the effect of contraction ratio and Froude number on the backwater rise is analyzed and a multiple regression equation is derived. The effect of multiple piers, arrayed in both lateral and longitudinal directions, on the backwater rise is analyzed in terms of the contraction ratio, Froude number, longitudinal pier spacing and the total length of the covered reach. A multiple regression equation for the backwater rise estimation is proposed based on the experimental data collected in the present study.

Flood Runoff Characteristics in Urbanized Basin

Han, Kook Hee, Assistant Prof., Dept. of Civil Engr., Ahnyang Technical College
Lee, Kil Choon, Prof., Dept. of Civil Engr., College of Engr., Dankuk Univ.

This study is runoff analysis of the recently urbanized San Bon basin. The relationships between peak discharge and total discharge were examined by applying the ILLUDAS runoff analysis model to the measured data. In urbanized streams, it is found that channel adjustment had the most significant effect on the increase of peak discharge. Significant increases in the peak discharge occurred as rainfall duration or return period increases 10% and 7~16% increases in peak discharge were observed when the roughness coefficient were 0.04 and 0.015, respectively. When the natural river channel with n=0.04 was converted into a sewerage system of n=0.015 the peak discharge was greatly increased by 51~158%. Generally, flood peak discharge was increased during heavy rain, but in the case of urbanized basin, river stage was reduced owing to an increase of flow velocity by the adjustment of drainage system.

Explicit Design of Uniformly-Rough Pipe on a Slope with Pumping Power

Yoo, Dong Hoon, Prof., Dept. of Civil-Design Engr., College of Engr., Ahju Univ.
Kang, Chan Soo, Prof., Dept. of Civil-Design Engr., College of Engr., Ahju Univ.

When a pipe is deployed on a sloping bed, pumping power required for a discharge can be estimated immediately without any iteration process with an explicit form of a friction factor equation. Pumping power being given, however, traditional method requires an iteration process for the solution of discharge and pipe diameter even for the uniformly-rough pipe. Yoo (1995b) has suggested explicit equations for the estimation of discharge and pipe diameter particularly for the cases of pipe on a sloping bed without pumping and pipe on a horizontal bed with a pumping power. Based on his approach and previous results, the present researchers have developed explicit equations of discharge and pipe diameter for the general case of pipe on a sloping bed with a pumping power. The equations of boundary criteria are also presented in explicit way which render proper choice of various equations suitable for the flow condition between five characteristics. Verification studies are also carried out by applying the explicit equations to a practical example.

Water Quality Impact Assessment Due to Dredging in the Downstream of the Nakdong River

Cho, Hong-Je, Prof., Dept. of Civil Engr., Woolsan National Univ.
Han, Kun Yeun, Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.
Kim, Sang Ho, Graduate Student, Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.

QUAL2E model was applied to assess the water quality variations due to dredging of the bottom deposit in the downstream of the Nakdong River. A variedflow analysis was performed for the reach of Namji to Nakdong Estuary to estimate the hydraulic parameters. BFGS (Broyden-Fletcher-Goldfarb-Shanno) method was applied to determine the optimum reaction parameters and model verification was performed based on these. Water quality modeling of dredging effects for BOD and DO in the reach was performed under low and average flow conditions and alternatives. It revealed that dredging had significant effects on the improvement of water quality in the reach.

Hourly Rainfall Surface Prediction with Meteorological Radar Data

Jung, Jae Sung, Researcher, Water Resources Research Institute, Korea Water Resources Corporation
Lee, Jae Hyoung, Prof., Dept. of Civil Engr., College of Engr., Chunbuk National Univ.

In this study, a methodology for the hourly prediction of rainfall surfaces was applied to the Pyungchang river basin at the upstream of South Han river with meteorological radar and ground rainfall data. The methods for the exclusion of abnormal echoes, and suppression of ground clutter, and the augmentation of attenuation effects associated with rainfall phenomena were reviewed, and the relationship between radar reflectivity (Z) and rainfall rate (R) was analyzed. The transformation of augmented radar reflectivities into the radar rainfall surfaces was carried out, and afterward they were synthesized with the ground rainfall data generating the hourly rainfall surfaces. For the prediction of hourly rainfall surface, the moving factors of rainfall field estimated by the cross correlation coefficient method and the temporal variation of radar rainfall intensities were considered. The synthesized hourly rainfall surfaces were used to predict the hourly rainfall surfaces up to 3 hours in advance and subsequently the results were compared with the measured and the synthesized. It seems that the prediction method need to be verified with more data and be complemented further to consider the physical characteristics of rainfall field and the topography of the basin.

Development of Rehabilitation and Management Techniques for Old Water Distributions Systems

Kim, Joong Hoon, Assistant Prof., Dept. of Civil-Environmental Engr., Korea Univ.
Geem, Zong Woo, Graduate Student, Dept. of Civil-Environmental Engr., Korea Univ.
Lee, Hyun Dong, Senior Researcher, Environmental Research Division, Korea Institute of Construction Technology
Kim, Seong Han, Korea Water Resources Corporation

Flow carring capacity of water distribution systems is getting reduced by deterioration of pipes in the systems. The objective of this study is to develop a managerial decision-making model for the rehabilitation of water distribution systems with a minimum cost. The decisions made by the model also satisfy the requirements for the discharge and pressure at demanding nodes in the system.

