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S. K. Fullalove, *Editor*

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Load-carrying capacity of flooded masonry arch bridges

K. M. Hulet, C. C. Smith and M. Gilbert

Proceedings of the Institution of Civil Engineers—Bridge Engineering, **159**, No. 3, September, 97–103

Many existing codes of practice for masonry arch bridge assessment fail to provide engineers with adequate guidance on the adverse effects that saturated environmental or flood conditions are likely to have on load-carrying capacity. Analysis indicates that the load-carrying capacity of a fully flooded arch bridge backfilled with cohesionless fill could typically be reduced by a factor of 1.6–1.8, or even more in specific circumstances. The significant influence of flooding on load-carrying capacity has now been verified using small-scale experiments which are described in the paper. The effects of flooding on waterproofed and unwaterproofed bridges are also analysed numerically and the circumstances under which capacity reductions are likely to be highest are identified. This paper should be useful to engineers dealing with bridges which are at risk of flooding.

Climate change: man-made or natural?

R. Freer

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 1, February, 3

In December 2005 in Montreal the world's governments effectively adopted the Kyoto protocol on reducing greenhouse gases to limit global warming. Robert Freer assesses a recent book by Australian meteorologist William Kininmonth, who argues we can have little effect on climate change.

Dams still not being properly planned

U. Collier

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 1, February, 4

Five years after the World Commission on Dams report, some dams are still being built without proper planning and risk

further erosion of public support. Ute Collier of WWF looked at six dams started since the report and found options and impacts were still not properly considered.

The Deep, Hull: urban regeneration with attitude

M. Finlay

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 1, February, 16–23

Success of Lottery-funded visitor attractions on derelict UK sites is also a bit of a lottery. However, if you combine stunning architectural design with outstanding engineering and then fill the whole thing with sharks, you have a winning ticket. The Deep oceanic experience centre was built on a former shipyard site at the point where the Hull and Humber rivers meet in northeast England. Since the £53 million attraction first opened in 2002, visitor numbers are running at more than double the amount anticipated. As this paper reports, designing and building its main 10 m deep, 3000 t aquarium tank were just some of the many engineering challenges on what is now widely regarded as a benchmark regeneration project.

What lies beneath: surveying the Thames at Woolwich

J. Lenham, V. Meyer, H. Edmonds, D. Harris, R. Mortimore, J. Reynolds and M. Black

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 1, February, 32–41

Line 1 of the Crossrail project is planned to cross the River Thames via twin tunnels at Woolwich in east London. This paper reports on the fascinating investigation into the riverbed of Woolwich Reach, involving integration of a wide range of data from historical, geophysical and borehole sources. It illustrates how combining detailed desk studies and focused borehole investigations with over-water seismic, sonar and magnetic gradiometer surveys can assist civil engineers in the design of major structures within historic urban and tidal river environments.

Lessons learned from tsunami damage in Sri Lanka

P. Dias, R. Dissanayake and R. Chandratilake

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 2, May, 74–81

Around 300 000 people were killed by the tsunami that followed the Sumatra–Andaman earthquake on Boxing Day 2004, making it one of the worst disasters in modern history. Up to 40 000 died in Sri Lanka alone, where around 80 000 houses were also destroyed when waves up to 15 m high swept ashore. This paper reports on how coastal buildings and infrastructure in Sri Lanka behaved under various tsunami wave heights and the many lessons learned for reducing vulnerability to future events. In particular, newly published national guidelines for reconstruction emphasise the importance of tying down structures against upward and lateral loads as well as the need to anticipate and reduce soil scour around foundations, especially of backfilled earth.

Britain finally begins to rise to the energy challenge

R. Freer

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 4, November, 148

In July this year the UK Government launched its third publication on national energy policy in just over four years. Robert Freer says there are at last some signs of positive action to solve the main problem, which is keeping Britain's lights on.

