

## Abstracts of Papers in the Journals of KAHS

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### Vol. 26. No. 1

#### **A Study on the Improvement of Annual Runoff Estimation Model**

*LEE, Sang Hoon, Assistant Prof., Dept. of Civil Engineering, Suwon Univ.*

The most significant factor in estimating annual runoff must be the precipitation. But in the previous study, the watershed area instead of precipitation was included as an independent variable in regression model in the process of checking accurate data. The criterion of accurate data was the runoff ratio in the range of 20% to 100%. In this study the valid range of evapotranspiration was adopted as a criterion of accurate data and the same data were reexamined. It came up with following model which has a high coefficient of determination and conforms to hydrologic theory.

$$R = -518.25 + 0.8834P \text{ where, } R : \text{runoff depth(mm)} \quad P : \text{precipitation(mm)}$$

This regression model was found to be stable by cross-validation and is proposed as annual runoff estimation model applicable to ungaged small and medium watersheds in Korea.

#### **Ultrasonic Enhancement of Flow in Clayey Sands**

*LEE, Kwang Yeol, Manager, Sunkyong Engineering Company Ltd.*

Remediation technology becomes an issue in environmental engineering. The vibro-recovery technique is one of popular means to remove pollutants from contaminated soils and groundwater. Using Ultrasonic excitation in soil-fluid medium, it was found that removal efficiency in a mechanical effects was significant. In this paper, therefore, laboratory experiments were conducted on clayey sand soil columns using a probe-type ultrasonic processor.

Ultrasonic treatment with simultaneous pumping enhances dislodgement of clay particles, and ultrasonic excitation reduced the proportions of finer particles and thus result in increased hydraulic conductivity significantly. Also, the results provided the changes in grain size distribution curve of the soil due to ultrasonic excitation. The results indicated that the maximum size of particles mobilized by Ultrasonic is about 0.004mm and particles in the size range from 0.04mm to 1.0mm were subjected to fracturing.

The economic feasibility of Ultrasonic implementation is considered in power requirement of the generator and maintenance of the horn. At a specified amplitude of vibrations, the power requirement of the generator depends on overburden pressure of the horn, temperature and viscosity of fluid in the soil medium. For comparisons, the power requirement of a one inch and two inch diameter horn sonicators are compared with the power required for pumping water from different depths.

## **Nonlinear Wave Transformation and Air Pressure Variation of Air-Chamber Structure**

*KIM, Do Sam, Graduate Student, Dept. of Civil Engineering, Nakoya Univ./IWATA Kochiro, Prof., Dept. of Civil Engineering, Nakoya Univ./YANG, Yun Mo, Advisor, Samuha Engineering Company Ltd.*

Nonlinear characteristics of air pressure variation and wave transformation of a fixed air-chamber structure are discussed theoretically and experimentally. Two analytical methods (method I and II) based on the perturbation method and Green's formula are employed in order to evaluate nonlinearities by the submerged and semi-submerged air-chamber structure. Moreover, an air compression model is newly developed to estimate the dynamic air pressure in the air-chamber inside the structure, assuming the Boyle-Charles's law with adiabatic process in the air pressure variation. Theoretical values of the method I considering evanescent mode waves at a fictitious boundary, are in good agreement with those of method II employing the fictitious boundary which is not affected by evanescent mode waves. Both theoretical values are shown to agree well with experimental values.

## **Simulation of Moving Storm in a Watershed Using a Distributed Model ( II ) — Model Application —**

*CHOI, Gye Woon, Principal Researcher, Water Resources Research Institute, Korea Water Resources Corporation/LEE, Hee Seung, Executive Vice President, Korea Water Resources Corporation/AHN, Sang Jin, Prof., Dept. of Civil Engineering, Chungbuk National Univ.*

In this paper, a moving storm in the real watershed was simulated using a distributed model. Macks Creek Experimental Watershed in Idaho, USA was selected as a target watershed and the moving storm of August 23, 1965, which continued from 3:30 P.M. to 5:30 P.M., was utilized. The rainfall intensity of the moving storm in the watershed was temporally varied and the storm was continuously moved from one place to the other place in a watershed. Furthermore, runoff parameters, which are soil types, vegetative cover percentages, overland plane slopes, channel bed slopes and so on, are spatially varied. The model developed in the previous paper was utilized as a distrib-

uted model for simulating the moving storm. In the model, runoff in a watershed was simulated as two parts which are overland flow and channel flow parts. The good agreement was obtained between a simulated hydrograph using a distributed model and an observed hydrograph. Also, the conservations of mass are well indicated between upstream and downstream at channel junctions.

