

Research Focus

Issue No.49

MAY 2002

PROMOTING THE APPLICATION OF RESEARCH IN BUILDING AND CIVIL ENGINEERING

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Rural landslide risk assessment

Landslides pose a major threat to rural development in mountain regions. Landslide risk is particularly high in the context of rural access corridor management in developing countries where resources for landslide investigation and control are limited, and where changing land-use patterns and engineering practices are often in conflict with slope stability and soil conservation. Rural road construction is increasing in the Himalayas, despite landslides blocking or destroying sections of road on a regular basis and giving rise to fatality, injury and economic loss. Much of this road construction is taking place with limited regard to landslide risk at the planning stages due to lack of data and technical resources.

DFID are sponsoring research as part of its Knowledge and Research programme with the aim of developing low-cost, easy to apply methods of landslide hazard and risk assessment for rural access planning and management. The research, by Scott Wilson Kirkpatrick with the University of Durham, started in September 2000 with state-of-the-art reviews of remote sensing and of landslide hazard and risk mapping. From the reviews, idealised approaches were put forward as working hypotheses for using satellite image and air photograph interpretation, landslide hazard mapping and risk assessment for rural access planning purposes.

Three main study sites in Nepal with varied geology and land use were selected to test and develop the techniques. Desk study and field data acquisition has been successfully undertaken in these areas and a database developed of landslide events, frequencies and socio-economic impacts.

Desk study data sources have been used to develop factor maps of land use, geology, slope angle and slope aspect, drainage, relative relief, and terrain evaluation categories. These factor maps have been correlated against mapped landslide distributions to determine which are the most significant. Several published schemes have been tested and others have been developed based on project data.

So far, the results indicate that an analysis of rock type versus slope angle is able to account for in excess of 70% of landslide locations mapped in the field. The strength of the correlation is not improved by adding any of the other factors. This has significant implications for the wider use of landslide susceptibility and hazard mapping by road and rural development authorities, and further tests are being carried out in Nepal and Bhutan to refine and confirm the most suitable methods.

Methods of assessing landslide frequency are being researched through an interpretation of historical aerial photography, interviews



Landslides pose a major hazard to road maintenance in Bhutan

with local inhabitants and desk study data searches. In the Nepal study areas, estimates of landslide frequency have been combined with landslide susceptibility, and with land use and population distribution, to yield prototype risk maps that describe landslide hazard in terms of potential economic loss over given time periods.

Training and dissemination form important components of the research programme. Several field and college workshops have promoted landslide awareness and provided local development staff with a grounding in the use of satellite image and aerial photograph interpretation for landslide recognition purposes. GIS workshops have also proven highly successful. The findings of the research will be presented at a seminar in Kathmandu from 18–22 November 2002, and other researchers will be given the opportunity to present related work.

For further details, please contact Dr Gareth Hearn of Scott Wilson Kirkpatrick, Scott House, Basing View, Basingstoke, RG21 4JG (01256 461161; fax: 01256 816835; E-mail: gareth.hearn@scottwilson.com).



DFID Department for International Development

ABOUT RESEARCH FOCUS

Aims

The principal aim of *Research Focus* is to promote the application of research in building and civil engineering.

Supported by many organisations in the British construction industry, its brief articles on current research are written for practising engineers, architects, surveyors and their clients with the objective of disseminating research news as widely as possible. Its sponsors wish to promote the benefits of research, improve contacts between industry and researchers, encourage investment by industry in research and the use of research in practice, and facilitate collaboration between all the parties involved.

Formally, *Research Focus* is an unrestricted newsletter containing invited factual records or case studies of building or civil engineering research projects. Articles may be reproduced, provided the source is acknowledged.

Enquiries and Comments

If you wish to know more about a specific project, you should contact the person named at the end of the relevant article. Look on the back page for addresses, telephone and fax numbers of the sponsoring research organisations and professional institutions. General information about their activities may be obtained from them directly.

We welcome your ideas on ways to improve Research Focus and so help it to achieve its goals. If you have a suggestion, or an article about an interesting piece of R&D, please send it to the Editor, Roger Venables, at the address below.

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E-mail: abigail.dua@ice.org.uk).

Research Focus is also downloadable from the ICE website (www.ice.org.uk) and readable using Acrobat software.

MATERIALS & BRIDGES

Fibre-reinforced polymer (FRP) in bridge construction and rehabilitation

TRL is undertaking research for the Highways Agency on the use of new materials for bridge construction and rehabilitation. FRP is the first new structural material for civil engineering in almost a century. It offers great advantages in terms of high strength, light weight and durability, but lack of experience and design guidelines has hindered its uptake in bridge engineering.