Acute decompression illness in UK tunnelling

D. Lamont and R. Booth

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, No. 4, November, 185–191

Civil engineers have used compressed air to stabilise wet ground for over 150 years and continue to do so. But since 2001, compressed-air workers in the UK can no longer decompress on air alone—it now has to be done with the aid of oxygen. Despite one of the strictest regulatory environments in the world, Britain's construction industry recorded 428 cases of decompression illness between 1984 and 2002, leading to air-only decompression being banned. This paper provides an analysis of the UK's uniquely comprehensive database of compressed air exposure and decompression illness records which led to the ban. It provides a benchmark for assessing the effectiveness of oxygen decompression as well as informing other countries considering making the change.

Dams: setting a new standard for sustainability

R. Bridle

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, Special Issue 1—Water worldwide: principles and practicalities, May, 21–25

Dams are important elements of water infrastructure and bring many benefits to society. The World Commission on Dams addressed concerns about them and practice is improving. The UN Millennium Development Goals aim to halve several unsatisfactory situations by 2015, and infrastructure contributing to their achievement should therefore be designed to halve current risks. Quantitative risk assessment methods have been developed to enumerate the safety of UK dams. Any quantitative assessment of risk necessarily raises the need to establish what risks are acceptable to society, and the work on dams has prompted the thought that acceptable risk could become an impartial, apolitical and conscionable means of

establishing the standards of infrastructure that should be delivered. How the approach could be applied and developed is described.

A partnership approach to managing flood risk

M. Crossman, D. Richardson and J. Milne

Proceedings of the Institution of Civil Engineers—Civil Engineering, **159**, Special Issue 2—Risk: facing the reality, November, 41–45

Flood risk poses a significant threat to many communities and, whereas measures can be taken to reduce the likelihood and impact of flooding, the risk can never be eliminated altogether. Insurance provides a useful means of spreading the residual risk and this paper provides a description of the UK partnership that enables insurance, backed by private-sector capital, to be made available on the basis of Government commitment to manage risks. It describes the benefits of this approach compared with that taken in other parts of Europe and makes the case for further broadening and deepening of partnership as climate change and socio-economic development give rise to increasing risks.

GRP offshore: applications and design for fire

J. M. Davies and P. Currie

Proceedings of the Institution of Civil Engineers—Construction Materials, **159**, No. 3, August, 95–103

In many respects, advanced glass-reinforced plastic (GRP) composites appear to be excellent, well-researched construction materials looking for practical applications that are economically viable. However, this simplistic overview is not valid for offshore installations, where the combination of high strength, light weight and supreme resistance to corrosion has ensured their economic viability. In many potential practical applications, the main hindrance to their widespread acceptance is cost. However, in the demanding offshore environment, it is more likely to be their performance in fire. Offshore, the main applications that have been considered to date are pipes, tanks and vessels including fire deluge systems, fire protection systems, cladding panels, gratings and stairways. The most successful practical applications have been in pipework and fluid handling. More recently, a feasibility study has been carried out that considers the use of composites for the primary structural members of offshore platforms. This paper will briefly review these applications before proceeding to summarise some of the research that has been carried out at the University of Manchester in order to demonstrate that advanced composites can meet the design requirements for offshore applications. Particular attention will be given to the fire performance of composites, and it will be shown that, although all the plastic materials used in the manufacture of composites are flammable, it is not necessary to be pessimistic regarding their performance in hydrocarbon fires, even in certain fire-critical situations.

