

ENGINEERING

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ABSTRACTS

HERPIC — County Storm Drainage Manual. CHRISTOPHER B. BURKE, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907. —The Highway Extension and Research Project for Indiana Counties (HERPIC) has funded the writing of a drainage manual for the state of Indiana. This manual has been written for practicing engineers and designers who are involved in the design of drainage facilities. The content includes chapters on precipitation, runoff, open channel flow and the design of gutter and inlets, storage facilities, and storm sewers. Each chapter presents a general review of the subject, a discussion of design procedures and required graphs, tables or figures, example problems illustrating applications, and references for further investigation. Three appendices are included to provide the user with auxiliary references. The first two appendices review the basics of statistical analysis (as it applies to the analysis of precipitation and runoff) and hydraulics. The third appendix provides a brief listing of regulatory agencies (local, state and federal) which have jurisdiction over drainage projects in Indiana. The manual may be purchased by writing to HERPIC, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.

Anthropometric Data Error Detection and Correction with a Computer. DAVID D. CHESAK, St. Joseph's College, Rensselaer, Indiana 47978. —Data obtained with automated anthropometric data acquisition equipment is subject to short term errors. These errors are due to random reflections of light, masking of the light rays and other types of interference, optical and electrical. These signals are impossible to eliminate from the initial data produced by the television cameras. There is a need to ascertain which data values are erroneous and to replace them with corrected values, if possible. This is primarily a software problem and requires a digital computer to refine the data off line. This paper discusses the use of the least squares method for this purpose.

History and Computer: An Unorthodox Approach to River Hydraulics. ALDO GIORGINI and DEAN RANDALL, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907. —When a river bed is very tormented, there may be different flow patterns corresponding to different discharges. As an example, if a river has a low water bed carved in the rock, with very tortuous patterns, when the discharge is high, the low water river bed may be a mere "accident" on the pattern of the high water regime. In this instance it is not sufficient to have only one numerical model for the river (i.e. for the use of HEC2); but one should have at least 2 models, sometimes quite different from each other.

This is illustrated in a very dramatic fashion by the study of the determination of the low water discharge of the Ohio river across the Louisville Chutes at the time when the Louisville-Portland Canal was not there and the barges or boats had to brave the Indian Chutes.

PHOTO: A Computer Program for the "Photographic" Rendition of Three-Dimensional Objects. ALDO GIORGINI and MARK SMITH, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—The photograph-like rendition of simple three-dimensional objects by computer is a problem that has attracted the attention of most computer graphics specialists. The degree of success of the operation depends on several factors among which the most important is the versatility of the color terminal that is used for the rendering. The work described here is tailored to a TEKTRONIX 4027 color terminal. The screen of such terminal has 480 x 640 pixels singularly addressable by only one out of eight colors with invariant beam density. While this provides sufficient ground for what is mis-called "high resolution graphics", it still yields somehow rough images. The color palette has to be extended by software, and this has been done as a preliminary task of the development of PHOTO. In order to prepare an object for representation, two families of curves are drawn on its surface. Each facet so obtained then is projected on a picture plane with the color attributes that depend on: facet color, light source(s) colors, facet surface reflectivity, relative position of source(s), facet, and observation point.

Several examples of color rendition are shown together with the technical problems that had to be overcome.

Performance of Embankments Constructed with Compacted Clays. M. J. GOODMAN and J. L. CHAMEAN, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—Embankment performance must be evaluated at the end of construction as well as for the long term conditions. The long term conditions are frequently critical because of water saturation occurring with time. The performance criteria are stability with respect to slope failure and settlement and/or swell of the embankment. Slope failure leads to loss of the embankment while settlement or swell results in pavement distress.

The performance criteria are affected by compaction variables such as compactive effort, compactive prestress, dry density of the clay, optimum moisture content, molding water content, and state of saturation. Unfortunately, for typical compactive efforts, manipulation of these variables to optimize either performance criterion may be detrimental to the other.

The STABL2 program developed by Boutrup (1977) is used to evaluate the slope stability of embankments. Settlement and/or swell are evaluated by a computer program developed by the authors. Examples are presented to illustrate the maximization of embankment performance. The analyses are performed using compaction variables for a clay typical of Southern Indiana.