The replacement cost, pipe break repair cost, and pumping cost are considered in the economic evaluation of the decision along with the break ratio and interest ratio to determine the optimal replacement time for each pipe. Then, the hydraulic integrity of the water distribution system is checked for the decision by a pipe network simulator, KYPIPE, if the discharge and pressure

requirements are satisfied. In case the system does not satisfy the hydraulic requirements, the decision made for the optimal replacement time is revised until the requirements are satisfied. The model is applied to an existing water distribution system, the Metropolitan Water Supply Project (1st Phase). The result shows that the decisions for the replacement time determined by the economic analysis are accepted as optimal and the hydraulic integrity of the system is in good condition.

A Study on the Variation of Runoff and Travel Time in Urban Stream due to Watershed Development

Seo, Kyu Woo, Graduate Student, Dept. of Civil Engr., Yonsei Univ.
Bae, Deg Hyo, Assistant Prof. , Dept. of Civil Engr. , Changwon Univ.
Shim, Jae Hyeon, Senior Researcher, Korea Regional Administration Research Institute
Lee, Jae Joon, Associate Prof., Dept. of Civil Engr., College of Engr., Kumoh Univ.

The subject research attempts to evaluate the variations of total runoff volume, peak flow, and travel time depending on the urbanization, return periods and rainfall patterns under the situations that the preparation of a large residential site at the lowland areas of the downstream of Dongsu stream in Bupyung-Gu, Incheon city is progressed and the area will be eventually fully developed. The ILLUDAS model was used for the runoff analyses based on 3 different steps of urbanization and 4 different types of Huff's quantile according to 7 return periods. It is shown that the order of magnitude of peak flow according to rainfall patterns is Huff's 4 quantile,. Huff's 2 quantile, Huff's 3 quantile and Huff's 1 quantile. Under the 80 and 90% of urbanization to the 70% of urbanization, the mean increasing ratio of total runoff volume for each case is 3.5 and 5.5%, that of peak flow is 4.2 and 8.8%, and mean decreasing ratio of travel time is 4.4 and 10.1%, respectively. The mean increasing ratio of total runoff volume according to the return periods is 3.0 and 5.4%, that of peak flow is 3.9 and 8. 0% under the same conditions of urbanization.

Flow Routing in Prismatic Symmetrical Compound Channels by Applications of Apparent Shear Force

Chun, Moo-Kab, Senior Researcher, Rural Development Corporation
Jee, Hong-Kee, Prof., Dept. of Civil Engr., College of Engr., Yeungnam Univ.

A new routing computer model for the symmetric compound channel called the ASFMCS (Apparent Shear Force Muskingum-Cunge Method in Symmetry) is developed. The Muskingum-Cunge routing method is adapted. The Apparent Shear Force (ASF) between the deep main channel and shallow floodplain flow is introduced while the flow is routed. The nonlinear par-

ameter method is applied. The temporal and spatial increments are varied according to the flow rate. The adaptation of above schemes is tested against the routed hydrographs using the DAMBRK model.

The results of general routing practice of Muskingum-Cunge Method (GPMC) are also compared with those of the above two models. The results of the new model match remarkably well with those of DAMBRK. The routed hydrographs show smooth variation from the inflow boundary condition without any distortions caused by the difference of cross-section shape. However, the results of GPMC, showing earlier rising and falling of routed hydrograph, have considerable differences from those of the ASFMCS and DAMBRK.

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A Study on rainfall Prediction by Neural Network

Oh, Nam Son, Full-time Lecturer, Dept. of Ocean & Shipbuilding, Mokpo Ocean Engr. College
Sonu, Jungho, President, Seoul National Univ.

The neural networks is a mathematical model of theorized brain activity which attempts to exploit the parallel local processing and distributed storage properties. The neural network is a good model to be applied for the classification problem, large combinatorial optimization and nonlinear mapping. A multi-layer neural network is constructed to predict rainfall. The network learns continuousvalued input and output data. Application of neural network to 1-hour real data in Seoul metropolitan area and the Soyang River basin shows slightly good predictions. Therefore, when good data is available, the neural network is expected to predict the complicated rainfall successfully.

Comparison of Daily Soil Water Contents between Energy Balance-Water Budget Approach and TDR

Rim, Chang Soo, Senior Researcher, Water Resources Research Institute, Korea Water Resources Corporation

The daily soil water contents were obtained from the time domain reflectometry (TDR) method and energy balance-water budget approach with eddy correlation at the two small semiarid watersheds of Lucky Hills and Kendall during the summer rainy period. There was a comparison of daily soil water content measured and estimated from these two different approaches. The comparison is valuable to evaluate the accuracy of current soil water content measuring system using TDR and energy balance-water budget approach using eddy correlation method at small watershed scale. The degree of similarity between the regressions of these two methods fo

measuring soil water content was explained by determining the correlations between these methods. Simple linear regression analyses showed that soil water content measured from TDR method was responsible for 58% and 63% of the variations estimated from energy balance-water budget approach with eddy correlation at Lucky Hills and Kendall, respectively. The scatter plots and the regression analyses revealed that two different approaches for soil water content measurement at small watershed scale have no significant difference.