Banked realignment: a case study from the Humber Estuary, UK

N. I. Pontee, S. C. Hull and J. R. Moore

Proceedings of the Institution of Civil Engineers—Engineering Sustainability, **159**, No. 3, September, 99–108

The majority of realignment schemes undertaken in the UK to date have involved breached realignment. However, banked

realignment schemes can offer benefits in terms of creating habitats that have greater physical and biological connectivity with the wider estuary. These benefits are illustrated through a case study of a scheme at Welwick in the Humber Estuary, which is one of the few recent managed realignment schemes to involve the wholesale removal of the fronting flood embankment rather than the creation of breaches. In this example, the scheme design was heavily influenced by the requirement to create a compensatory mudflat habitat and, in this regard, the methods used to assess the future evolution of the scheme are described. The paper goes on to discuss the generic design issues relevant to managed realignment schemes at other locations, including the target habitat to be created. It is suggested that the benefits of banked realignment schemes, in terms of delivering more sustainable estuary morphologies, merit increasing consideration by developers in the future.

Hydro-electric power without water storage

T. L. Shaw

Proceedings of the Institution of Civil Engineers—Engineering Sustainability, **159**, No. 4, December, 139–143

Although reservoirs benefit the performance of hydropower schemes there is no overriding operational need for them. Wind and solar power projects function well without storage, as will the planned range of marine energy devices. This paper reviews the equivalent features of 'run-of-river' hydro schemes which in essence operate in response to rainfall, that is, according to the variation of river flow resulting from the natural release of water from catchments.

Foundation design for a large arch bridge on alluvial soils

J. Monnet, D. Allagnat, J. Teston, P. Billet and F. Baguelin
Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **159**, No. 1, January, 19–28

The Crozet bridge is located on the Grenoble–Col du Fau motorway, on the Grenoble–Sisteron route, 15 km south of Grenoble, France. It crosses a 350 m wide valley and the RN75 national road. The adaptation of the bridge into the landscape has involved an arch design with three bays (in the Grenoble–Sisteron direction) and one bay (in the Sisteron–Grenoble direction). The supports of the structure were difficult to build because of the huge horizontal force and the low displacement tolerance. The low stiffness and strength characteristics foreseen led to a geotechnical investigation by cyclic pressuremeter tests with a friction angle and cohesion interpretation. The foundation calculations were carried out by a finite element calculation using the CESAR-LCPC program to determine the support rigidity. The complete computation of the bridge was done with the calculated support rigidity, which showed that displacements of the arches were lower than the tolerance. The bridge is located in a low seismic area of France, and the design takes into account the maximum foreseeable magnitude, and analysis of the soil liquefaction risk. Monitoring carried out for completion of the bridge in 1999 and along the surveying shows displacements lower than tolerance values. Since 1999, the bridge has withstood huge service weights without any difficulty.

Analysis of behaviour of a high rockfill dam

A. Soroush and A. Aghaei Araei

Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **159**, No. 1, January, 49–59

This paper reviews the effects of first impounding on rockfill dams. In particular, saturation collapse phenomena induced by wetting of rockfills are highlighted. Major attention is given to the effects of impounding-induced saturation on the mechanical behaviour of rockfills. The paper presents a comprehensive study of the behaviour of the Masjed-E-Soleyman rockfill dam during its construction and first impounding, by means of thorough analyses of instrumentation results and numerical modelling. Results of the instruments show that impounding-induced saturation collapse has occurred in the upstream shell of the dam. Also, the numerical analyses suggest that the Hardening Soil, elasto-plastic constitutive model employed in the analysis, using reduced strength and stiffness parameters for the saturated rockfills, is able to capture the behaviour of the rockfill dam during the first impounding. The results of the analysis compare well with the similar results of the instrument monitoring.

Repairs to River Trent navigation locks 1981–2002

J. Pickles

Proceedings of the Institution of Civil Engineers—Structures and Buildings, **159**, No. 3, June, 127–144