The Effect of Body Shape on the Growth and Structure of Turbulent Wakes. DONALD D. GRAY and GERALD F. SHELDON, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—Traditional theories of the turbulent far wake predict that the mean velocity field depends only on a few gross parameters such as the free stream velocity and the drag on the body producing the wake. They imply that the wakes of comparable objects, such as a sphere and a circular disk normal to the free stream, are indistinguishable when appropriately normalized. The rationale for this conclusion may be that wake turbulence achieves a universal structure or that differences in the structure of turbulence do not effect the mean flow.

Bevilaqua and Lykoudis [1] compared the wakes of a sphere and a porous disk of equal drag. A near wake recirculation zone was found behind the sphere but did

not form behind the porous disk. In both wakes the mean velocity profiles quickly reached the same self-preserving form, yet the sphere wake spread twice as fast as the disk wake. Behind the sphere, periods of non-turbulent flow were observed on the centerline starting at 20 diameters; but the centerline flow behind the disk remained fully turbulent for more than 100 diameters. Flow visualization revealed that this phenomenon was due to the presence of large eddying bulges in the sphere wake in contrast to the generally smooth disk wake boundary. Bevilaqua and Lykoudis concluded that the rapid spread of the sphere wake was due to the high entrainment efficiency of these eddies and that their formation was related to the shape of the drag producing body.

Castro [2] studied the near wake within 20 chords of long flat strips mounted normal to the flow in a wind tunnel. A series of 11 solid and perforated strips were used which had ratios of open area to total frontal area (porosities) ranging from 0 to 0.645. For porosities of less than 0.3, a recirculation zone formed behind the strips. Considered as functions of porosity, the drag coefficient and eddy shedding frequency dropped abruptly at a porosity of 0.2. Castro concluded that for small porosities the shear layers from the strip edges interact to form a vortex street. At higher porosities the flow through the perforations prevents vortex street formation.

The present experiments emphasized far wake mean velocity measurements behind solid and porous (porosity = 0.425) strips similar to those used by Castro. Velocity profiles were made at 20, 40, 60, 80, and 100 chords behind the strips at a Reynolds number of 25000. It was found that the normalized velocity profiles approached the same self-preserving form beyond 20 chords, yet the normalized growth rate of the solid strip wake was about 40% faster than that of the porous strip wake. This is attributed to the presence of efficiently entraining vortices in the solid strip wake which are not present in the porous strip wake.

Taken together, the studies suggest that the presence of large eddies in far wakes is crucial to the entrainment process and that their formation does depend strongly on the details of the body geometry.

1. Bevilaqua, P.M. and P.S. Lykoudis, 1978, Turbulence Memory in Self-Preserving Wakes, *Journal of Fluid Mechanics*, Volume 89, pp. 589-606.
2. Castro, I.P., 1971, Wake Characteristics of Two-Dimensional Perforated Plates Normal to an Airstream, *Journal of Fluid Mechanics*, Volume 46, pp. 599-609.

How and Where to Find Water. ROBERT H. L. HOWE, West Lafayette, Indiana 47906.—A rapid and economical method has been developed, tested, and used for finding and assessing the availability of ground and surface water in a defined watershed. The method is based on pilot office studies of the geology, land uses, physiology, soils, vegetation, topography, climatic data, and other pertinent hydrological elements by aerial photographic (low altitude and high altitude photos, infrared and color photos, etc.) information and technique of recognition, of the selected pilot area.

Equations are derived and tested on field studies in areas similar to pilot models. The reliability of this method by remote collection of information is further verified by actual ground surveys and physical comparison. A water resource inventory can be produced for an area where limited hydrological data are available. A computerized model and system can thus be produced for different areas. Results are used for satellite surveys verification.

The technique developed for finding ground and surface potential and

availability in relation to industrial development, urban water supply, agricultural demand, hydroelectric power estimation, pollution control, hydraulic model construction, etc., is illustrated by a color movie. Appreciation is acknowledged hereby to Dr. Robert Calwell of NASA and the University of California, co-investigator and project co-advisor of the author, and also to Dr. Shirley Griffith, Special Assistant to the President of the United States where the project was undertaken.

Reservoir Optimal Operating Rules Generated by Stochastic Optimization.