## **Influence of the Peace-Dam Construction on the Flood Discharge and the Flood Stage of the Hwachun-Dam**

*JUN, Byong Ho, Prof., Dept. of Civil Engineering, Korea Military Academy/SHIN, Hyun Suk, Graduate Student, Dept. of Civil and Environmental Engineering, Korea Univ./LEE, Jae Chul, Graduate Student, Dept. of Civil Engineering, Seoul City Univ./YOON, Yong Nam, Prof., Dept. of Civil and Environmental Engineering, Korea Univ.*

Because of the Keumkangsan-Dam and the Peace-Dam constructed in recent years, it is expected that the peak flood discharge and the peak flood stage at the Hwachun-Dam site have been changed. In this study, two methods were used to simulate and compare the effects of the upstream dam construction on the change of the discharge and the stage. One is the storage function method widely used for the hydrological routing in this country. The other is the DWOPER (Dynamic Wave Operational Model) package developed by the U.S. NWS for the hydraulic routing. Flood routing simulations have been performed on four different scenarios: 1) Before the construction of the Keumkangsan-Dam and the Peace-Dam, 2) The exclusion of the Keumkangsan-Dam watershed (before the construction of the Peace-Dam), 3) The exclusion of the Keumkangsan-Dam watershed (after the construction of the Peace-Dam), 4) The exclusion of the Peace-Dam watershed. The results of the four test cases from the two methods show that the peak flood discharge and the peak flood stage at the Hwachun-Dam site are reduced due to the construction of the Peace-Dam. From these findings, it is suggested that the operational criteria for the optimal dam-operation of the Hwachun-Dam need to be modified.

## **Migration Characteristics with Forms of Channels and Bed Conditions**

*CHA, Young Kee, Prof., Dept. of Civil Engineering, Dankuk Univ./LEE, Jong Seok, Graduate Student, Dept. of Civil Engineering, Dankuk Univ.*

Migration characteristics with forms of channels and bed conditions are studied by constant-radius curve (CRC), sine-generated curve (SGC) and small-wave theory (SWT) method. For channels which are meandering and of which bed conditions are of coarse materials, transverse bed slope, depth and velocity distributions are predicted by CRC and SGC method, and the results are compared with measured field data. And for fine bed-materials of the sinuous channels, lateral and downvalley migration rates are computed by SWT method. It is confirmed from this investigation

that transverse mass-flux factor plays significant roles in determining of magnitude and direction of meander migration.

## Design of Detention Pond and Critical Duration of Design Rainfall in Seoul

*LEE, Jong Tae, Prof., Dept. of Civil Engineering, Kyongki Univ./YOON, Sei Eui, Prof., Dept. of Civil Engineering, Kyongki Univ./LEE, Jae Joon, Assistant Prof., Dept. of Civil Engineering, Keumoh Eng. College/YOON, Yong Nam, Prof., Dept. of Civil and Environmental Engineering, Korea Univ.*

This study is to determine the critical duration of design rainfall and to utilize it for the design of detention pond with pump station. To examine the effect of the duration and temporal distribution of the design rainfall, Huff's quartile method is used for the 9 cases of durations ranging from 20 to 240 minutes with 10 years return period, and the ILLUDAS model is used for runoff analysis. The storage ratio which is the ratio of maximum storage amounts to total runoff volume, is introduced to determine the critical duration of design rainfall. The duration which maximizes the storage ratio is adopted as the critical duration. This study is applied to 18 urban drainage watersheds with pump station in Seoul, of which the range of watershed area is 0.24~12.70 km<sup>2</sup>. The result of simulation shows that the duration which maximizes storage ratio is 30 and 60 minutes on the whole. It is shown also that the storage ratio of 2nd- and 3rd-quartile pattern is larger than that of 1st- and 4th-quartile pattern of temporal distribution. A simplified empirical formula for Seoul area is suggested by using the regression analysis between the maximum storage ratio and the peak ratio, and can be utilized for the preliminary design and planning of detention pond with pump station.