The research has focused on two applications: the use of FRP for strengthening bridge decks and supports, and the use of FRP as the main structural element for the bridge itself ('plastic' bridges). The former has been investigated and a standard based on the TRL research is due to be published in early 2002. The latter is being investigated through the testing of a full-scale deck section using TRL's Trafficking



FRP bridge deck being tested in Trafficking Test Facility

Test Facility. The main test consisted of applying over 4.5 million load cycles using a 35 kN wheel load, equivalent to about 50 years' service life. This project will result in guidelines for the fatigue design of FRP deck components.

For further information please contact Albert Daly (01344 770449;

fax: 01344 770356;

E-mail: adaly@trl.co.uk.



GROUND ENGINEERING & DESIGN

Risk-based geotechnics design

Geotechnical design is performed under a considerable degree of inherent uncertainty, without complete knowledge of the underlying ground conditions, material properties or applied loadings. Quantitatively evaluating these uncertainties, using probabilistic risk and reliability methodology, may help to reduce the cost attributed to over-conservative design as well as minimising the likelihood of failure. Risk-based techniques can balance safety and economy in a more rational way than traditional factor of safety analysis.

Part of the programme of research at Napier University is aimed at contributing to the geotechnical profession's understanding of uncertainty, reliability and risk associated with design.

Significant developments in geotechnical risk and reliability theory have stemmed from universities in the USA. The award of a J M Lessells Engineering Scholarship from the Royal Society of Edinburgh funded a study tour throughout North America during September 2001. This provided an opportunity for face-to-face meetings with key academics and practitioners, with the aim of reviewing the current state-of-the-art.

Large Federal agencies are particularly interested in the use of risk analysis methods for the safety evaluation of their assets, which include embankment dams, floodwater levees, highway cuttings and

embankments, and retaining walls, in addition to justifying funding requirements for their maintenance and rehabilitation. Mainstream consultants are now also beginning to use the techniques for practical purposes such as slope stability, bearing capacity and settlement evaluation.

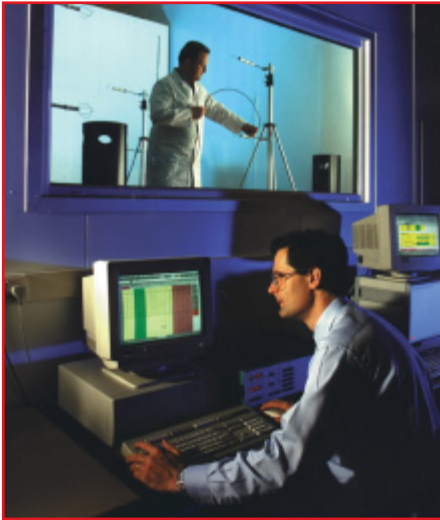
It is recommended that the probabilistic techniques be used to complement the conventional design methods and employed along with traditional engineering judgement. Sensible results may be achieved if sufficient statistical and probabilistic knowledge can be coupled with sound geotechnical know-how.

For further information please contact Gordon Cameron in the School of the Built Environment at Napier University (0131 455 2312; fax: 0131 455 2239; E-mail: g.cameron@napier.ac.uk).

Perimeter chilled beams – more guidance needed

BRE

Perimeter chilled beams (see box) can give valuable energy savings, but a gap in current guidance means that many designs do not deliver the performance and energy efficiency improvements of which they are capable.



BRE's Environmental Test Chamber

Tests have highlighted a problem in integrating perimeter chilled beams with other elements of the building fabric, and prompted the Government to fund a project to:

- improve the design of the interface between the building fabric and perimeter chilled beams;
- develop design guidance for architects, ceiling manufacturers, and manufacturers of chilled beams.

Predicting interactions between the building's interior structural elements and the heat gains in the area of its perimeter is difficult. This is particularly important with displacement ventilation because the air displacement can be disrupted by air mixing from the perimeter.

Demonstrating the problem and its solutions is not easy because of the low velocity of the air movements in these systems. The only viable method is to build physical mock-ups and measure the cooling performance and thermal comfort in the perimeter zone.

Developing design solutions to the problems caused by the interactions between heat gains and interior structural elements will involve testing a wide range of physical

'Chilled beams' are passive cooling systems designed to counter the effects of solar gain in buildings. Cold water passes through the beams in thin tubes, cooling the room by natural convection. The use of perimeter chilled beams to offset solar gain reduces the need for full air conditioning and is potentially very energy efficient. Chilled beams can be used in conjunction with displacement ventilation to produce high levels of thermal comfort and indoor air quality.

component combinations. This will be done at BRE's Environmental Test Facility and supplemented with numerical modelling.