A series of repairs to three large concrete locks on the River Trent navigation was carried out between 1981 and 2002, involving works to counter the effects of degrading Mercia Mudstone foundation material and unsatisfactory stability of the structures. The current paper describes the history of the locks and the problems which developed, the assessments and investigation undertaken to determine the failure modes and the development of appropriate repair strategies. Significant factors included closure of the navigation, dewatering arrangements and temporary load cases, the preservation of existing stability and the effects of difficult site access. Construction activities are also briefly described. The projects originated from emergency works following a near failure at Stoke Lock (1981–1983), reactive works following monitoring at Newark Nether Lock (1993/1994) and preventative works identified through an asset inspection process at Cromwell Lock (2001/2002). The 1981–1983 works involved external sheet pile anchors and ties and a reinforced concrete trough section built in the lock chamber together with major temporary works. At Newark Nether, mini-piling was installed through the lock walls to improve stability prior to replacement of the lock floor, avoiding many of the temporary works needed at Stoke Lock. The Cromwell Lock works were similar to Nether Lock but utilised vertical mini-piling and an underfloor drainage system in a refinement of earlier designs. Use was made of British Waterways' own temporary works equipment where available.

A high-speed railway through marshlands (CTRL)

S. W. Dyson and M. J. D. Kirk

Proceedings of the Institution of Civil Engineers—Transport, **159**, No. 2, May, 75–82

Providing a high-speed railway from the Channel Tunnel to London St Pancras has brought a wide variety of engineering challenges. This paper describes some major features of contract 310 of the Channel Tunnel Rail Link (CTRL), where the challenge

was the construction of a high-speed railway formation across marshlands adjacent to the River Thames. Contract 310 provided the main civils works from where the Thames tunnel emerges westward from under the Thames to the start of the London tunnel just to the west of Dagenham Dock Station leading to Stratford and St Pancras. The contract extends over 12 km on an alignment mostly at grade through Aveley, Wennington and Rainham Marshes where, for the most part, the railway formation is supported on concrete piled slabs. In some areas, ground strengthening has been used instead. Three significant viaducts carry the track over obstacles from roads, railways and rivers (Thurrock, Aveley and Rainham Creek Viaducts). Construction started in January 2002 and was completed in July 2005.

Use of waste tyre bales to construct a flood embankment

M. W. Bo and A. Yarde

Proceedings of the Institution of Civil Engineers—Waste and Resource Management, **159**, No. 2, May, 57–64

A case study in the use of tyre bales in the design of a UK flood embankment is presented and the legal, technical and environmental issues are briefly discussed. A few major risks in the use of tyre bales in a flood prevention embankment—such as possible buoyancy of the tyre bale under water, possible piping of underlying soil and overlying capping soils due to their extremely high permeability, possible rebound of the bales upon release or deterioration of metal ties, release of unacceptable leachate to the controlled water from old tyres—were taken into consideration in the design stage and necessary steps and precautions were adopted. The use of tyre bales on the project provided a cost-effective and environmentally sustainable solution and has potentially paved the way for other applications. The pilot project scheme, which is now complete, has used around 1 million tyres, which is approximately 10% of the total number of tyres that would normally go to landfill in any one year in the UK.

Introducing the Flood Risk Management Research Consortium

G. Pender

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 3–8

This paper reports on the formation of the Flood Risk Management Research Consortium and the research that is under way within the 'towards whole systems modelling' (WSM) priority area. Funding for the consortium is provided from a wide range of research funders in the UK including the national research councils, government departments and agencies with responsibility for flood risk management. The research portfolio has been formulated to address key research needs identified by the funders. This briefing note explains the relationship between the planned research in the WSM area and the UK Environment Agency's Strategy for Flood Risk Management. Additionally, it provides an introduction to the companion research papers in this issue by Villanueva and Wright, Hunter *et al.*, Lin *et al.* and Néelz *et al.* The research reported in these companion papers focuses on flood inundation modelling and is an important subset of the work to be undertaken within WSM.

