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Ma'rib Dam and irrigation project—a wonder in the desert

R. Chakraborty
Proceedings of the Institution of Civil Engineers—Civil Engineering, **158**, No. 4, November, 170–177

Building major infrastructure projects in adverse social and climatic conditions is never easy. The Ma'rib irrigation project in Yemen is a classic case, with the £65 million scheme taking over 30 years to complete. Civil unrest, tribal feuds, flash floods and windblown sand all played their part in its delay, but work is finally scheduled to be completed next year. A total of 74 km^2, including nearly 50 km^2 of former desert, will soon be irrigated by the country's largest dam, enabling the land to be farmed again—as it was in ancient times. This paper describes the design and prolonged construction of this technologically straightforward yet hugely challenging and beneficial civil engineering project.

Hydroelectric power: present role and future prospects

A. Bartle and G. Hallowes
Proceedings of the Institution of Civil Engineers—Civil Engineering, **158**, No. 6, November, 28–31

Hydropower currently provides around 19% of the world's supply of electricity, but only 1·5% in the UK.This paper argues that although hydropower will never be sufficient alone to meet increasing world needs for electricity, it is a clean renewable source of energy that should be exploited to the maximum possible extent. It reports that significant potential exists for both development of new hydro schemes and the uprating, at relatively low cost, of existing ones. The greatest potential is available in developing countries but there is scope for substantial development in many parts of Europe, where only 45% of the resource has been exploited. In the UK, more small hydro could be developed and more pumped storage schemes may be required to balance increasing investment in wind and tidal power.

Modelling sustainable urban water management options

I. Sakellari, C. Makropoulos, D. Butler and F. A. Memon
Proceedings of the Institution of Civil Engineers—Engineering Sustainability, **158**, No. 3, September, 143–153

This paper describes the development of a prototype decision-support tool, termed optioneering tool-1 (WaND-OT1), supporting decisions for urban water management, which explores issues of the compatibility of alternative sustainable technologies and sustainability evaluation at a strategic level. TheWaND-OT1 prototype was developed in Excel and Matlab (SIMULINK) to be both computationally strong and user-friendly. The user interacts with the WaND-OT1 through the Excel platform, which exchanges data and user preferences with a SIMULINK-based systems model. To explore its potential and identify research directions, the prototype WaND-OT1 was tested under a variety of urban water management scenarios, including water recycling, rainwater harvesting and introduction of low water consumption devices. It is concluded that even at this early stage of its development, the WaND-OT1 can be considered as a flexible tool that successfully represents the main components of the urban water cycle and produces plausible and useful results in terms of the interaction of components.

Economic assessment tool for greywater recycling systems

F. A. Memon, D. Butler, W. Han, S. Liu, C. Makropoulos, L. M. Avery and M. Pidou
Proceedings of the Institution of Civil Engineers—Engineering Sustainability, **158**, No. 3, September, 155–161

The implementation of water demand management strategies, particularly in urban environments, can contribute towards improved sustainability (or at least reduce unsustainability) in the water sector. Greywater treatment, and its subsequent use for toilet flushing, is one of the demand management options offering considerable water-saving potential. The uptake of greywater recycling systems (GRSs), particularly in the UK, is

low. One of the reasons for such a low uptake is the perception that GRSs have a high (unsustainable) cost/benefit ratio. This paper presents progress on the development of a whole-life cost (WLC) model, aimed at facilitating decision making for the implementation of GRSs in relation to their economic viability.

Integrated systems approach to managing urban pollution

C. Pettit, A. Azopagic and S. Jefferis
Proceedings of the Institution of Civil Engineers—Engineering Sustainability, **158**, No. 3, September, 163–169

This paper outlines a new integrated decision-support framework for a more sustainable management of urban pollution, developed within the project 'Pollutants in the urban environment' (PUrE). The framework comprises a suite of appropriate models and tools that can be selected by different stakeholders or end-users (such as policy-makers, local authorities, industry, researchers and non-government organisations) to conduct simple screening studies and/or detailed modelling assessments of the effects of pollution in the urban environment. The models and tools enable consideration of individual pollutants and their mixtures released from a wide range of urban sources, as well as evaluation of local and global effects of urban pollution. Examples of the tools and models integrated into the decision-support framework include: life-cycle assessment; substance flow analysis; air and water dispersion and advection modelling; and human health assessment. The important features of the framework are that it is tiered, flexible and modular, allowing the users to choose the appropriate models or tools as well as decision-making paths, depending on their needs and the type of decision-making problem they are addressing. Although the framework is in its early stages of development, its application has already been demonstrated on a number of case studies, as detailed in this paper.

Numerical modelling of groundwater pumping processes

M. Mavroulidou, M. J. Gunn and R. I. Woods
Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **158**, No. 2, April, 83–93

Engineers need versatile tools in order to design successful dewatering schemes to counteract the effects of changing groundwater levels in cities. In the present paper, a finite-element program is used to perform pumping analyses, involving moving phreatic surfaces and possible desaturation of materials. First, a problem of local dewatering from a line of wells is analysed, involving desaturation of the soil. The results from an analytical solution as well as those of the numerical model are compared with field data. It is shown that the numerical results, accounting for soil desaturation, are closer to field measurements. Second, the ability of the finite-element program to model falling and subsequently rising groundwater levels in cities due to variable water abstraction (as in the case of London) is assessed. The techniques show promise and are sufficiently flexible to be applied to other geologies and boundary conditions.