A Study of Optimal Operation of Sewage Treatment Plants Using NLP

Kim, Joong Hoon, Assistant Prof., Dept. of Civil-Environmental Engr., Korea Univ.
Yoon, Yong Nam, Prof., Dept. of Civil-Environmental Engr., Korea Univ.
Ahn, Jae Hyun, Graduate Student, Dept. of Civil-Environmental Engr., Korea Univ.
Kim, Jeong Hwan, Graduate Student, Dept. of Civil-Environmental Engr., Korea Univ.

The objective of this study is to develop an optimal operation model for the sewage treatment plants using nonlinear programming (NLP) technique and the QUAL2E model. The model finds the minimum-cost operation of sewage treatment plants while satisfying all design constraints and water quality (BOD) standard. The model is applied to four sewage treatment plants in Han River for the city of Seoul. It has been found that optimal operation schedule for the sewage treatment plants can be computed and it is more economic to operate the plants according to the schedule which satisfies the water quality constraints in the river. In additions, the water quality in the river can be predicted using the model under the treament policy.

Determination of Design-Width for Medium Rivers of Central Area in Korea

Ahn, Sang Jin, Prof., Dept. of Civil Engr., College of Engr., Chungbuk National Univ.
Kwon, Pong Hee, Dept. of Flood Control, Chungbuk Province

The stream morphological characteristics of river basin has a close correlation with the hydrological and hydraulic characteristics of the basin. This study was conducted to suggest a river width formula for medium rivers of central area in Korea. As a result, The following conclusions are made: (1) The model for the stream-width to be applied to the medium rivers of central area in Korea is developed as suggestion model-a function of the design flood discharge-of which the formula is $B=1.532Q^{0.6444}$, (2) The model for the stream-width to be applied to the medium rivers of central area in Korea is developed as suggestion model-a function of the watershed Area-of which the formula is $B=12.392A^{0.511}$, (3) The model for the stream-width to be applied to the medium rivers of central area in Korea is developed as suggestion model-a function

of the stream length of which the formula is $B=10.509L^{0.852}$.

A Study on the Introduction of Fuzzy Theory to the Adjustment of Time-Variant Parameter of Storage Function Method

Lee, Jong Kyu, Prof. , Dept. of Civil Engr., Hanyang Univ.

Lee, Chang Hae, Full-time Lecturer, Dept. of Environmental Engr., DaeJin Univ.

The parameters of the storage function model (SFM) are taken as constants, while they have different values every rainfall events and time of the runoff.

Therefore, the results of the SFM show remarkably large errors in general. In this study, the modified storage function model (MSFM), in which the time variant parameters are introduced, is proposed to improve the SFM which is a conceptual rainfall-runoff model. The fuzzy reasoning is applied as a real-time control method of the time-variant parameters of the proposed model. The applicability of MSFM was examined in the Bochung river, a tributary of Geum river in Korea. The pattern of predicted outflow hydrograph and peak outflow by the MSFM with fuzzy control are much similar to the measured values in comparison with the results produced by the SFM.

Development of a Method for Determining the Instream Flow and Its Application : Ⅰ. Estimation Method

Kim, Kyu-Ho, Senior Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Lee, Jin-Won, Senior Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Hong, Il-Pyo, Senior Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Woo, Hyo Seop, Director, Water Resources Engr. Division, Korea Institute of Construction Technology

Methods for determining the instream flow in the stream were explored and examined through careful reviews and evaluations fo available literatures. Development of the instream flow estimation method is based on the reviewed results and methods which can be used within the acceptable levels. The newly-developed method was tested on the streams which require maintaining some riverine functions, such as the instream flow and river-management flow at the specific channel reach or representative station of the river. The riverine functions mainly considered in this study are the minimum flow, water quality conservation, fish habitat rehabilitation and conservation, riverine aesthetics, river navigation and recreation, and so on. As a re-

sult, the newly-developed instream flow estimation method is expected to be used effectively for determining the instream flow, which is necessary in order to maintain the natural or artificial riverine functions.

Developement of Transverse Bed Slope Model for Nonuniform Sand Bed at River Bend

Choi, Jong In, Associate Prof., Dept. of Civil Engr. , Samchug Industrial Technology College
Ko, Jae Ung, Prof., Dept. of Civil Engr., College of Engr., Keonkuk Univ.