MOHAMMAD KARAMOUZ and MARK H. HOUCK, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—This study considers a stochastic optimization model to determine general operating rules for a given single reservoir system. The optimization model is a stochastic dynamic program which requires a discrete, lag-one Markov process as the streamflow descriptor. This optimization technique produces a set of optimal operating rules which can be tested by simulation of actual reservoir operation.

The Markov process which is assumed to describe the streamflows is based on the probabilities of transitioning to an inflow in season $t + 1$, conditioned on the inflow for season t . A set of characteristic storage volumes and streamflow are chosen so that the entire range of storage volumes and streamflows are considered. The operating policy designated by this model is a set of rules specifying the storage levels at the beginning of the next season for each combination of storage levels at the beginning of this season and inflow during the season.

The stochastic optimization model was successfully developed and tested for annual and monthly time periods for the Gunpowder River, Maryland, the Osage River, Missouri and the Blacksmith River, Utah. The reservoir capacity, number of discrete storage levels, and number of inflow intervals were varied to determine the best state increment. A complete description of the algorithm and test results is given in the paper.

Computer-aided Analysis of Radar Data for Forest Cover Mapping.

DOUGLAS J. KNOWLTON and ROGER M. HOFFER, Department of Forestry and Natural Resources & LARS, Purdue University, West Lafayette, Indiana 47906.—Tremendous progress has been made over the past decade in demonstrating the potentials and limitations for applying computer-aided analysis techniques to multispectral scanner data obtained in the optical portion of the electromagnetic spectrum. Such techniques are being utilized operationally to identify and map various earth surface features, such as forest cover types, water bodies, geologic features, agricultural crops, and others. With the continual interest in and development of sensors that obtain data at wavelengths beyond the optical portion of the spectrum, (i.e., Synthetic Aperture Radar [SAR] systems) additional data sources are becoming available.

Dual-polarized, X-band SAR imagery was obtained from an altitude of 60,000 feet over a test area near Camden, South Carolina on June 30, 1980. The imagery was digitized so that computer-aided analysis could be performed. However, before the classification algorithms could be used, the SAR data had to undergo various preprocessing techniques.

One of the preprocessing requirements was to overlay the two different polarizations so that they shared common line and column coordinates. A simple linear or biquadratic fit was to be used to overlay the data, but the geometric characteristics of the data proved to be much more complex than anticipated. The first portion of this paper describes the steps which had to be followed in order to

successfully overlay the digitized dual-polarized radar data. The second portion describes the results obtained from the computer classification of the overlaid radar data.

The results from this work in overlaying and classifying the SAR data provided important insights into some of the characteristics of the data itself. The steps between the collection and classification of the data can appear to be straight forward; however, they may turn out to be very complex. New data sources, such as SAR, are important and can lead to very interesting and useful applications, but one must also be aware that the use of digitized dual-polarized SAR data has some distinct limitations, and special preprocessing procedures will be required in order to effectively utilize quantitative data processing techniques.

HECSECT: A Computer Program for the Graphical Representation of River Cross Sections. H. R. LEMMER and ALDO GIORGINI, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—A major difficulty with computer analysis is to ensure the accuracy and correctness of the large amount of input data required. As the complexity of the program increases the less likely it becomes that errors in the input data can be easily detected in the output.

Graphical representation of data is a very useful tool in comprehending and understanding large sets of numbers. This program HECSECT was therefore developed to enable the user of HEC2 to check the accuracy of the cross-sectional data required by the program.

One additional control card must be added to the cross-sectional data required by HEC2 in order to obtain CALCOMP or VERSATEC drawings of the cross-sections as they are to be used by HEC2. Various options are also added to the program to cater to the various needs that the user might have.

Although the program was developed for use with HEC2, it can also be used to plot cross-sections in areas other than river cross-sections.

The program was developed for a project in river hydraulics and has been very useful in pointing out errors in the data, that had previously gone undetected.

A specially useful application of the tool consists in the comparison of data taken in different surveys. The river channel modification can be perceived at a glance.

Specification of Fill Compaction. C. W. LOVELL, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—The specification of fill compaction has a single objective, viz., to produce a structure of compacted material of *predictable* performance. Such performance is predictable through appropriate controls over: (a) the material used, (b) the compaction process employed, and (c) the end result produced. Performance to be predicted may include drainage, lateral pressure, settlement and shear strength. Parties to the specification include the owner, engineer, constructor, and construction manager, and all want to avoid the situations of (a) no specification, (b) incorrect specification, (c) arbitrary specification, and (d) excessive specification, since any of these either fails to produce predictable performance or wastes resources.