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## A prediction Method of Wave Deformation in Harbors Using the Mild Slope Equation

*CHOI, Seon Ho, Graduate Student, Dept. of Civil Engineering, Pusan Univ./PARK, Sang Kil, Associate Prof., Dept. of Civil Engineering, Pusan Univ.*

Since major reason of disaster in coastal area is wave action, prediction of wave deformation is one of the most important problems to ocean engineers. Wave deformations are due to physical factors such as shoaling effect, reflection, diffraction, refraction, scattering and radiation etc. Recently, numerical models are widely utilized to calculate wave deformation. In this study, the mild slope equation was used in calculating wave deformation which considers diffraction and refraction. In

order to solve the governing equation, finite element method is introduced. Even though this method has some difficulties, it is proved to predict the wave deformation accurately even in complicated boundary conditions. To verify the validity of the numerical calculation, experiments were carried out in a model harbour of rectangular shape which has mild slope bottom. The results by F.E.M. are compared with those of both Lee's method and the experiment. The results of these three methods show reasonable agreement.

## **Critical Duration of Design Rainfall for the Design of Storm Sewer in Seoul**

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A hydrological method is performed to determine the critical duration of design rainfall for the design of storm sewer in Seoul. To seize the effect of the duration and the temporal distribution of the rainfall to the peak discharge of the storm sewer, the Huff's quartile method is used as a temporal pattern for the design rainfall of any durations (9 cases for 20~240 min.) with 10 years return period. The critical duration of design rainfall is determined as the duration which maximizes the peak discharge. This study is applied to 18 urban drainage systems in Seoul. The ILLUDAS model is applied to runoff analysis, and the result shows that the duration which maximizes peak discharge is 30, 60 minutes generally. The relation diagram between peak discharge for the critical duration and watershed area is prepared for the design of storm sewer.

## **An Estimation of the Peak Flood Discharges Based on the Mean Daily Discharges during a Flood Event**

*WONE, Seog Yeon, Graduate Student, Dept. of Civil and Environmental Engineering, korea Univ./YOON, Yong Nam, Prof., Dept. of Civil and Environmental Engineering, korea Univ.*

In the present study the methods proposed by Fuller and Sangal were evaluated to estimate the peak flood discharge based on the mean daily discharges during a flood period. The total of 198 flood events observed at seven stage gauging stations in the Han River basin were analyzed. The results showed that the peak flood discharges estimated based on the mean daily flows have a relatively high correlation with the observed peak floods. Hence, a regionalized relation and method is proposed for a possible application to estimate the peak flood discharges at the stage gauging stations with no hourly flood stage data, but with the mean daily stages.

## **Tidal Effect on the Stage of Indokyo due to the Variation of Flood Discharge in Han River**

*LEE, Jong Tae, Prof., Dept. of Civil Engineering, Kyongki Univ./HAN, Kun Yeun, Prof., Dept. of Civil Engineering, Kyongbuk Univ./SEOH, Byung Ha, Director, Water Resources Eng. Division, Korea Institute of Construction Technology.*

The increased water level caused by tidal motion at Indokyo is analyzed by the NETWORK model. The tidal effect is studied for 3 real floods in 1990 and 8 classified hypothetical floods in which the peak discharges are in the range of 2,000~20,000CMS. The result of numerical simulation shows that the tidal effect is decreased as the flood is increased. The surged level is 50cm when the flood discharge is 2,000CMS, showing that its effect is considerable. However it shows only 9cm when the discharge is 7,000CMS which corresponds to 4.5m of standard flood level of MOC. Therefore, so it may be possible to neglect the influence of the tidal fluctuation when the peak discharge of a flood is bigger than 7,000CMS.

## **A Random Sampling Method in Estimating the Mean Areal Precipitation Using Kriging**

*LEE, Sang Il, Assistant Research Prof., Center for Water Resources and Quality Management, Chungbuk National Univ.*

A new method to estimate the mean areal precipitation using Kriging is developed. Unlike the conventional approach, points for double and quadruple numerical integrates the conventional approach's necessity of dividing the area into subareas and calculating the center of each subarea, which in turn makes the developed method more powerful in the case of complex boundaries. The algorithm to select random points within an arbitrary boundary, based on the theory of complex variables, is described. The results of Monte Carlo simulation showed that the error associated with estimation using randomly selected points is inversely proportional to the square root of the number of sampling points.

