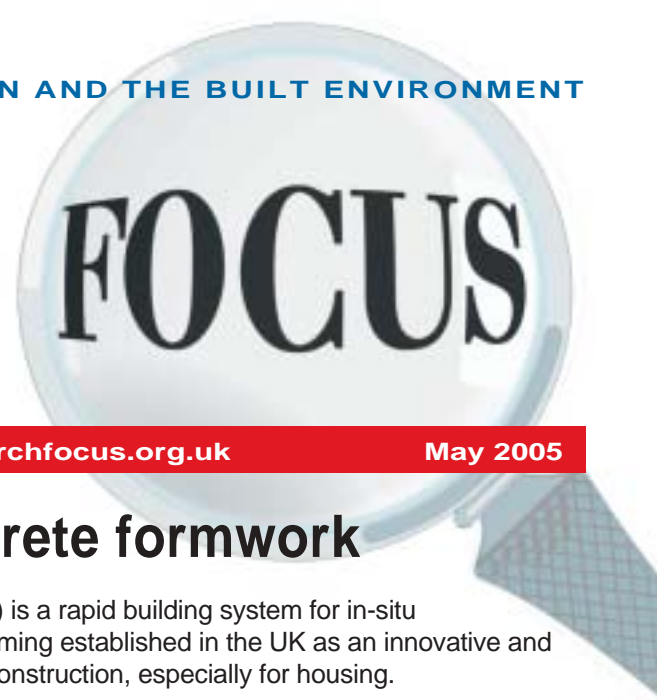


# Innovation & Research



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## Insulating concrete formwork

Insulating concrete formwork (ICF) is a rapid building system for in-situ concrete structures, which is becoming established in the UK as an innovative and cost-effective modern method of construction, especially for housing.

ICF consists of twin-walled expanded polystyrene panels or blocks that are built up to create the walls of a house or other building.

This formwork is then filled with ready-mixed concrete to create a structure that can accept the roof or floor construction. The polystyrene remains permanently in place to provide complete thermal insulation for the walls of the finished building. It also provides a uniform surface ready for the direct application of most finishes and proprietary cladding systems.

Typically, the walls have a U value of around 0.20 W/m<sup>2</sup>K, which easily exceeds the tougher standards included in the proposed revisions to Part L of the Building Regulations. Heat loss is further reduced by the structural properties of ICF, which is inherently airtight and can lessen the overall infiltration level of a building. This will help to ensure compliance with the new pressure-testing requirements that are also included in the Part L revisions. In percentage terms, the good thermal characteristics of ICF can reduce heating energy requirements by around 20% (BRE Report 347).

From the builder's perspective, speed of construction is the key attribute of ICF. The fast build time makes it possible for a team of four to erect and concrete the walls of a house in about one day. This is helped by the off-site manufacture of ICF and its light weight, which means that mechanical handling is not required.

Houses built using the ICF process are not outwardly distinguishable from any other home, whether they are brick-clad or otherwise. However, the occupier will benefit from lower running costs along with good acoustic performance. The transmission of structure-borne sound is very low, making it suitable for party wall construction where the concrete core can be made up to 300 mm thick.



(Top) A Typical ICF Corner section  
(Above) A house being built using the ICF System

For further information on ICF please contact Ms Anna Scothern at the Concrete Centre (01276 606800; E-mail [scothern@concretecentre.com](mailto:scothern@concretecentre.com)).



### DISTRIBUTION CHANGES

Have you received this copy of *Innovation and Research Focus* by direct mail, rather than as an insert in *New Civil Engineer*? And is that because you expressly requested to be sent a copy each quarter? If so, we regret to have to tell you that the physical mailing is to be discontinued, now that each issue is placed on the IRF website. However, we hope this will not be too much of a hardship – not only can you see and download each issue from the site, but can be sent an emailed reminder each time an issue is published on the site. To register for this service, please go to [www.innovationandresearchfocus.org.uk](http://www.innovationandresearchfocus.org.uk) and register under the Mailing List button. Thank you for your continued interest in IRF and the sponsors' work.

# Occupying buildings sustainably



The overall objective of this DTI-sponsored project, due for completion in mid-2005, is to enable building occupiers to work more effectively with owners, managing agents and their own service supply chains in addressing sustainability issues.