The findings and design guidance (due October 2003) will be disseminated through articles in professional and technical journals, a workshop looking at physical mock-ups in BRE's Environmental Test

Chamber, and a project website, with video clips showing the physical configurations and air distribution patterns.

For further information please contact David Butler at BRE (01923 664300; fax: 01923 664095; E-mail: butlerd@bre.co.uk).

CONSTRUCTION PROCESS

Standardisation and pre-assembly: Occasional clients can benefit

It is generally assumed that standardisation and pre-assembly can only provide benefits for large, repeat clients. CIRIA's project report 652: *Delivering standardisation and pre-assembly to occasional clients*, aims to make clients and their designers aware that this is not true, and demonstrate the benefits of efficiency and quality of construction as well as reduced time and costs these techniques can bring. This project follows previous CIRIA work, undertaken with Loughborough University, in particular the current project demonstrating the use of the Toolkit, which will result in a revised version of the Toolkit produced as an interactive CD-ROM, due to be completed in September 2002.

The Toolkit is a result of a project, Standardisation and pre-assembly – client's guide and toolkit, which is designed for clients to provide a methodical approach for considering, and if appropriate initiating, a standardisation strategy from a project's inception. Its development and evaluation has been based on three construction projects and client interviews.

Single occasional clients are disparate and notoriously difficult to address as a group. Many have little experience or understanding of the construction industry or the process of construction. It is proposed to address them, where possible, through their design consultants as well as directly. Publicity for Report 652 will be undertaken in two phases. The first phase is a series of 15–20 half-day countrywide workshops and seminars between June and November 2002, targeting designers and clients who are unfamiliar with standardisation and pre-assembly. They will be presented jointly by CIRIA and Loughborough University and based on the revised Toolkit and experience gained from demonstrating the Toolkit on five live projects. CIRIA is seeking professional institutions and associations, client bodies, universities etc. who would be willing to help with arranging these workshops and seminars by providing venues and contacts of relevant people to be invited.

CIRIA hopes the workshops and seminars will generate sufficient interest and enthusiasm to be able to identify four or five



Pre-assembled modularisation units

projects for occasional clients that can be used as demonstration projects. The aim is to represent different common building types, for example doctors' surgeries, warehouses, and community centres. In the second phase of the project the Toolkit would be applied to these projects to demonstrate its practical use and tailor it to meet the needs of occasional clients and assess the benefits obtained.

For further information please contact CIRIA (020 7222 8891; fax: 020 7222 1708; E-mail: rfocus@ciria.org.uk; website: www.ciria.org.uk).



Steelbiz: Electronic information at your fingertips

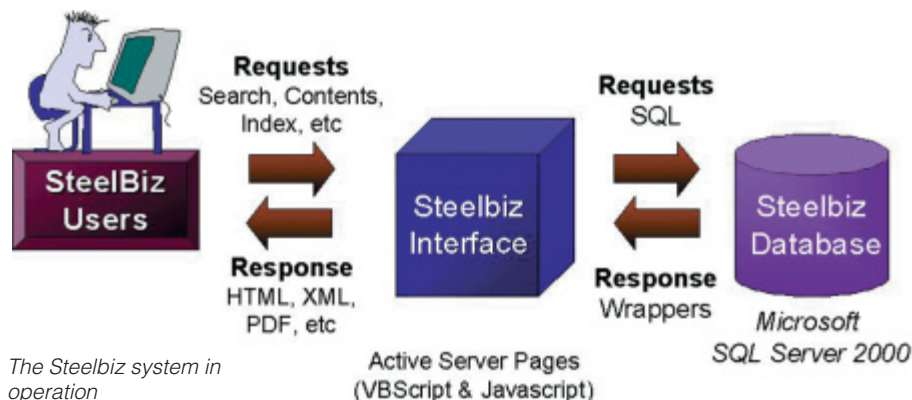


In May 2000, with a grant from the DTI, the SCI began work on a Eureka framework research project, Esteel.con. A recent outcome of this work has been the Steelbiz website (<http://www.steelbiz.org/>). Launched in January 2002, Steelbiz will grow to become a comprehensive system of electronic information for steel construction. By the end of 2002, all engineers in the offices of SCI's member companies will have SCI's formal knowledge at their fingertips.