## **Simplification of Monte Carlo Techniques for the Estimation of Expected Benefits in Stochastic Analysis of Multiple Reservoir Systems**

*LEE, Kwang Man, Ph.D. Program in Chungang Univ., Researcher, Water Resources Research Institute, Korea Water Resources Corporation/KO, Seok Ku, General Manager & Chief Investigation & Planning Department, Korea Water Resources Corporation.*

For the systme benefit optimization by considering risk or reliability from a multiple reservoir

system using the Monte Carlo technique, many stochastically generated inflow series have to be used for the system analysis. In this study, the stochastically generated inflow series for the multiple reservoir system operation are preprocessed according to the considered system objectives and operating time periods. Through this procedure, several representative inflow series which have discrete probability levels and operation horizons are selected among the thousands of generated inflows. Then a deterministic optimization technique is applied to the power energy estimation from the Han River Reservoirs System which considers five reservoirs in this study. It took much lower computational requirements than using the original Monte Carlo Technique, even though estimated result was almost similar.

### **Flood Forecasting for Pre-Release of Taech'ong Reservoir**

*LEE, Jae Hyung, Prof., Dept. of Civil Engineering, Jeonbuk National Univ./SHIM, Myung Pil, Prof., Dept. of Civil Engineering, Inha Univ./CEON, Ir Kweon, Graduate Student, Dept. of Civil Engineering, Jeonbuk National Univ.*

A practical flood forecasting model(FFM) is suggested. The output of the model is the results which the initial condition of meteorological parameters and soil moisture are projected on the future. The physically based station model for rainfall forecasting(RF) and the storage function model for runoff prediction(RP) are adopted respectively. Input variables for FFM are air temperature, pressure, and dew-point temperature at the ground level and the flow at the rising limb(FRL). The constant parameters for FFM are average of optimum values which the past storm events have. Also loss rate of rainfall can be predicted by FRL.

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### **A Tank Model Shell Program for Simulating Daily Streamflow from Small Watersheds**

*PARK, Seung Woo, Associate Prof., Agricultural Engineering Department, College of Agriculture & Life Sciences, Seoul National Univ.*

A menu-driven shell program DSFS (Daily Streamflow Simulation Model), that can process the input data, optimize the parameters, execute the program, and graphically display the results of a modified tank model, was developed and applied to simulating daily streamflow from small watersheds. The model defines daily watershed evapotranspiration losses from potential values multiplied by monthly landuse coefficients and correction factors for soil water storage levels. The parameters were calibrated using observed hydrologic data for fifteen watersheds, and the results were correlated with watershed parameters to define empirical relationships. The proposed model was tested with

## **Estimating Sediment Deposits and Trap Efficiencies for Irrigation Reservoirs**

*KIM, Jin Taek, Graduate Student, Agricultural Engineering Department, College of Agriculture & Life Sciences, Seoul National Univ./PARK, Seung Woo, Associate Prof., Agricultural Engineering Department, College of Agriculture & Life Sciences, Seoul National Univ.*

The objectives of this paper were to apply the gross erosion and sediment delivery ratio method for estimating sediment deposits at selected reservoirs of various sizes, and to define their trap efficiencies. Twenty reservoirs that have sediment survey data were selected and the annual average soil losses from subareas within each watershed were estimated using the Universal Soil Loss Equation (USLE). The gross erosion was defined from the soil losses and estimated channel erosion. By applying the sediment delivery ratios that were defined from an empirical relationship with watershed areas, net incoming sediment yields at reservoirs were defined. Trap efficiencies were applied, sediment deposits estimated, and compared to the surveyed data. The results were in general agreement with the data.

Trap efficiencies were also defined from the ratios of sediment deposits to incoming sediment yields. They were within 20% differences from Brune curve, which indicates that Brune curve may be applied for irrigation reservoirs. And an empirical relationship was proposed, that appeared more reliable for estimating trap efficiencies for typical irrigation reservoirs.