Improved simulation of flood flows using storage cell models

N. M. Hunter, P. D. Bates, M. S. Horritt and M. D. Wilson

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 9–18

Storage cell codes for inundation modelling treat the floodplain as a series of discrete basins, with the flow between cells calculated using some analytical flow formulae such as the Manning equation. These codes have many of the advantages of full two-dimensional schemes but without the computational cost. However, with this class of model the propagation speed of the inundation front over the floodplain can be shown to be highly dependent on the model grid scale and insensitive to floodplain friction. To overcome these problems adaptive time step techniques have recently been proposed; however, to date these have only been tested against highly idealised analytical solutions. In this paper the authors compare fixed and adaptive time step storage cell codes for flood inundation modelling against a real world data set for the first time. The data consist of a satellite synthetic aperture radar image of inundation extent at ~ 12.5 m spatial resolution taken during a 1-in-50-year flood, which occurred in 1998 on the upper River Severn in the UK; gauged flows at the upstream and downstream ends of an approximately 60 km reach of the river; and a digital elevation model developed from channel survey and an airborne laser altimeter survey of the floodplain topography. Results show that the adaptive model produces a modest improvement in simulation performance over the fixed time step code, yet is much better able to simulate realistically the drying of the floodplain in the upper reaches of the model domain. The adaptive code also demonstrates a more realistic sensitivity to floodplain friction which is likely to account for its markedly different dynamic behaviour and, in this respect, intuitively better performance.

Integrating 1D and 2D hydrodynamic models for flood simulation

B. Lin, J. M. Wicks, R. A. Falconer and K. Adams

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 19–25

The one-dimensional (1D) hydrodynamic model ISIS has been extensively used for designing river engineering and irrigation schemes and mapping flood risks. This paper presents the integration of a two-dimensional (2D) model with ISIS to enhance its capability for simulating floodplain flows. The 2D model is based on the DIVAST model, a research model widely used for predicting flows and water quality indicators in estuarine and coastal waters. One of the main advantages of using DIVAST is that the model has a very robust subroutine for simulating flooding and drying processes. In this study DIVAST is dynamically linked to the ISIS model and the linked model is used to predict overland flood flows. In order to increase the flexibility of the DIVAST model for dealing with complex flow situations while minimising the computational time, several modelling options were considered. These options include the so-called hydrodynamic approach, gravity wave approach and flood wave approach. A series of numerical tests were undertaken to assess the accuracy and efficacy of these approaches for simulating flows over initially dried land and dam-break flows.

The model was then used to predict the flood flow in an urban area for an assumed extreme flood flow condition.

Linking Riemann and storage cell models for flood protection

I. Villanueva and G. T. Wright

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 27–33

As part of the nationally funded Flood Risk Management Research Consortium the use of linked one-dimensional and two-dimensional models has been investigated with a view to optimising the balance of accuracy, model complexity and run times. This has been developed in research software named TRENT using a Riemann approach for both dimensional representations. In this paper the details of the method are presented along with a storage cell scheme similar to that implemented in the software known as LISFLOOD-FP developed at the University of Bristol. Remotely sensed data are used to provide the digital terrain model for a test case at Upton-upon-Severn in the UK and airborne imagery is used for validation. The storage cell and Riemann approaches are compared and conclusions drawn.

Using remotely sensed data to support flood modeling

S. Néelz, G. Pender, I. Villanueva, M. Wilson, N. G. Wright, P. Bates, D. Mason and C. Whitlow

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 35–43

Recent severe flooding in the UK has highlighted the need for better information on flood risk, increasing the pressure on engineers to enhance the capabilities of computer models for flood prediction. This paper evaluates the benefits to be gained from the use of remotely sensed data to support flood modelling. The remotely sensed data available can be used either to produce high-resolution digital terrain models (DTMs) (light detection and ranging (Lidar) data), or to generate accurate inundation mapping of past flood events (airborne synthetic aperture radar (SAR) data and aerial photography). The paper reports on the modelling of real flood events that occurred at two UK sites on the rivers Severn and Ouse. At these sites a combination of remotely sensed data and recorded hydrographs was available. It is concluded first that light detection and ranging Lidar generated DTMs support the generation of considerably better models and enhance the visualisation of model results and second that flood outlines obtained from airborne SAR or aerial images help develop an appreciation of the hydraulic behaviour of important model components, and facilitate model validation. The need for further research is highlighted by a number of limitations, namely: the difficulties in obtaining an adequate representation of hydraulically important features such as embankment crests and walls; uncertainties in the validation data; and difficulties in extracting flood outlines from airborne SAR images in urban areas.