Steelbiz is a mechanism for bringing together a number of separate systems. It can be seen as a gateway (or 'Portal') to information contained in a number of formats held on a variety of computer platforms. However, it presents this disparate collection of information within a structured software environment.

SteelBiz does this by holding resource discovery information in a database that allows resources to be linked and placed within a structured hierarchy. This database holds expertly prepared catalogue records for each resource, searchable using free text, a contents classification and/or keywords. A particularly useful feature is the ability to refine the initial search results to focus the results to the user's precise needs.

Information resources (such as technical publications, advisory notes, and lectures) are catalogued in an information database. The resources are indexed using terms from a controlled vocabulary held within a structured multilingual thesaurus. Contact details relating to users, authors, and publishers are



The Steelbiz system in operation

managed in the contacts database.

The type of information that SteelBiz users will have access to will depend on their status. The interface (shown in the figure) is composed of Active Server Pages – written in VBScript and Javascript – that generate Structured Query Language statements based on user inputs, for submission to a Microsoft SQL Server 2000 database management system (DBMS). The

results of these queries are then processed to generate either HTML or XML pages containing data extracted from the database, allowing the retrieval of HTML, XML, PDF or files of other formats.

For further information please contact Dr Andrew Crowley, The Steel Construction Institute (01344 623345; fax: 01344 622944; E-mail: a.crowley@steel-sci.com).

RIVER ENGINEERING & FLOODING

New tools to calculate river flood conveyance



In response to the Environment Agency's vision for reducing uncertainties in the estimation of flood levels, a team of experts led by staff at HR Wallingford (HRW) is developing a new Conveyance Estimation System (CES). This project is the first to be carried out under a new Research Framework Agreement between HRW and the Environment Agency (EA) and will produce software tools to be adopted at a national scale.

Public interest in flooding is high, especially since the events of winter 2000/2001. To manage its flood defences, the EA requires accurate information on the capacity of river channels and their associated floodplains. Past work has provided flow data for straight, compound and vegetated channels, but bridges are needed between academic findings and practical problem-solving techniques.

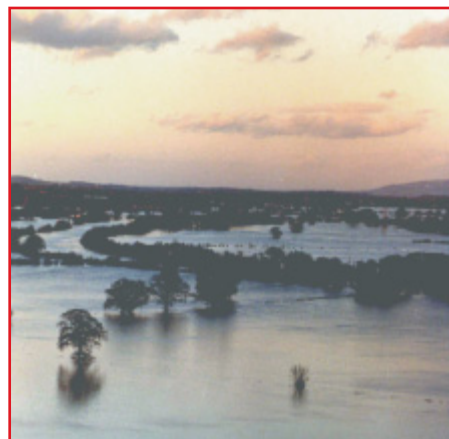
In 2001 HRW carried out a scoping study to investigate the need for improved flood conveyance estimation, and to define a work plan for the development of a new CES. The work involved wide consultation and the findings can be accessed through the EPSRC Network on Conveyance website (<http://ncrfs.civil.gla.ac.uk>).

Funded via the joint EA/DEFRA flood defence research programme, HRW is now reviewing various conveyance estimation methods, many of which are currently used only in research. Key to the whole issue is an

understanding of the effect of vegetation on river flow. Flood risk mapping and the design of new defences rely on an assumed standard of maintenance in rivers, from which roughness coefficients are derived for use in models. The scoping study highlighted the need for more-accessible and accurate ways of estimating roughness. It suggested developing a 'roughness advisor' – a dual paper and software system using photographs of different types of vegetation to 'match' a roughness coefficient to the channel under investigation.

The final CES is due for delivery at the end of 2003, both as stand-alone computer software and implemented within the ISIS software used by the Agency and its consultants. The CES will also be available as open code to enable future research work and the enhancement of other software packages. The project will provide a new, improved tool for general use by those involved in flood defence and river management.

For further information please contact Manuela Escarameia at HR Wallingford (01491 822337; fax: 01491 832233; E-mail: mme@hrwallingford.co.uk).