Proper specifications are developed via previous experience, test fills, or laboratory testing. Unfortunately, the specification can seldom be based directly upon the material properties which must be predicted, because these are too difficult to directly measure in the field. Rather, the desired performance properties are related to simple measures such as, (a) density, relative density, relative com-

paction; (b) water content or degree of saturation; and (c) penetration resistance or proof rolling.

Examples of proper specification are given.

SURZUNI: A Computer Laboratory for Numerical Experiments with Liquid Motion in the Presence of Surface Tension. MARK SMITH and ALDO GIORGINI, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.—The program ZUNI, developed by the Los Alamos Laboratories of the University of California, has been known for some time as one of the most versatile computer laboratories for numerical experiments on fluid flows with free surfaces. The program is general enough to include both two dimensional problems expressible in terms of Cartesian coordinates and two dimensional problems expressible in terms of cylindrical coordinates. Either ideal fluid or viscous fluids can be simulated by the program and the "test section", the region within which the fluid motion takes place, is a rectangular region for Cartesian coordinates and a cylinder for cylindrical coordinates. Furthermore, fluid can enter and leave the test section through openings at the boundaries.

The limitation of the ZUNI Program is constituted by the fact that no surface tension provision is made. This limitation excludes from consideration all those fluid motions where surface tension is an important parameter, like drop and bubble vibration, drop and bubble collapse, etc. . .

The program SURZUNI has been developed with this category of problems in mind. The modifications to the original program are of considerable finesse. The first difficulty to overcome was the accurate determination of the curvature of the free surface for a grid size that would make the numerical calculations feasible in a reasonable amount of time; then the problems related to the merging of two surfaces when two liquid bodies approach each other, before coalescing, and the problem of the splitting of one liquid body into two. These problems have been resolved very successfully as the several numerical experiments describing different hydromechanic problems illustrate.

Wide use is made of computer graphical techniques.

Multiobjective Approach for Energy Planning and Allocation. T. TREZOS and A. RAVINDRAN, School of Industrial Engineering, Purdue University, West Lafayette, Indiana 47907.—The problem of energy planning and allocation is approached through the use of multiobjective optimization. Two models are developed in this study. The first one makes use of the goal programming concepts and optimizes certain objectives according to their priorities in a sequential procedure. The second one derives the trade-off between any two objectives (bicriterion problem), using the Non-Inferior Set Estimation algorithm. The developed models take into consideration any constraint on the energy consumption (energy shortage), all the available forms of energy resources, new technologies of energy production, as well as the increase of energy prices and the reduction of the unemployment rate with respect to the level of the energy consumption. The models are illustrated using energy data for the State of Indiana. Energy data related to the State were collected from various sources for the model applications. Through these applications, the models are shown to be a useful tool to assess the impact of future energy shortage, higher fuel prices, introduction of newer technologies, and various allocation policies.

Virtual Instrumentation: Microcomputers at Work in the Laboratory. DAVID R. VOLTMER and ROGER N. GALLION, Department of Electrical Engineering, Rose-

Hulman Institute of Technology, Terre Haute, Indiana 47803.—The development of a new instrumentation concept, virtual instrumentation, holds the promise of versatile, cost-effective instruments for undergraduate laboratories. Virtual instrumentation exploits the increasing cost-effectiveness of digital technology through an approach which designs around a microcomputer, emphasizes digital system techniques, and uses self-contained software to operate the instrument. The microcomputer under the control of user-selected software electronically configures the hardware and processes the data to perform the desired measurement.

The user, following instructions displayed on a CRT screen, controls the virtual instrumentation via the microcomputer keyboard. In response to user commands, test signals are generated as digital numbers which are converted to analog form for application to the circuit under study. The response signals from this circuit are detected and converted to a sequence of digital numbers. Software algorithms process these numbers according to the selected instrument functions and presentation format. The results are displayed to the user.

The encouraging results of the prototype system feature increased capability, versatility and cost-effectiveness. With increased development efforts and technological advances, the future of virtual instrumentation is bright.