Future flood risk management in the UK

E. Evans, J. Hall, E. Penning-Roswell, P. Sayers, C. Thorne and A. Watkinson

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 53–61

The Foresight Future Flooding project has analysed future flood risk in a scenario framework for the whole of the UK. The analysis predicts increasing flood risk unless current flood management policies and investment levels are changed, with up to a twentyfold increase in economic risk by the 2080s. The increase is attributable to a combination of climate change and increasing value of household, industrial and infrastructure assets. Potential responses are assessed in terms of the three pillars of sustainability: social, environmental and economic. The work described has formed much of the evidence base for the new government strategy for flood risk management in England, 'Making space for water'.

Application of 3D hydrodynamic model to flood risk assessment

B. Li, M. Phillips and C. A. Fleming

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 1, March, 63–75

In this paper a newly developed three-dimensional hydrodynamic model has been used to investigate the consequences of the site redevelopment of Llanwern and flooding prevention measures. The 3D model includes hydrodynamic pressure without static pressure assumption. Two possible flooding risks have been analysed—tidal flooding from the south and fluvial flooding from the River Usk. Modelling results show that the consequences of the redevelopment and flood prevention measures are minimal on the surrounding area.

Modelling sediment loads in the Lower Ganges, Bangladesh

G. M. Tarekul Islam and S. T. Jaman

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 2, June, 87–94

The Ganges is one of the three major rivers in Bangladesh. It is a sediment laden, wide, meandering river. This paper deals with the stochastic modelling and prediction of sediment loads of the Lower Ganges river in Bangladesh. The annual variability of sediment loads has been examined. The annual sediment load series is trend free at 5% significance level. The means and standard deviations of monthly sediment load data show periodicity. Monthly sediment load data have been modelled and predicted using the Thomas–Fiering model for the dependent stochastic component and by taking variable month-to-month correlation structures into account. The statistical parameters of observed and predicted data fit very well and hence the predicted sediment load data may be used for future planning of water resource projects in Bangladesh. The limitations of the model have also been discussed.

Analysing river bank seepage with a synthetic design hydrograph

I. Butera and M. G. Tanda

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 2, June, 119–127

The design conditions of a river embankment are usually computed in a steady state, in a similar way to those due to the maximum river level of an assigned return period. The seepage analysis of the water pressure that stresses the embankment, with

an increase in the risk of failure owing to both static instability and piping effects, results in an overly prudent evaluation that can be recognised as a non-economic design. The seepage steady state condition is, however, rarely verified in most river embankments, owing to the limited duration of floods and the poor conductivity of the soils that are usually adopted to construct river banks. Attempts to design in an unsteady regime have been made in recent years by means of mathematical models, but the selection of a design hydrograph in a river remains an ongoing problem. Over recent years, a new procedure for the identification of an efficient synthetic design hydrograph (SDH), with an assigned return period, has been developed by Maione and co-workers. This procedure has been successfully applied in the design of flood control reservoirs and in the evaluation of flood routing in rivers with large flood plain storage. In the current paper this SDH is applied in the analysis of seepage through a river embankment, as an attempt to design the river embankment in an unsteady regime; the SDHs of a given return period are applied to a levee with a simple geometry using a semi-analytical model and the main hydraulic quantities (maximum water level, time of maximum, etc.) of the seepage through the soil can be determined. All the real floods are then used as input for the model and the main hydraulic quantities of each flood are determined. The reliability of the design flood methodology has been tested by way of a comparison between the outcomes from the SDHs and the application of real floods.