The analytical approach to determine transverse sand bed slope at river bend are based on two phases that the flow is considered as fully developed flow and the bed is fluvial having bed load. All existing methods ard theoretically dervied from the initiation of motion of the particles at river bed. They assume that the Shields parameter has a constant value of 0.06. In this study, the variability of Shields parameter due to the differences of shape of grain size distribution is considered. Therefore the parameter is not a constant, 0.06, but depends on the shape of the grain size distribution. This result gives good agreement to estimate transverse bed slope with actual field data at river bend.

A Numerical Method for Dispersion of Unsteady Horizontal Line Source in Turbulent Shear Flow

Jun, Kyung Soo, Assistant Prof., Dept. of Civil Engr., College of Engr., Seongkyoonkwan Univ.

A numerical model for unsteady dispersion of horizontal line source in turbulent shear flow is developed. A fractional step finite difference method is used which splits the unsteady two-dimensional advective diffusion equation into the longitudinal advection and the vertical diffusion equations, and solves them alternately for half time intervals by the Holly-Preissmann scheme and the Crank-Nicholson scheme, respectively. The developed numerical model is verified using a semi-an-alyti solution for steady dispersion in turbulent shear flow. Dispersion of an instantaneous plane source in turbulent shear flow is analyzed using the model.
The degree of mixing at the same dimensionless time is almost the same regardless of the friction factor, and the travel distance required to reach a certain degree of mixing is inversely proportional to the square root of the friction factor.

Calculation of Watershed Topographic Index with Geographic Information System

Kim. Sang Hyun, Research Assistant, Dept. of Civil Engr., Purdue Univ., USA
Han, Kun Yeun, Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.

The multiple flow direction algorithm to calculate the spatial variation of the saturation tendency, i. e. topographic index, is integrated into the Geographic Information System, GRASS. A procedure is suggested to consider the effect of a tile system on calculating the topographic index. A small agricultural subwatershed (3.4㎢)is used for this study. The impact of a tile system on the groundwater table can be effectively considered by the Laplace's equation to the DEM. The analysis shows that a tile system has a high degree of saturation compared to the case without tile drainage, and the predicted riparian area is well fitted to the actual watershed condition. A procedure is suggested to consider the effect of tile system on calculating the topographic index.

Comparison of Runoff Models for Small River Basins

Kang, In Shik, Researcher, Production Technology Institute, Pusan National Univ.

It may be difficult to make exact estimates of peak discharge or runoff depth of a flood and to establish the proper measurement for the flood protection since water stages or discharges have been rarely measured at small river basins in Korea. Three small catchments in the Su-Young river basin in Pusan were selected for the study areas. Various runoff parameters for the study areas were determined, and runoff analyses were performed using three different runoff models available in literatures; the storage function method, the discrete, linear, input-output model, and the linear reservoir model. The hydrographs calculated by three different methods showed good agreement with the observed flood hydrographs, indicating that the models selected are all capable of sucessfully modeling the flood events for small watersheds. The storage function method gave the best results in spite of its weakness that it could not be applicable to small floods, while the linear reservoir model was found to provide relatively good results with less parameters. The capabilities of simulating flood hydrographs were also evaluated based on the effective rainfall from the storage function parameters, the ϕ-index method, and the constant percentage method.

For the On-Cheon stream watershed, the storage function paraneters prpvided better estimates of effective rainfall for regenerating flood hydrogrpahs than any others considered in the study. The ϕ-index method, however, resulted in better estimates of effective rainfall for the other two study areas.

Predicting Flow Resistance Coefficients in Water Supply Mains

Son, Kwang-Ik, Full-time Lecturer, Dept. of Civil Engr., College of Engr., Yeungnam Univ.

For the most efficient operation of water mains, 124 head losses in domestic water supply steel mains were measured to provide the values of friction coefficient and the variables affecting the deterioration rate of Hazen Williams' and Darcy-Weisbach's friction coefficient. The experimental results show that pipe age is governing the friction coefficient of large mains (Diameter > 1100 mm).

On the other hands, pipe age and pipe diameter are affecting the variation of carrying capacity for small mains (Diameter < 1100 mm). The friction coefficient of water mains in foreign countries is higher than that in Korea by about 5 to 10 in Hazen Williams' C value. The growing rate of roughness height of domestic water main is about 0.41 mm/year which is higher than the average of United States of America. So further study is required to find out what causes the serious deterioration rate.

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Unsteady Flow Analysis by the Looped Network Channel Model

Park, Bong Jin, Korea Water Resources Corporatior

Lee, Hwan Ki, Korea Water Resources Corporation

Jung, Kwan Sue, Korea Water Resources Corporation

Loopnet model was developed to simulate unsteady flow in the looped network channel, considering change of the time and space. In this study, the looped solution algorithm was derived and the accuracy and stability of the model was tested. The Gulpo river system was used to calculate the flood water levels considering the hydraulic structures, tidal effect and inflow hydrographs. The result of the simulation showed that the accuracy and stability of this model was reliable. The change of flood water level of the Gulpo River system and the spillway section were not greatly affected by the operation water level of the navigation channel. But this analysis showed that roughness was one of the very important physical factor in changing flood water level.