The project has been building on an earlier Partners in Innovation project *Managing buildings sustainably*. This developed the 'MBS' approach for integrating sustainability requirements into the procurement of property and facilities management services. However it was recognised that occupiers, not just service suppliers, have a critical role in determining how sustainable buildings are overall.

Accordingly the current project has developed the 'Managing and occupying buildings sustainably' (MOBS) approach to allow owners, service providers and occupiers to respond in a joined-up way to the challenge of achieving optimum sustainability.

There will be three key outputs, aimed primarily but not exclusively at building occupiers.

- **Occupier action plans** should enable occupiers to tackle sustainability issues, focusing on their own actions.
- **Procurement guidance for building occupiers** will assist in integrating sustainability considerations into procurement processes.
- **Engagement plans** should enable all key stakeholders – landlords, managing agents, service providers as well as occupiers – to undertake negotiations fully informed on sustainability issues and objectives.

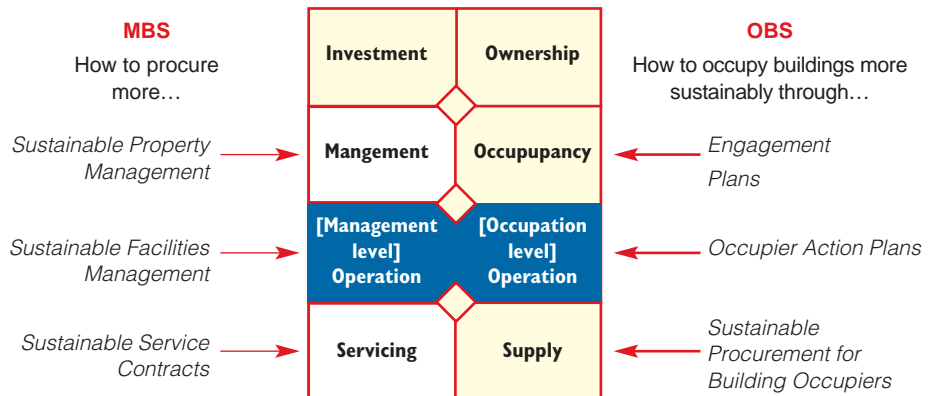
The MBS approach encompassed a database of good practice sustainability measures covering:

- headline sustainability issues;
- issues against which organisations set typical objectives;
- property-specific issues;
- service lines, covering 'hard' and 'soft' facilities management and consultancy services.

This database is being expanded and improved to increase the number of measures, and to cross-reference them to a range of exemplar building types across key sectors – residential, education, healthcare, commercial, hospitality, leisure and retail.

The guidance documents will be available by download from the MOBS website ([www.mobs.org.uk](http://www.mobs.org.uk)), which will also provide access to the good practice database. A summary document is already available in hard copy for the Managing Buildings Sustainably project and one will also be made available for the Occupying Buildings Sustainably project shortly.

*For further information please contact Ms Vivien Fairlamb, FaberMaunsell (020 7601 1652; E-mail: [vivien.fairlamb@fabermaunsell.com](mailto:vivien.fairlamb@fabermaunsell.com)).*



A simplified model of a property management chain

## DRAINAGE

# Grease separator test method



Very large quantities of oil, fat and grease are used or produced in the processing and preparation of food. The grease is carried into wastewater drainage systems by hot water used in the cleaning of dishes, utensils and food processing equipment. As the water cools, the grease coagulates on the walls of the pipes. Maintenance staff from Thames Water alone have to remove 1000m<sup>3</sup> of grease every six months from the main wastewater drainage system in their region. Major commercial or retail operators are required to install grease separators, but the devices often do not work satisfactorily for a range of reasons such as incorrect location, infrequent emptying or hydraulic inefficiency.

The European Standard EN1825 has recently been finalised, to define the required performance of grease separators and where they should be used. It details a test procedure based on an earlier German Standard (DIN 4040) for testing light liquid separators using a light marine oil as the medium and water at ambient temperature. However, UK representatives consider this procedure to be inappropriate as it does not represent conditions within a grease

separator under typical use. In fact some DIN 4040 grease separators installed in the UK have failed to perform satisfactorily.