## **A Study on Changes of Water Quality in River by Hydrologic Factors—QUAL2E Model Application**

*LYU, Heui Jeong, Prof., Dept. of Civil Engineering, Anseong National Univ.*

In this study, reach boundaries in QUAL2E Model were set by the locations of point-waste discharge or tributary input and measured or direct calculated hydrologic factors were used in computation as much as possible. South Platte Experimental River in Colorado, USA was selected as a target river and data collected during September 1991 and January 1992 periods were used for calibration and verification, respectively. Constituents modeled in this study are 5-day carbonaceous biochemical oxygen demand(CBOD<sub>5</sub>) and dissolved oxygen(DO). The good agreement was obtained between a calculated using this model and observed, less than 5% to DO and about 20% to CBOD<sub>5</sub>. According to the result of water-quality prediction, experimental river is classified as the 4th category by the criteria of environmental protection agency in the USA in 2001.



## **Finite Element Model for the Hydrodynamic Analysis in a River**

*HAN, Kun Yeun, Prof., Dept. of Civil Engineering, Kyongbuk Univ./LEE, Jong Tae, Prof., Dept. of Civil Engineering, Kyongki Univ./KIM, Hong Tae, Graduate Student, Dept. of Civil Engineering, Kyongbuk Univ.*

A finite element model RIV-FEM2 for the hydrodynamic study in a river is developed based on two-dimensional shallow water wave equation and dissipative Galerkin's method. RIV-FEM2 consists of pre-processing, analysis processing and post-processing. Pre- and analysis processing is programmed with Fortran-77 and post-processing with turbo-Pascal respectively. The model is tested with two dimensional problems, including flow through bends, bridges, and symmetric contraction. The two dimensional tests shows stable and efficient results for various situations. Applicability of the model is verified by applying to natural river. The model will provide a basic contribution to the hydrodynamic analysis in a river.

## **On Application of Computation Method of Water Surface Profile Using HEC-2**

*LEE, Jong Kyu, Prof., Dept. of Civil Engineering, Hanyang Univ./LEE, Chang Hae, Graduate Student, Dept. of Civil Engineering, Hanyang Univ.*

The HEC(Hydrologic Engineering Center)-2 program, which utilize the standard step method, is usually adopted in the practical works for the water surface profile computation of natural channels. Water profile computation is, in general, carried upstream for subcritical flow. On the other hand, when the reference water surface is given upstream, numerous efforts and a great deal of time are necessary to compute the downstream water surface profile for subcritical flow. A simple method, computing the water surface profile from upstream to downstream for subcritical flow by HEC-2, is suggested in this paper. The applicability and the accuracy of this method are discussed by applying this method to both prismatic and natural channels.

## **An Evaluation of the Emptiness Passage Time of the Kuemgang Estuary Reservoir by Two-Step Transition Model**

*LEE, Jae Hyung, Prof., Dept. of Civil Engineering, Jeonbuk National Univ./CHUNG, Mahn, Associate Prof., Dept. of Ocién Civil Engineering, Yosu National Fisheries Univ.*

This study aims at the evaluation of the stationary distribution and the emptiness passage time for the effectiveness of water utility in the Keumgang estuary reservoir by two-step transition model. It was taken discrete Markovian correlated inflows for the joint probability of inflows and storage, and was used binomial distribution for inflows distribution. As the results, it was decreased

from 0.952 to 0.904 the emptiness probability of the reservoir stationary distribution during 1952–1980, and from 0.900 to 0.829 during 1981–1989, and the average emptiness passage time was increased from 23 days to 37 days during 1952–1980, and from 29 days to 61 days during 1981–1989 at low state of storage. From this, it is found that the emptiness passage time is varied with the increase of the inflows auto-correlation coefficient in the Keumgang estuary reservoir. Therefore, it is understood that auto-correlation coefficient must be taken into consideration for the evaluation of water utility in a small reservoir at drought time.

## **A Simulation of the Runoff and the NPS Pollutants Discharge using SWMM Model**

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*YOON, Yong Nam, Prof., Dept. of Civil and Environmental Engineering, Korea Univ.*

This study was conducted for two purposes. The first was the selection of the proper model for the urban runoff, and NPS(non-point source) loads and the second was the adjustment of the selected model through the calibration and the verification of the observed data on an urban drainage basin.

The selected model for this study was the Storm Water Management Model(SWMM) developed and maintained by the US Environmental Protection Agency(EPA). In particular, the Runoff Block for the surface discharge and the Transport Block for the flow routing was used. The study basin is Youngdu basin, which is a typical developed urban drainage basin. The four rainfall events for the runoff and the two for the four NPS pollutants(SS, BOD, COD and TN) were used for the calibration and the estimation of the model parameters.