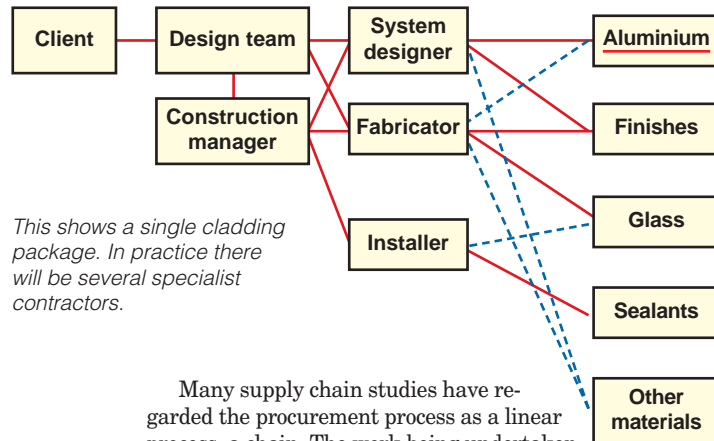
Recent flooding in the Severn Valley

Communicating down the cladding supply chain

Façades are predominantly procured using performance-based specifications, which makes specification easier for the building design team and allows specialist sub-contractors to detail façades on the basis of their extensive specialist knowledge. This study, funded by the DTI, looks at how these specifications and other relevant information is passed down the supply chain so that informed decisions on choice of materials and components can be made.

Delivered performance depends on many factors beyond the simple environmental conditions. For example, issues such as durability are dependent upon materials used in adjoining construction packages, and on the proposed maintenance and repair programme through the life of the building. Clearly the correct selection of components such as gaskets and sealants requires a fuller knowledge of the building and its intended use than is commonly available to the person making the decision. Furthermore, specifications are modified as they are passed down the supply chain.

This project is mapping the flow of information down the supply chain. It includes studies of the information required to select particular materials and components and of the most appropriate providers of information.



This shows a single cladding package. In practice there will be several specialist contractors.

Many supply chain studies have regarded the procurement process as a linear process, a chain. The work being undertaken in this study recognises that a façade may comprise several adjacent, or even overlapping, construction packages and that the term 'supply net' is probably more appropriate. It also recognises that no two façades are the same, so that different suppliers will be drawn into the process to satisfy the requirements of each building contract.

The project will lead to a series of guides to good practice for the selection and specification of façade components and materials, plus a software package to manage the transfer of information through the supply chain.

The diversity of materials used and complex performance requirements make the façade one of the most difficult parts of a building to specify. Although this project focuses on the use of glass, sealants, gaskets, finishes and fixings within the façade, the methodology developed will be extendable to other materials and components within the façade and to elements of the building other than the façade.

For further information contact Alan Keiller at CWCT (01225 826541; fax: 01225 826556; E-mail: cwct@bath.ac.uk).

ENVIRONMENT & MANAGEMENT

MITigation of Climate-induced natural Hazards



Natural hazards – storms, floods, droughts and landslides – can cause substantial damage and disruption. They bring distress to those involved and can pose a significant risk to life. Europe has not escaped: N Europe has suffered from severe flooding in recent years, Italy has experienced major landslides and S Europe endures regular droughts.

Over recent years, the European Commission has funded research into the applications of weather radar, forecasting models, real-time flood monitoring, landslides and debris flow prediction, and drought management procedures. MITCH (MITigation of Climate-induced natural Hazards) is a new Concerted Action (CA) that aims to help translate these advances into practical benefits. It brings together research institutions and end-users with a leading involvement, or interest in, the mitigation of natural hazards with a meteorological cause.

Academics, consultants, environmental management agencies and insurers from 13 organisations across seven European countries have come together as partners in this work. The project is funded through the Energy, Environment and Sustainable Development theme of the



Delegates at the first MITCH Workshop

EC 5th Framework Programme, plus support from the UK Environment Agency.

'The project includes three Workshops

covering different aspects of natural hazard planning,' says Bridget Woods Ballard, MITCH coordinator. 'We have also set up an active website discussion group to promote debate and dialogue, evaluate best practice and promote effective dissemination.'