Predicting ground displacements caused by pipe splitting

D. N. Chapman, C. D. F. Rogers and P. C. F. Ng
Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **158**, No. 2, April, 95–106

Pipe splitting is used for the on-line replacement of pipelines made from ductile materials, for example ductile iron and steel. It is a relatively new technique, and so there is limited knowledge about the associated ground displacements, in contrast to the pipe-bursting operations used for pipelines constructed of brittle materials, such as clay, concrete or cast iron. Understanding, and hence predicting, the ground displacements generated by pipe splitting is of vital importance when considering safe distances to other services and controlling possible damage to the road surface. This paper describes the results from some analytical studies that have been conducted in an attempt to develop such a method of prediction, and follows on from a series of full-scale laboratory experiments and an instrumented field trial. The observed ground displacements obtained from this work showed that an elliptical expansion of the soil locally to the existing pipe best represented the general behaviour of the ground for the most common types of pipe splitter currently used in practice. Consequently the analytical work has concentrated on assessing this assumption. The results from these analyses suggest that the elliptical assumption for the localised displacement is generally valid as a first estimate. However, pipesplitting operations cause more complicated ground displacements than pipe-bursting operations as the displacements are less symmetrical in nature, and are controlled to some extent by the way the pipe-splitting device is used in practice.

The first 30 years of Lefkara Dam

K. Kyrou, A. Penman and C. Artemis
Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **158**, No. 2, April, 113–122

The 74 m high Lefkara embankment dam was built in the early 1970s for the Republic of Cyprus Water Development Department in order to supply domestic water to the cities of Famagusta and Larnaca. It is a rockfill dam with a central clay core composed of a combination of residual soils and colluvium supported by diabase rockfill shoulders. The dam was well instrumented using total pressure cells, piezometers and internal settlement gauges as well as surface settlement markers. These instruments are still working and the results are discussed in the paper. The dam is curved in plan since it was anticipated at the time of its design that the arched plan would help resist the thrust from the reservoir, but in reality it made virtually no difference to the behaviour that would be expected from a straight dam. Instead of the conventional vertical valve shaft for housing the water intakes at various levels, a semi-buried inclined gallery (shaft) has been adopted. Leakages of reservoir water through the gallery joints into the gallery have been creating problems at high reservoir levels. The embankment and its foundation proved to be quite watertight and the seepages recorded are remarkably low.

Effect of trenchless technologies on existing iron pipelines

A. Hunter
Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **158**, No. 3, July, 159–167

Impact moles and directional drilling units form tunnels of up to approximately 300 mm in diameter at a depth of 1–2 m. They are typically used for the installation of electricity cables or

small-diameter pipelines. This type of tunnelling differs from conventional tunnelling owing to the lack of soil excavation. The tunnel is formed by dynamically expelling soil outwards in a predominantly radial direction. This creates a stress and displacement field that has the potential to damage existing services and buildings. To reduce the risk of damage to existing structures installation guidelines detailing acceptable proximity distances need to be provided. This paper details a methodology that has been used to calculate acceptable proximity distances to existing grey iron pipelines that have a transverse geometric configuration to the new pipeline. The study utilises finite difference techniques in conjunction with analytical cavity expansion solutions to determine the stress–strain field induced by tunnelling operations in idealised cohesive and frictional soils. Results from the finite difference study have been used in conjunction with a knowledge of acceptable pipeline strain and joint rotation levels to form acceptable proximity guidelines for this type of tunnelling operation.

Hull wastewater flow transfer tunnel: tunnel collapse and causation investigation

W. J. Grose and L. Benton
Proceedings of the Institution of Civil Engineers—Geotechnical Engineering, **158**, No. 4, October, 179–185

The Kingston upon Hull wastewater tunnel was 80% complete in 1999 when a collapse occurred 200 m behind the tunnel boring machine. The majority of the tunnel was in glacial soils, although the collapse occurred in a relatively short length of tunnel in alluvium. There were no obvious reasons for the collapse, so an investigation was undertaken to examine systematically all credible factors. It was concluded that the primary factors leading to the collapse were an extensive layer of single-sized fine sand under considerable water pressure beneath the tunnel, and a leak large enough to admit sand particles. The leak was most likely caused by differential movement between the tunnel and an access shaft immediately adjacent to the seat of the collapse, a consequence of relatively compressible peat at the crown of the tunnel that was probably adversely affected by the stress relief of boring the tunnel. The paper describes the works under construction, the collapse and the events leading up to it, and the investigation after the event. The most likely reasons for the collapse are presented, together with the steps taken to ensure that the remainder of the tunnelling progressed safely.