This study performed the calibration with regard to the peak discharge, the time to peak discharge, the volume and the relative error for three items. It was shown that SWMM can successfully be used for the prediction of the runoff and the NPS pollutants discharge.

The result of this study can be used as the basis for the analysis of the correlation between the runoff and the NPS pollutants discharge, and the analysis of the mass balance with the monthly and annual NPS loads in an urban drainage basin.

## **An Eulerian–Lagrangian Hybrid Numerical Method for the Longitudinal Dispersion Equation**

*JUN, Kyung Soo, Researcher, Dept. of Civil Engineering, Seoul National Univ./LEE, Kil Seong, Prof., Dept. of Civil Engineering, Seoul National Univ.*

A hybrid finite difference method for the longitudinal dispersion equation was developed. The method is based on combining the Holly–Preissmann scheme with the fifth-degree Hermite interpo-

lating polynomial and the generalized Crank–Nicholson scheme. Longitudinal dispersion of an instantaneously-loaded pollutant source was simulated by the model and other characteristics-based numerical methods. Computational results were compared with the exact solution. The present method was free from wiggles regardless of the Courant number, and exactly reproduced the location of the peak concentration. Overall accuracy of the computation increased for smaller value of the weighting factor,  $\theta$  of the model. Larger values of  $\theta$  overestimated the peak concentration. Smaller Courant number gave better accuracy, in general, but the sensitivity was very low, especially when the value of  $\theta$  was small. From comparisons with the hybrid method using the third-degree interpolating polynomial and with split-operator methods, the present method showed the best performance in reproducing the exact solution as the advection becomes more dominant.

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### **Analysis of the Flood Level Variation through Bridges**

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The variations of water surface elevation due to bridge are studied using one-dimensional dynamic wave equation. The Preissmann scheme is used to solve the dynamic wave equation and the bridges was treated as internal boundary conditions. Main causes of bridge backwater are the proportion of the contracted area due to bridge, roughness coefficient and discharge coefficient. The effect of discharge coefficient in weir flow condition is comparatively small. This model is verified by applying to the Suyoung River, which suffered a severe damage by typhoon Gladys. The rise of water level through bridge is 1.53–1.08m in the reach of 4.25–6.20km from the downstream of river. The simulation results of the model have good agreements with the observed data.

### **An Analysis on Groundwater Flow Properties in the Gneiss of the Ingulam Valley**

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The evaluation of groundwater flow in the Ingulam valley catchment area in the vicinity of Sam-Kwang mine was studied. In this study, field hydraulic tests, groundwater flow measurement, and MODFLOW model application were carried out. The results of analysis are described as follows. The

rainwater infiltrated into the ground in the study area, hardly reached the gneiss region deeper than EL.(+)100 m above the surface of seawater. The rainwater infiltrated into the ground near the water system boundary, flowed out into the vicinity of streams and the travel time was between 15 and 263 years. Also, the estimated total flow rate of the groundwater in the study area was 307m<sup>3</sup>/day.

## **A Numerical $k-\epsilon$ Two-Equation Model for Investigating the Hydrodynamics of Flow in Two-Dimensional Density Fields**

*HUH, Jae Yeong, Assistant Prof., Dept. of Civil Engineering, Daejun Univ.*

To investigate the structure of internal flow hydrodynamically, the complete vertical equation of motion should be assembled into the model. In the present study a numerical simulation model not hydrodynamically approximated is established. From the comparison of the predicted results with the computed results from  $k-\epsilon$  two equation turbulence model by Huh et al.(1991) and the experimental data by Nakatsuji(1984), the vertical acceleration and its effects on the development of buoyant surface jets are evaluated quantitatively.

## **Separation Effect Analysis for Rainfall Data**

*KIM, Yang Su, Senior Researcher, Water Resources Engineering Division, Korea Institute of Construction Technology/HEO, Jun Haeng, Research Prof., Colorado State Univ.*

This study focuses on the separation effect analysis of rainfall data for 2-parameter log-normal, 3-parameter log-normal, type-extreme value, 2-parameter gamma, 3-parameter gamma, log-Pearson type-III, and general extreme value distribution functions. Difference in the relationship between the mean and standard deviation of skewness for historical data and relations derived from 7 distribution functions are analyzed using the Monte Carlo experiment. The results show that rainfall data has the separation effect for 6 distribution functions except 3-parameter gamma distribution function.