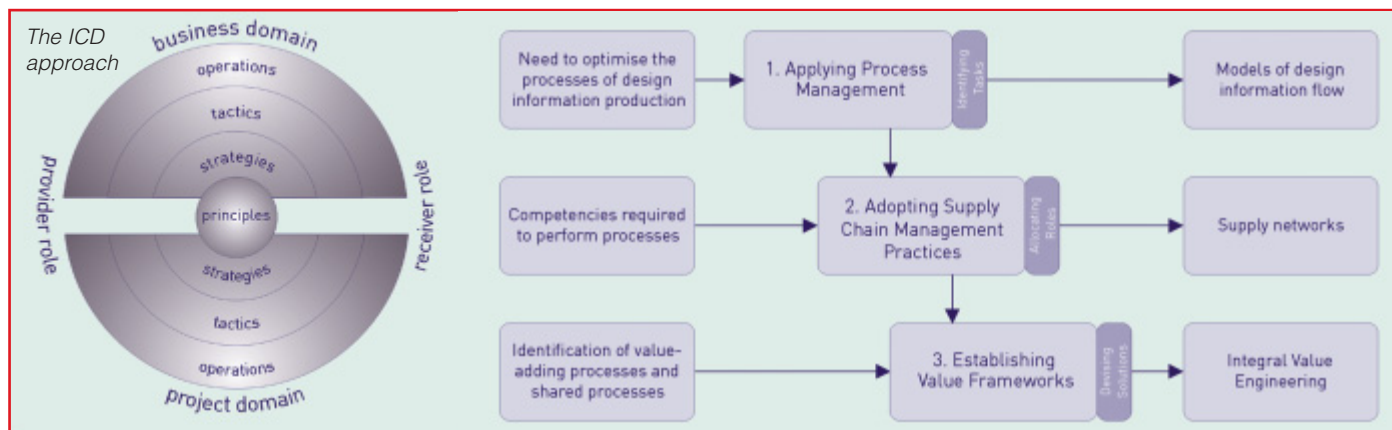
The first Workshop – on 'Floods, Droughts and Landslides: Management in a Changing Climate' – was held in the Netherlands in December 2001. The second, entitled 'Advances in Flood Forecasting, Flood Warning & Emergency Management' is scheduled for 10–12 June 2002 in Barcelona and the third, covering the role of spatial planning, insurance and risk assessment, will follow in the Autumn.

For further details of the Workshops, or the CA generally, please contact Bridget Woods Ballard at HR Wallingford (01491 822382; fax: 01491 825916; Email: baw@hrwallingford.co.uk) or Website: http://www.mitch-ec.net.

Integrating the design chain



New ideas in supply chain management have arisen from the Integrated Collaborative Design (ICD) project, a combined industry and academic initiative between Loughborough University and twelve construction companies led by AMEC, with financial support from the EPSRC and DTI as part of the LINK Integration in Design and Construction programme. ICD offers a new approach to integrated design management – the design chain.



Industry has evolved methods of accommodating this complexity, particularly in the area of site assembly and production, with delivery being continually refined with improved working methods and technologies. However, design remains an area where the complexity of the process is not yet understood or managed effectively. For many, design is an unknown process – a ‘black box’. It occurs at a particular time in the schedule, is performed by different parties, is creative and is often poorly controlled.

Over the last three years the ICD project has investigated how design supply chains are managed and has identified factors critical to improvement. The findings increase our understanding of design in the supply chain and the roles individuals play in it. A design chain provides a context for Integrated Collaborative Design, (www.designchains.com) in which companies can understand each other to develop sustainable relationships that reflect design complexity. The approach emphasises the flow of design solutions within short-term project teams, and the assembly and maintenance of long-term business relationships, using key principles and supporting strategic, tactical and operational practices.

The 25 practices developed through ICD are described in a new book (*Design Chains: a handbook for integrated collaborative design*, Thomas Telford, 2001, ISBN 0 7277 3039 8) and can help companies manage their design collaborations to deliver projects that meet client needs. The benefits include:

- creating business-level frameworks that facilitate collaboration for mutual benefit;
- improved understanding of the exchange of design information;
- helping organisations align their business and project competencies and business cultures;
- promoting value-adding design solutions on projects;

- providing tools to integrate processes across organisations.

For further information please contact

Professor Simon Austin, Centre for Innovative Construction Engineering (01509 222608; fax: 01509 223981; E-mail: s.a.austin@lboro.ac.uk).

GROUND ENGINEERING & DESIGN

The engineering properties of chalk

Better understanding of chalk as an engineering material was the aim of preparing a recently completed CIRIA report, which synthesises the knowledge built up during more than twenty years of research by CIRIA and others into the formation, post-depositional history and engineering behaviour of the material. The project was funded by the Construction Directorate (DETR, now part of DTI), CIRIA's Core Programme, and by a contribution from the proceeds of the International Chalk Symposium, Brighton, 1989, donated by the Symposium's organising committee.

Economical design relies very much on a good understanding of soil-structure interaction. This in turn relies on appropriate investigation of the ground (in this case the chalk), an accurate classification, and the correct assessment of its engineering properties. Such tasks require the involvement of a geotechnical engineer capable of fulfilling them.

In the new CIRIA Report, the chalk's geological setting, its origins, occurrence, its stratigraphy, weathering and geomorphological situations, and the material and mechanical properties are described with a comprehensive set of supporting photographs. There are explanations of recommended schemes for the engineering description and classification of chalk in foundations and in earthworks.