Effect of Change of Numerical Parameters on Outflow Characteristics in the Linear Muskingum-Cunge Method

Kim, Jin Soo, Assistant Prof., Dept. of Agricultural Engr., College of Agriculture, Chungbuk National Univ.

This paper presents the effect of numerical parameters, such as grid size and grid ratio, on the outflow hydrograph of a unit-width plane in the linear Muskingum-Cunge method. The numerical results depend on Courant number C and cell Reynolds number D, two physically and numerically meaningful parameters. As C approaches 1 and D increases, the numerical dispersion-relating oscillations are difficult to occur. The numerical oscillations occur in the front of a propagating wave for $C < 1$, while smaller oscillations occur behind the wave for $C > 1$ due to the numerical diffusion effect. For a plane with a small value of characteristic reach length L (e.g., a steep plane), the numerical solution of the Muskingum-Cunge method is similar to that of the kinematic wave method, which shows no wave attenuation. However, for a plane with a large value of L (e.g., a mild plane), the Muskingum-Cunge method leads to the diffusion waves which are essentially independent of the Courant number. Accordingly, the Muskingum-Cunge method will be suited for the routing of the catchment with relatively mild slopes.

Development and Analysis of Stage-Damage Curves for the Kum River Basin

Yoo, Ju Hwan, Research Assistant, College of Engr., Chungnam National Univ.
Kwon, Oh Hun, Prof., College of Engr., Chungnam National Univ.
Ko, Jae Ung, Prof., Dept. of Civil Engr., College of Engr., Keonkuk Univ.

In the flood surveys, it is fundamental to set up the relations of stage-damage.
And this makes it possible to evaluate the flood regulation effects of the multipurpose dam and/or levee construction for optimum formulation. Unfortunately in the previous basin studies excluding the Han river basin survey, the conventional approaches on this matter have not been performed due to its time-comsuming complexity. In thos study we attempted a new method based on the disaster status, and constructed six stage-damage curves along the reaches of the Kum river basin, based upon the flood events records for recent 12 years (1981-92).

Pipe Network Analysis according to Friction Factor of Commercial Pipe

Yoo, Dong Hoon, Prof., Dept. of Civil-Design Engr., College of Engr., Ahju Univ.
Wun, Yoo Seung, Graduate Student, Dept. of Civil-Design Engr., College of Engr., Ahju Univ.
Yoon, Kye Sup, Executive Director, Environmental Project Division, Daewoo Engr. Corporation

Studied are the existing equations of Hazen-Williams and Colebrook-White, and the equations of Yoo's (1995) mean zero velocity point and mean friction factor developed for the estimation of commercial pipe friction factor. Simple arrangements of pipe network are devised by changing the diameter, flow discharge and length, and the characteristics of four equations are inverstigated by comparing the computed results of pressures at each node. Three groups of pipe diameter, small, medium, large, are considered in the comparison, and various problems of existing equations are discussed based on the computed results of pressures and velocities.

Finite Volume Method for Two-Dimensional Unsteady Flow in Open Channel

Lee, Jin Hee, Former Graduate Student, Dept. of Civil Engr., Inha Univ.
Kim, Kyung Tak, Graduate Student, Dept. of Civil Engr., Inha Univ.
Shim, Myung Pil, Prof., Dept. of Civil Engr., Inha Univ.

In this study, a two-dimensional shallow-water equation was used to develop the mathematical model for computing water levels and flow distribution. In the discretization equations, based on the finite volume method (FVM), the third order Runge-Kutta method and the third order upwind scheme were introduced to handle the unsteady and convective terms in the governing equations. To determine the accuracy of the developed model, it was applied to the rectangular horizontal channel in a frictionless flow. The water depth and velocity obtained by the numerical model were found to agree closely with the exact solution. The model was also applied to the rectangular channel with both the symmetric and the non symmetric constriction. The velocity distribution of the flow and the propagation of the flood wave were simulated and the results well described the flow characteristics.

Development of a Method for Determining the Instream Flow and Its Application : Ⅱ. Application and Result

Kim, Kyu-Ho, Senior Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Kim, Sun-Mee, Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Lee, Sam-Hee, Researcher, Water Resources Engr. Division, Korea Institute of Construction Technology

Woo, Hyo Seop, Director, Office of Planning & Coordination, Korea Institute of Construction Technology

The newly-developed method for estimating the instream flow, proposed by the authors (1996), was applied to the main channel reach of the Kum River basin in Korea. Performance of the suggested method was tested through the evaluations of the required flow, instream flow, and river-management flow which were estimated at five main reaches with each representative station. The mean drought flow was used as the object flow to evaluate the minimum instream flow for the mid and large-size rivers. Water quality prediction by using the QUAL2E model was made for both cases that the planned wastewater treatment facilities may and may not be constructed. The required flow for the fish habitat was evaluated for 9 representative fish species. The instream flows required for the riverine-aesthetics at Kong-ju and Puyo scenary points, for river navigation at natural channel conditions, and for current and potential recreation activities were evaluated, respectively. The instream flows required for other items are not quantified. On the whole, it is shown that the instream flow to maintain the natural riverine functions such as fish habitat, and riverine aesthetics govern the upstream reaches of the Kum River, and the artificial riverien functions such as conservation of water quality, navigation and recreations govern the middle and downstrean reaches. Especially, it is found that the instream flow requirement depends largely upon the construction of wastewater treatment facilities at the Kum River basin.