## **An Estimation of NPS Pollutant Loads using the Correlation between Storm Water Runoff and Pollutant Discharge in a Small Urban Drainage Basin**

*SHIN, Hyun Suk, Graduate Student, Dept. of Civil and Environmental Engineering, Korea Univ./YOON, Yong Nam, Prof., Dept. of Civil and Environmental Engineering, Korea Univ.*

Three purposes of this study are as follows : The first was the development of the extension meth-

od for the limited data observed in an urban drainage basin. The second was the analysis of the correlation between storm water runoff and NPS(non-point source) pollutant discharge. The last was the calculation of the monthly and annual specific NPS loads using the established correlation. The selected model was the SWMM(Storm Water Management Model) developed by the US EPA(Environmental Protection Agency).

As a result of this study, the best correlation between storm water runoff and NPS pollutants discharge was produced by the non-linear correlation between runoff rate(mm/hr) and specific loads rate(g/ha/sec) for all pollutants studied ; SS, COD, BOD, and TN.

The best correlation through the anlysis based on evently total mass was made by the linear correlation between the specific accumulated runoff(mm) and specific accumulated loads(kg/ha) for CASE 1., and by the non-linear correlation for CASE 2.

The NPS annual specific loads for the urban basin studied were 4993kg/ha/year for SS, 775kg/ha/year for BOD, 3094kg/ha/year for COD, 257kg/ha/year for TN, respectively. And the proportion of the NPS annual specific loads to the total annual specific loads were 41% for SS, 13% for BOD, 29% for COD, and 21% for TN.

## **The Effects of the Capsule Density Uniformity on the Behavior of Cylindrical Capsules Transported through a Pipeline**

*RHEE, Kyong Hoon, Assistant Prof., Dept. of Civil Engineering, Jeonnam Univ.*

This paper presents the results of a study conducted to improve the understanding of the characteristics of cylindrical capsule flow in a pipeline by taking into account of the effect of capsule density uniformity. The effect of capsule density variation in the axial direction was studied both experimentally and analytically. The experiments were conducted in a 190mm diameter straight pipe 17m long. The velocity, gap and tilt of capsules were measured under various conditions. In order to interpret the data on various capsule density conditions, the stability index given in the dimensionless number was introduced. The motion of capsules in pipelines is strongly affected by the stability of the capsules characterized by the stability index. The experiments conducted proved that the stability index is a valid criterion for explaining and correlating data on the capsule motion and the capsule density uniformity.

## **Armouring Effect on Local Scour around Bridge Piers**

*LEE, Jong Kyu, Prof., Dept. of Civil Engineering, Hanyang Univ.*

The results of laboratory experiments on the clear-water local scour of cohesionless bed sediment at three types of the pier shape are presented. Based on the experimental data, the relative equilibrium depth of local scour is related to the pier shape, the geometric standard deviation of the bed ma-

terial, the velocity ratio and the pier Froude number. The relative local scour depths were smallest at the round-nosed pier and remarkably reduced at the non-uniform bed sediment, comparing with those at the uniform bed material. The effect of sediment grading on the local scour reduction was discussed and compared with Raudkivi and Ettema's experiments.

## **Flood-Flow Management System Model of River Basin**

*LEE, Soon Tak, Prof., Dept. of Civil Engineering, Yeungnam Univ.*

A flood-flow management system model of river basin has been developed in this study. The system model consists of the observation and telemetering system, the rainfall forecasting and data-bank system, the flood runoff simulation system, the dam operation simulation system, the flood forecasting simulation system and the flood warning system. The Multivariate model(MV) and Meteorological-factor regression model(FR) for rainfall forecasting and the Streamflow synthesis and reservoir regulation(SSARR) model for flood runoff simulation have been adopted for the development of a new system model for flood-flow management. These models are calibrated to determine the optimal parameters on the basis of observed rainfall, streamflow and other hydrological data during the past flood periods. The flood-flow management system model with SSARR model(FFMM-SR, FFMM-SR(FR) and FFMM-SR(MV)), in which the integrated operation of dams and rainfall forecasting in the basin are considered, is then suggested and applied for flood-flow management and forecasting. The results of the simulations done at the base stations are analysed and were found to be more accurate and effective in the FFMM-SR and FFMM-SR(MV).