The mechanical and material properties of intact, *in-situ* and compacted chalk are reported and the implications of geological and material characteristics for the design and construction of engineering works in

chalk – earthworks, cuttings, retaining walls and anchorages – are examined.

Major sections deal with the selection and design of shallow and piled foundations in chalk. Design procedures for shallow foundations including advice on construction aspects and the treatment of dissolution features are put forward. Analysis of the results of pile testing leads to recommendations for the design of bored, CFA, driven cast-in-place and preformed piles in chalk and for the estimation of shaft and base resistances. These recommendations are principally for vertical, static loadings. Guidance is given on the choice of shallow or piled foundations and on pile selection. Recommendations are also given for site investigation in chalk.

For further information please contact CIRIA (020 7222 8891; fax: 020 7222 1708; E-mail: rfocus@ciria.org.uk, quoting RP458).



Finding benefits in rising-groundwater problems

BRE

Rising groundwater is becoming a problem in some of the UK's most heavily populated areas. A research team plans to identify how groundwater that is pumped away to prevent water tables rising to harmful levels can be fully exploited to benefit the environment, building owners and operators.

The groundwater levels under many British towns and cities have been rising for decades because of a decrease in local water abstraction. This results from the sealing of urban wells, changes in technology such as the demise of steam on the railways, the decline of traditional industries such as textile manufacture, and the cessation of mining.

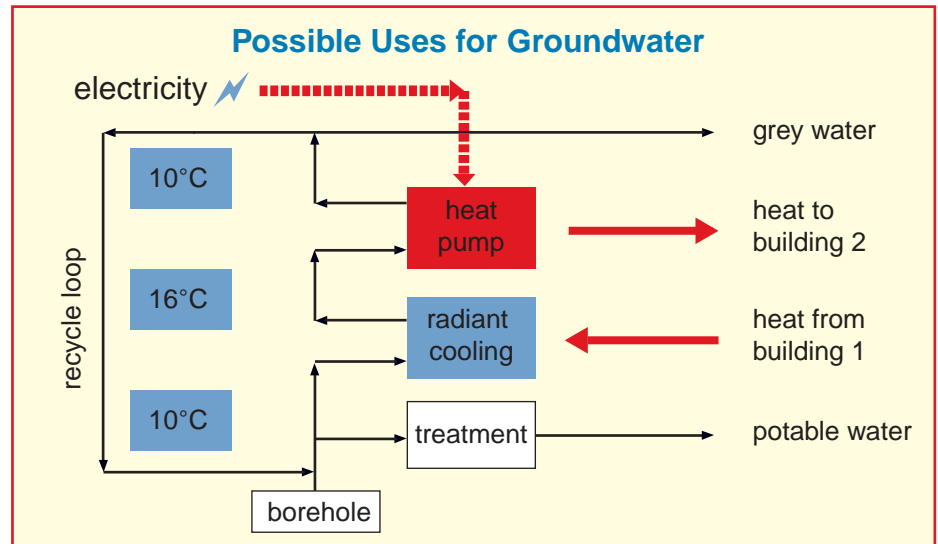
In most areas, water tables cannot be allowed to return to their pre-Victorian natural levels because of the risk of damage to infrastructures such as tunnels, sewers, and the foundations of civil engineering structures and buildings. The problem of rising groundwater is most acute in London, Liverpool, and the West Midlands. Action being taken at present includes:

- interested parties in London (such as London Transport and Thames Water) working jointly through the 'GARDIT' initiative (General Aquifer Research, Development and Investigation Team) to co-ordinate pumping schemes that will stabilise the water table;
- the first pumping scheme in Liverpool operating to protect some of the suburban Merseyrail system's tunnels;
- a research programme in the West Midlands addressing the issue of man-made groundwater contaminants.

The project team led by BRE has been awarded funding under the Carbon Trust's Energy Efficiency Best Practice Programme for their *Groundwater As a Thermal Energy Resource* (GATER) project. The thinking behind GATER is that, wherever groundwater must be pumped anyway, the best possible use should be made of it. The GATER research programme will investigate how groundwater can be used:

- as an alternative 'free' cooling medium for buildings, which avoids the use of energy-intensive air conditioning;
- as a low-grade thermal energy source for heat pumps, which could help enhance their cost-effectiveness;
- and after other uses, as greywater suitable for WC flushing, irrigation, etc, thus finally acting as a lower-cost and "green" substitute for drinking quality mains water in situations where potable water is not needed.