Practical estimation of flow resistance through emergent vegetation

A. A. Jordanova, C. S. James and A. L. Birkhead

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 3, September, 173–181

A computational model of vegetation-influenced flow has been applied hypothetically to identify the variables most significant in determining resistance to flow through emergent reed-type vegetation, and to develop a simple procedure for estimating conveyance. A rational form of stage-discharge relationship is adopted and a formulation for the resistance coefficient in terms of the significant variables (stem spacing, stem diameter and stem drag coefficient) is derived through application of the computational model. Experimental results are used to relate the stem drag coefficient to stem Reynolds number and foliage state. The stage-discharge and resistance coefficient equations and the drag coefficient relationship are applied through a simple iterative procedure for routine conveyance estimation. The procedure is verified by comparison of predicted and measured discharges for flow through natural vegetation.

Sediment transport formulae for compound channel flows

R. D. Karamisheva, J. F. Lyness, W. R. C. Myers, J. B. C. Cassells and J. O'Sullivan

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 3, September, 183–193

Nine sediment transport formulae were reviewed and applied to both inbank and overbank flows in straight and meandering compound channels. The predictive capabilities of the formulae were evaluated using experimental data obtained from the large-scale UK Flood Channel Facility and the small-scale Ulster Channel. The Yang formula (1979) was found to give the best prediction for

sediment discharge, performing well for both straight and meandering channels. The Schoklitch (1962) and Yang and Lim (2003) formulae also gave very good predictions for most of the data sets studied. The Ackers and White formula (1973) gave very good prediction for the large-scale facility but overpredicted the sediment discharge for the small-scale channel. The Karim and Kennedy (1981) formula could also be a good sediment discharge predictor, for the studied flow conditions, but the coefficient of proportionality used in the formula needs to be calibrated.

Overbank flow depth prediction in alluvial compound channels

R. D. Karamisheva, J. F. Lyness, W. R. C. Myers, J. B. C. Cassells and J. O'Sullivan

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 3, September, 195–205

Algorithms based on simple one-dimensional stage-discharge models for compound channels have been developed and tested for overbank flow data from the UK Flood Channel Facility and the University of Ulster channel with straight and meandering planforms. The proposed divided resistance approach takes into account the grain resistance, the bed form resistance and the roughness characteristics of the floodplain but it was found to give unsatisfactory prediction of the flow depth for compound channels with rough floodplains. A simple algorithm for stage-discharge prediction based on a lumped resistance approach was then proposed. It requires calibration of the overbank Manning n for a relative depth zero and a coefficient of proportionality, and this is achievable if measurements of the flow depth and velocity are taken for at least three overbank flow discharges. The application of the lumped approach to various flume and field data showed good agreement between the measured and predicted flow depths.

Reducing uncertainty in the hydraulic analysis of canals

R. W. Dun

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 4, December, 211–224

British Waterways is the largest navigation authority in the UK, managing a network of 3200km of inland waterway. Central to this function is the management of a large and complex water supply system: water is transferred across the network for resource management, to maintain navigation, for sale to third parties and for flood relief. Understanding the movement of water is essential to the effective and efficient management of this system. One-dimensional hydraulic models are routinely employed by water engineers to investigate such regimes throughout the UK. This paper describes recent studies aimed at reducing the uncertainties associated with the application of such models. This was achieved with a programme of primary research that included extensive site surveys, hydraulic trials and modelling. The outputs of this work include: validation of Manning's roughness representation for canals; determination of roughness coefficients for a range of bed and bank protection types; development of a practical relationship for determining the effective roughness of vegetated canals; and the quantification of the impact of canal constrictions. This work is of interest to consultants, researchers and those who undertake hydraulic modelling studies of canal systems.