Estimation of Water Balance based on Satellite Data in the Korean Peninsula

Shin, Sha Chul, Senior Researcher, Water Resources Research Institute, Korea Water Resources Corporation

Quantifying water balance components is crucial to understanding the basic hydrology and hydrochemistry. An importance of water balance has been suggested in order to grasp actual condition of water resources and environmental changes including climatic changes. The present paper proposes an evaluation method of the water balance components based on vegetation monitoring from remote sensing data. In this study, evapotranspiration model adopts a direct method by using NDVI (Normalized Difference Vegetation Index) calculated from NOAA/AVHRR data

and the detailed description of water balance by using the evapotranspiration in all over the Korean Peninsula. Areal distribution data sets of evapotranspiration, runoff ratio, water surplus and deficit are produced using NDVI and simplified water balance model. This method enables to discuss the hydrological problems for North Korea where enough meteorological and hydrological data are unavailable.

A Study on Logconductivity-Head Cross Covariance in Two-Dimensional Nonstationary Porous Formations

Seong, Kwanjae, Assistant Prof., Dept. of Mechanical Engr., Dongkuk Univ.

An expression for the cross covariance of the logconductivity and the head in nonstationary porous formation is obtained. This cross covariance plays a key role in the inverse problem, i.e., in inferring the statistical characteristics of the conductivity field from head data. The nonstationary logconductivity is modeled as superposition of definite linear trend and stationary fluctuation and the hydraulic head in saturated aquifers is found through stochastic analysis of a steady, two-dimensional flow. The cross covariance with a Gaussian correlation function is investigated for two particular cases where the trend is either parallel or normal to the head gradient. The results show that cross covariances are stationary except along separation distances parallel to the mean flow direction for the case where the trend is parallel to head gradient. Also, unlike the stationary model, the cross covariance along distances normal to flow direction is non-zero. From these observaions we conclude that when a trend in the conductivity field is suspected, this information must be incorporated in the analysis of groundwater flow and solute transport.

Daily Streamflow Model for the Korean Watersheds

Kim, Tai Cheol, Dept. of Agricultural Engr., College of Agriculture, Chungnam National Univ.
Park, Seong Ki, Dept. of Agricultural Engr., College of Agriculture, Chungnam National Univ.
Ahn, Byoung Gi, Dept. of Agricultural Engr., College of Agriculture, Chungnam National Univ.

Daily streamflow model, DAWAST, considering the meteorologic and geographic characteristics of the Korean watersheds has been developed to simulate the daily streamflow with the input data of daily rainfall and pan evaporation. The model is the conceptual one with three sub-models which are optimization, generalization, and regionalization models. The conceptual model consists of three linear reservoirs representing the surface, unsaturated, and saturated soil zones and water balance analysis was carried out in each soil zones on a daily basis. Optimization model calibrates the parameters by optimization technique and is applicable to the watersheds where the daily streamflow data are available. Generalization model predicts the parameters by re-

gression equations considering the geographic, soil type, land use, and hydrogeologic characteristics of watershed and is appicable to ungaged medium or small watersheds. Regionalization model cites the parameters from the analysed ones considerign river system, latitude and longitude, and is applicable to ungaged large watersheds.

Analysis of Stratified Lake using an Eddy Diffusion and a Mixed-Layer Models

Kim, Kyung-Sub, Assistant Prof., Dept. of Environmental Engr., Ahnsung Polytechnic Univ.

A one-dimensional eddy diffusion model and a mixed-layer model are developed and applied to simulate the vertical temperature profiles in lakes. Also the running results of each method are compared and analyzed. In an eddy diffusion model, molecular diffusivity is neglected and eddy diffusivity which does not need lake-specific fitting parameter and constant lake's level are applied. The heat exchanges at the water surface and the bottom are formulated by the energy balance and zero energy gradient, respectively. In a mixed-layer model, two layers approach which has a constant thickness is adopted. Application of these models which use explicit finite difference and Runge-Kutta methods respectively demonstrates that the models efficiently simulate water temperatures.

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Runoff Analysis Using a Distributed Rainfall-Runoff Model

Shin, Sha Chul, Senior Researcher, Water Resources Research Institute, Korea Water Resources Corporation

The main goal of this study is a rainfall-runoff analysis using a topographically-based distributed model. If consists of two parts: one is a direct runoff submodel and the other is a baseflow submodel. The direct runoff submodel is a distributed model which routed through the drainage networks with a kinematic wave model. The baseflow submodel is considered as a lumped system. This model makes it possible to take the effect of areal and temporal distribution of storm into account.