The research programme aims to estimate the size of the groundwater resource in selected areas and from these estimates extrapolate figures for the whole of the UK. The programme will then develop a strategy for optimising the energy and environmental benefits achieved through the use of such groundwater. In addition, the team will work to clarify the legal and other issues relating to extraction and use of groundwater, and



particularly to its subsequent disposal – either by discharging it into watercourses or by returning it underground where appropriate, typically in areas with low rainfall.

For more information please contact Robert Garwood at BRE (01923 664641; fax: 01923 664097; E-mail: garwoodr@bre.co.uk).

GROUND ENGINEERING & TUNNELLING

Ground-borne noise & vibration

Tunnels are assuming greater importance for new transport links as environmental pressures increase. During construction, ground-borne noise and vibration can cause disturbance to the occupants of properties above the tunnel and may damage property.

Empirical models for the prediction of these effects have been developed from fairly sparse data. TRL has collected vibration data from a range of tunnels under construction since the early 1970s. Recently, with the co-operation of Kent County Council, TRL has measured ground-borne noise and vibration above tunnelling operations on open ground and adjacent to and within houses, during the construction of the Ramsgate Harbour approach tunnel. This tunnel, through chalk, made the first UK use of the Perforex 'Prevault' tunnelling system.

Ground vibration from excavation was lower than that measured at other chalk sites. The shutter vibrators used to compact the concrete lining caused the highest levels measured, but were below those expected to cause any damage, and no damage was observed. However, the threshold of perception was exceeded for considerable distances from the tunnel.

Measured ground-borne noise was lower than predicted from ground vibration by a method used successfully elsewhere.

For further information please contact Geoff Crabb (01344 770437; fax: 01344 770356; E-mail: agrcabb@trl.co.uk),



Perforex tunnelling machine

Building a Carbon Neutral Toolkit

Innovation in sustainable construction usually comes at a cost to the client but a project by BioRegional Development Group, called the Carbon Neutral Toolkit, will show that this does not have to be the case.

BioRegional's Toolkit, being funded by the Partners In Innovation programme and by Biffaward, is based on the demonstration scheme, the Beddington Zero Energy Development (BedZED). It is expected to show how the construction industry can build desirable buildings that produce zero net carbon emissions, and that minimise environmental impact while yielding respectable financial returns on investment.

BedZED is a pioneering new 'sustainable urban village', developed by the Peabody Trust Housing Association in partnership with BioRegional. It is nearing completion, with first residents having moved in during February 2002. Situated in Hackbridge, South London, BedZED comprises 82 flats, maisonettes and houses, community facilities and 2,500m² of workspace. It employs state-of-the-art techniques in:

- passive solar design with super-insulation and thermal mass;
- renewable on-site energy generation from biomass and solar;
- water saving, rainwater harvesting and wastewater recycling;
- integrated green transport provision; and
- attractive and affordable green lifestyles.

Construction of the village over the last 18 months has made use of local, reclaimed and low-impact building materials. Post-construction, BioRegional will be working to see that the 'green lifestyles' for which BedZED is designed actually work in practice and provide residents with a higher quality of life than more traditional urban estates. Facilities include free charge points for electric cars, a car club service, on-site composting for kitchen and garden waste, a range of cycling facilities and discounts at local bicycle shops and bulk deliveries of local and organic fresh food.

BioRegional identified the BedZED site in 1997 and worked with Bill Dunster Architects to develop an affordable, mixed-use model of urban sustainability for the site. In 1998, the Peabody Trust agreed to develop the scheme and achieved planning permission in 1999. Arup's environmental services engineers have designed the innovative building physics for the scheme while Ellis & Moore have provided structural



*BedZED – Testing the Carbon Neutral toolkit
Courtesy of BioRegional Development Group*

and infrastructure engineering design. Gardiner & Theobald are the cost consultants and construction managers for the project.

The Carbon Neutral Toolkit project will define what has been done at BedZED and summarise the associated costs and benefits. It will look at the key areas in which BedZED has achieved innovations by reducing environmental impacts, quantify those benefits and analyse how they were achieved within the cost constraints of a social housing project.

Some 'environmental upgrades' are funded by designing out the need for built items (eg. radiators, electric fans) and so produce cost savings. Others produce savings for the Peabody Trust or occupants over the lifespan of the building (eg. low energy and maintenance bills). Costs and savings will be grouped according to who pays for them, who benefits and when. By defining the financial mechanisms for achieving improvements, the Toolkit will make BedZED features transferable to other schemes.

The project is aimed at stimulating a more competitive industry. By analysing the rate of sales of the BedZED properties and comparing sales values achieved by local conventional dwellings, it is expected to demonstrate the market for sustainable homes.

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