Prediction of pollutant movement in a regulated large river

C.-S. Rim, J.-T. Lee, S.-E. Yoon and J.-K. Shin

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 4, December, 225–233

The major purpose of this study is to find out how possible it is to predict long-term river water quality variation using the coupled water quality prediction model in the lower reach of the River Geum from Daechung Dam, South Korea. The Water Quality Analysis Simulation Program 5 (WASP5) and Hydrologic Engineering Centre (HEC-2) models have been coupled and applied to find the possibility of simulation of long-term river water quality variation. The chlorophyll-a concentration in the main river was estimated by changing the $\text{PO}_4\text{-P}$ and/or $\text{NH}_3\text{-N}$ concentrations flowing from tributaries. The study results show that the trend of longitudinal variation of simulated water quality variables is consistent with that of measured water quality variables. The variation of chlorophyll-a concentration in the main river was almost negligible except when both $\text{NH}_3\text{-N}$ and $\text{PO}_4\text{-P}$ concentrations from Gab stream and Miho stream are decreased by about 70%. Based on the study results, it can be concluded that the coupled water quality prediction model is highly applicable to this regulated large river for water quality management.

Conveyance estimation for channels with emergent vegetation

C. S. James and M. J. Makoa

Proceedings of the Institution of Civil Engineers—Water Management, **159**, No. 4, December, 235–243

Emergent vegetation strips occur commonly in rivers, especially along the banks, and have a significant influence on channel conveyance. A simple approach is presented for estimating the conveyance in such rivers, and the method is tested against laboratory and field data. Field data are also used to determine a realistic value of the resistance coefficient for marginal vegetation boundaries. Laboratory experiments have shown that the resistance of vegetation strips depends on the number of vegetation/ clear channel interfaces, and that the overall Manning resistance coefficient n varies strongly with flow depth. For practical purposes, conveyance can be estimated by summing the discharges in vegetated and clear channel zones, calculated separately but with allowance made for the interzonal interaction. The clear channel discharge usually makes the major contribution and can be reliably determined by application of familiar composite roughness formulae, accounting for different bed and side boundary resistance. Field data indicate a Manning's n of about 0.13 for a typical emergent vegetation side boundary. The vegetated zone discharge is invariably underestimated by using a basic vegetation resistance equation without accounting

for interzonal interaction effects, especially for narrow strips, but its contribution to the total channel discharge is usually relatively small.

Electronic verification of flowmeters in the water industry

R. C. Baker, P. I. Moore and A. Thomas

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For water public limited companies in the UK verification of key flowmeters is becoming an increasingly essential element of the required management and maintenance of installed meters demanded by the regulation authorities. In order to achieve regulatory compliance, new electronic solutions are being proposed to supplement or partially replace the current in situ meter verification using insertion probes and other methods. The validity of the claims made for currently available electronic verification devices is reviewed. The measurements required for this approach and their likely achievable uncertainties are considered. There is a brief discussion of the administration of the procedure by users. Successful electronic verification strategies will be dependent on the quality of the manufactured product and the necessary good housekeeping within the manufacturing company. The authors conclude by suggesting that the current concept is promising but may need to be developed if it is to yield a generally acceptable tool capable of achieving all aspects of regulatory compliance.

Local scour due to free overfall jet

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A study was conducted to determine how the tailwater depth beneath a free-falling water jet affects the dimensions of local scour. Available data on scouring in uniform bed material due to circular and rectangular outflow jets were compiled and analysed. It was found that the scour hole geometry (i.e. maximum depth of scour, width of scour hole, length of scour hole and height of ridge formed downstream of the scour hole) is a function of the densimetric Froude number and the ratio of tailwater depth to drop height. The effect of tailwater on scour was investigated and limiting values for tailwater are introduced. It was observed that at low values of tailwater depth, increasing tailwater depth is associated with increasing scour hole dimensions, while at high values of tailwater depth the reverse trend occurs. For low tailwater conditions, the densimetric Froude number has little or no effect on the ridge height downstream of the scour hole, which is affected only by tailwater depth. New empirical equations for the prediction of scour hole geometry and ridge height are presented.