Development and Application of a Computer Program for the Analysis of Heat Transfer and Fluid Flow of Water Body : Lake and Primary Clarifier

Park, Byung Soo, Researcher, Daewoo Advanced Technology Research Institute
Kim, Kyung-Mi, Graduate Student, Dept. of Environmental Engr., Chungnam National Univ.
Song, Woo Young, Researcher, Research Center of Korea Electric Power Corporation
Jang, Dong Soon, Associate Prof., Dept. of Environmental Engr., Chungnam National Univ.
Kwon, Oh Hun, Prof., Dept. of Civil Engr., Chungnam National Univ.

A computer program is developed in order to investigate the fluid flow and heat transfer of a water body in a 2-D vertical rectangular coordinate. The specific purpose of this study is to obtain a physical insight of several fluid flow problems which occur in a lake and the water and wastewater treatment facility like a primary clarifier. The performance of computer program developed is successfully evaluated by the comparison of other two experimental and computational data in open literature : the first comparison is made against the numerical data associated with the cooling water discharge and the other is numerical and experimental works for the primary clarifier of Sarina City at Ontario. Further, the computer program is applied to investigate the feature of lake flow, say lake turnover, and 2-D vertical channel flow in terms of temperature, wind velocity and flow rate, etc. The computational results appear to be physically acceptable and consistent. The computer program developed in this study shows the possibility of the viable tool to figure out the flow characteristics of water reservoir.

Markov Chain Model for Synthetic Generation by Classification of Daily Precipitation Amount into Multi-State

Kim, Ju Hwan, Senior Researcher, Water Resources Research Institute, Korea Water Resources Corporation
Park, Chan Young, Prof., Dept. of Civil Engr., Inha Industrial Technology College
Kang, Kwan Won, Prof. Emeritus, Dept. of Civil Engr., Inha Univ.

The chronical sequences of daily precipitation are of great practical importance in the planning and operational processes of water resources system. A sequence of days with alternate dry day and wet day can be generated by two state Markov chain model that establish the subsequent daily state as wet or dry by previously calculated conditional probabilities depending on the state of previous day. In this study, a synthetic generation model for obtaining the daily precipitation series is presented by classifying the precipitation amount in wet days into multi-states. To apply multi-state Markov chain model, the daily precipitation amounts for wet day are rearranged by grouping into thirth states with intervals for each state. Conditional probabilities as transition

probability matrix are estimated from the computational scheme for stepping from the precipitation on one day to that on the following day. Statistical comparisons were made between the historical and synthesized chracteristics of daily precipitation series. From the results, it is shown that the proposed method is a vailable to generate and simulate the daily precipitation series with fair accuracy and conserve the general statistical properties of historical precipitation series.

Finite Element Analysis of Gradually and Rapidly Varied Unsteady Flow in Open Channel : Ⅰ. Theory and Stability Analysis

Han, Kun Yeun, Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.
Park, Jae Hong, Research Assistant, Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.
Lee, Jong Tae, Prof., Dept. of Civil Engr., College of Engr., Kyongki Univ.

A finite element model for simulating gradually and rapidly varied unsteady flow in open channel is developed based on dynamic wave equation using Petrov-Galerkin method. A matrix stability analysis shows the selective damping of short wave lengths and excellent phase accuracies achieved by Petrov-Galerkin method. Whereas the Preissmann scheme displays less sellective damping and poor phase accuracies, and Bubnov-Galerkin method shows nondissipative characteristics which causes a divergence problem in short wave length. The analysis also shows that the Petrov-Galerkin method displays the desirable combination of selective damping of high frequency progressive waves over a wide range of Courant number and good phase accuracy at low Courant number. Therefore, the Petrov-Galerkin can be effectively applied to gradually and rapidly varied unsteady flow.

Drought Monitoring with Indexed Sequential Modeling

Kim, Hung Soo, Graduate Student, Dept. of Civil Engr., Colorado State Univ., USA
Yoon, Yong Nam, Prof., Dept. of Civil-Environmental Engr., Korea Univ.

The simulation techniques of hydrologic data series have been developed for the purposes of the design of water resources system, the optimization of reservoir operation, and the design of flood control of reservoir, etc. While the stochastic models are usually used in most analysis of water resources fields for the generation of data sequences, the indexed sequential modeling (ISM) method based on generation of a series of overlapping short-term flow sequences directly from the historical record has been used for the data generation in western USA since the eary of 1980's. It was reported that the reliable resuts by ISM were obtained in practial applications. In this study, we generate annual inflow series at a location of Hong Cheon Dam site by using ISM

method and first order autoregressive model (AR(1)), and estimate the drought characteristics for the comparison aim between ISM and AR(1).

Rainfall-Runoff Analysis by Calculation of the Time Distribution Models for Storms

Min, Byung-Hyung, Prof, Dept. of Civil Engr., Dongah Univ.
Lee, Young-Dae, Associate Prof, Dept. of Civil Engr., Bukyung Univ.
Seo, Jin-Ho, Director, Water Engr. Division, Samyoung Construction Technology Corporation
Min, Ill-Kyu, Researcher, Construction Technology Research Institute, Dongah Univ.