Impact of the EU Water Framework Directive

R. Freer
Proceedings of the Institution of Civil Engineers—Maritime Engineering, **158**, No. 1, March, 1–2

The EU Water Framework Directive1 (WFD) became law in England and Wales in 2003. It is a far-reaching piece of legislation which could affect the activities of many of those concerned with rivers, lakes, estuaries, coastal waters, and man-made water bodies. Although the objectives of the WFD are broadly supported by both the industry and international technical organisations, such as the International Navigation Association (PIANC) and the Central Dredging Association (CEDA), there are concerns that components of the Directive—and in particular the proposal for a daughter Directive dealing with priority substances and priority hazardous substances—could cause difficulties for some important maritime activities. To draw attention to these potential problems Greg Haigh, Chairman of the ICE Maritime Board, and Jan Brooke, a member of the ICE Maritime Board, presented a paper to a meeting of the Parliamentary Maritime Group in the House of Lords on 16 November 2004. A summary of their presentation is given below.

Modelling sediment transport using a lightweight bed material

O. Kocyigit, B. Lin and R. A. Falconer
Proceedings of the Institution of Civil Engineers—Maritime Engineering, **158**, No. 1, March, 3–14

Details are given of a combined physical and numerical model study of sediment transport processes in a square harbour caused by tidal motion. The effects on bed level changes due to tidal currents and the configuration of the harbour entrance were investigated. A lightweight material called Cation Resin was used in this study to represent bed sediments in the laboratory experiments. This material enabled the erosion and deposition processes to be exaggerated within the model harbour, in which the magnitude of the flow velocities was relatively small. An unstructured mesh generation technique, namely a quad-tree grid, was incorporated into an existing two-dimensional depth-integrated numerical model to predict the transport of water quality constituents and sediment particle fluxes. The numerical model was further refined to include the prediction of bed level changes. Detailed comparisons between the numerical model predictions and the laboratory data were undertaken. It was found that the numerical model predictions and the laboratory measurements were in good agreement. It was also concluded that Cation Resin was an appropriate material to use for physical modelling of sediment transport processes in laboratory model studies.

Effective flood alleviation design and construction

W. Bradley
Proceedings of the Institution of Civil Engineers—Municipal Engineer, **158**, No. 2, June, 107–113

Innovation and best practice designs can be encouraged through an effective design process. The award-winning Harbertonford Flood Defence Scheme was described as 'the future of flood defence schemes' by Sir John Harman, Chairman of the Environment Agency, and delivered a combination of in-village river channel improvement and upstream flood attenuation to alleviate regular flooding and the misery it caused. This paper focuses on how the design was developed and implemented to demonstrate the benefits that can be delivered through good teamwork and effective management of the civil engineering process.

SuDS—Innovation or a tried and tested practice?

A. Kirby
Proceedings of the Institution of Civil Engineers—Municipal Engineer, **158**, No. 2, June, 115–122

There are many obstacles to the implementation of sustainable drainage systems (SuDS) in England and Wales as a viable

alternative to conventional pipe systems. However, in Scotland these obstacles have been largely overcome and many SuDS schemes have been successfully implemented over the past decade. This paper will review SuDS in Scotland and compare the structure of the water companies north and south of the border, which is a major factor in implementing SuDS. Also, case study evidence will be used to show how a successful SuDS scheme was implemented in Aztec West, Bristol, over 20 years ago. This paper was awarded the 2004 James Forrest Medal.

Water utility consultation with the urban poor in developing countries

S. Coates, K. Sansom and J. Colin
Proceedings of the Institution of Civil Engineers—Municipal Engineer, **158**, No. 3, September, 223–230

Inadequate water services to the urban poor remain a serious problem in developing countries. Where services do exist, the chosen engineering solution often proves unsustainable. Engineers relying heavily on technical expertise can fail to understand the contextual factors determining what poor people want and are willing to pay. Although the concept of appropriate technology options is common enough, technology alone cannot provide a sustainable service. Tariffs and management options must also be designed to meet the needs of the poor. PREPP (participation–ranking–experience–perception– partnership), is a consumer consultation process for use by engineers with the support of social scientists and community development workers. These professionals traditionally see service provision from diverse perspectives and in developing countries they rarely work as a team. Through PREPP, engineers are able to understand the problems of service provision in poor urban settings through the eyes of poor consumers and the professionals that more commonly work with them. Likewise, social sciences professionals are better able to understand engineering parameters. The result is a cost-effective and relatively rapid process that helps engineers to design relevant engineering solutions with more chance of sustainability. Experiences in Zambia, India, Kenya and Uganda are illustrated.

Review of CIRIA Report 142 on highway pollutants

J. A. Patel
Proceedings of the Institution of Civil Engineers—Transport, **158**, No. 3, August, 137–138

Pollutants build up on highways and are washed off during a rainfall event and are usually discharged via an outfall to a watercourse. CIRIA report 142 (1994) guidance indicates that pollutant build-up on highways is a linear process which is proportional to traffic flow and time. This guidance has since been adopted in the Design Manual for Roads and Bridges. However, recent studies suggest that these assumptions may not be ideal. This article explores the pollutant build-up and runoff mechanisms on highways and suggests possible alternative assumptions which may be implemented to enhance the original CIRIA methodology.