The main objective of this study to determine the time distribution models of rainfall in Korea for estimating design floods and to suggest new runoff model(Geomorphologic Instantaneous Unit Hydrograph ; GIUH) in order to be easily use the rainfall-runoff model put rainfull models practice to be suitable for the regional characteristics of hydrologid situation by practicing engineers. As a result, the reappearance of triangular hyetograph and GIUH runoff model showed promising. The historical data from about 13,000 event-rainfalls and 73 rainfallrunoff measuring data during 12 years in International Hydrological Program(IHP) basins have been used to determine the statistical factors of the time distribution for rainfalls by the Yen-Chow, Huff, Pilgrim-Cordery and Mononbe models. The Rational, Kajiyama, Nakayasu and Clark model and GIUH model that this study runoff model were used for the purpose of application limit for basin area against design concept by the estimation of flood runoff and the dervation of empirical equations to estimate the parameters for ungaged basins.

Hydrologic Modeling of an Agricultural Watershed with Tile Drains and GIS

Kim, Sang Hyun, Post-Doc., Univ. of Illinois at Urbana-Champaign, USA
Son, Kwang Ik, Full-time Lecturer, Dept. of Civil Engr., College of Engr., Yeungnam Univ.
Han, Kun Yeun, Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.

A physically based model for rainfal-runoff simulation in agricultural watersheds equipped with tile drains is developed from the TOPMODEL framework. The model is based on detailed topographical information provided by the Digital Elevation Model (DEM), which is a available in the Georgaphic Information System GRASS. Nine possible flow generation scenarios are suggested and used in the development of the model. The storage and delaying effects in the soil matrix and in the tile system are simulated with a second order linear reservoir. The model can identify the portions of the hydrators resulting from tile flow, subsurface flow and surface runoff.

Determination Algorithm of Hydraulic Parameters in Water Distribution System

Park, Jae Hong, Research Assistant, Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.
Kim, Sang Hyun, Post-Doc., Univ. of Illinois at Urbana-Champaign, USA
Han, Kun Yeun, Prof., Dept. of Civil Engr., College of Engr., Kyongbuk National Univ.

In this paper, the evaluation of diameter, global velocity, global roughness coefficients of the water distribution pipes are examined by using pressure and flowrate measurements in selected points of the network. The selected pipe network parameters are determined through reformulation of the continuity and energy equation. Additional energy equation is considered to analyze the coefficient matrix. The resulting nonlinear equations are solved by using Newton-Raphson method. Three computer models with complex pipe system are used to demonstrate these procedures. The computed results of hydraulic parameters show good agreements with KYPIPE2 flow analysis model.

Hydraulic Characteristics and Upstream Migration of Fish by the Weir Type in a Pool-Weir Fishway

Kim, Jin Hong, Assistant Prof., Dept. of Civil Engr., College of Engr., Kwangju National Univ.

This study deals with hudraulic characteristics and their effects on upstream migration of fish by the weir type in a pool-weir fishway, and pressents an optimal type of weir for an easy upstream migration. Experiment was performed to estimate hydraulic conditions by the weir type and to determine which type was good. The results showed that a rectangular weir with a small rectangular notch installed by a zig-zag type was preferable to a simple weir with no notch or to a trapezoidal weir, since it makes possible for upstream migration even when a water level draws down and moreover, it makes falling flow through a notch which facilitates upstream migration. It was proposed that the notch must be designed that the flow situation may keep the streaming flow so long as the maximum flow velocity does not exceed the critical swiming velocity, i.e., the dimensioness flow rate may exist within the range of 0.27 and 0.41.

Comparison of the Rainfall-Runoff Models for Flood Forecasting in Watershed

Shim, Soon Bo, Prof., Dept. of Civil Engr., College of Engr., Chungbuk National Univ.
Park, No Hyuk, Researcher, Water Resources Research Institute, Korea Water Resources Corporation
Kim, Sun Koo, Graduate Student, Dept. of Civil Engr., College of Engr., Chungbuk National Univ.
Kim, Joo Hun, Graduate Student, Dept. of Civil Engr., College of Engr., Chungbuk National Univ.
Koh, Deuk Koo, Senior Researcher, Water Resources Research Institute, Korea Water Resources Corporation

In this study two rainfall-runoff models, the NWS-PC model and the Storage Function Model (SFM), were compared to see their applicability in the flood forecasting at the river system. The SFM has been adopted in the flood-forecasting and warning system for the major rivers in Korea since 1974, and the NWS-PC model, a physically based model, has been developed to simulate soil moisture changing as wel as the surface and subsurface flow at the watershed and in the river streams. Case studies were carried out using flood event data observed at the Mihochun watershed in Geum-river basin during 1985 to 1995. Simulated results from both models were compared with the observed data with respect to the RMS errors and relative errors for peak flow discharges and total runoff volumes to show the advantages and disadvantages of both models and to suggest the way to improve their performances.