This project, part-funded by DTI, has developed a realistic and practical test procedure for measuring the efficiency of grease separators, and has the aim of establishing an internationally acceptable standard.

The HR Wallingford research team worked closely with the Project Steering Group, comprising representatives from Wade International Ltd, Hunter Plastics Ltd, ACO Technologies plc, Thames Water Utilities, Whitby Bird & Partners, GMG Ltd, Institute of Plumbing and the Environment Agency. The team identified suitable criteria for the new test and agreed a test method and procedure.

Initial results have, not surprisingly, indicated significant differences between the performance of separators when tested using the 'new' method that uses hot water and vegetable-oil/lard as the test medium compared to using the present European Standard. The final output of the study will be a revised test method for grease separators that can provide manufacturers, inspectors and users with an appropriate benchmark.



HR Wallingford's experimental hall: Rig used to develop the proposed new standard test for grease separators

*For further information please contact HR Wallingford (01491 835381; E-mail [info@hrwallingford.co.uk](mailto:info@hrwallingford.co.uk)).*

# The use of recycled concrete aggregate in structural concrete

The principles of sustainable development require the prudent use of natural resources, and maximum use of recycled construction materials where appropriate. In keeping with this approach, the UK government is actively encouraging the use of recycled aggregate as an alternative to primary aggregate. Along with the direct cost savings associated with using a waste material, there are additional economic benefits associated with incentives to use recycled material and disincentives to use natural aggregates provided through land fill tax credits.

We welcome Highways Agency as a new sponsor of *Innovation and Research Focus*



There will, however, be increased costs in other areas. Recycled aggregates often require extra treatment to remove contaminants, along with a testing regime to ensure adequate and consistent quality. Dedicated processing, testing, storage and handling facilities may also be required.

From a sustainability point of view the ideal source of recycled aggregate would be a general material available from aggregate suppliers in the same way as for natural aggregate. It would come from mixed sources but meet a general specification ensuring appropriate quality. However, considering the wide potential range of source materials, it may be an onerous task for aggregate suppliers to achieve a consistent product.

Whilst the use of recycled aggregate has a reasonable track record in low-grade applications (e.g. as sub-base in road construction), its use in structural grade concrete is a relatively new area, and requires special consideration before use in particularly sensitive elements or structures until it has a longer track record.

TRL has recently completed a research project for the Highways Agency to investigate the use of recycled concrete aggregate (RCA) in structural concrete. The objectives of the project were to update the Specification for Highway Works (SHW) to permit the use of RCA, and to draft an Advice Note on the use of RCA.



*Crusting and stockpiling of crushed concrete from demolished paper-mill, at site of new regional distribution centre for Scottish & Newcastle Breweries, Thatcham (photo courtesy of Britpave)*

RCA was obtained from four sources, two of which were from crushed pre-cast concrete, one from general demolition waste, and one from a building demolition site. Measurement of the aggregate properties confirmed that the RCA from the pre-cast concrete and the general demolition waste could be classified as Type II RCA (as defined in BRE Digest 433). There was, however, too much brick in the material from the building demolition site for it to meet this classifica-

tion. The RCA tested was lighter and more porous than typical natural aggregates.

C50 concrete mixes were designed with up to 100% of the natural aggregates replaced with RCA. The water/cement ratio had to be reduced and the water content increased for the RCA mixes to maintain the required strength and workability, and it was necessary to use blended cements (containing either GGBS or PFA) to achieve alkali contents within the recommended range for controlling alkali silica reaction.

The density and dynamic modulus of the concrete reduced as the proportion of RCA increased, whereas the drying shrinkage increased. This may be significant for design. The freeze-thaw performance of mixes containing RCA was generally at least as good as those with natural aggregates. Further periods of exposure are required to assess the resistance to ingress of chlorides and carbon dioxide.

The results of this research will be presented at a seminar on the use of recycled concrete aggregates in structural concrete, to be held in the near future.

*For further information, please contact Neil Loudon, Highways Agency, Bedford (01234 796107; E-mail: [neil.loudon@highways.gsi.gov.uk](mailto:neil.loudon@highways.gsi.gov.uk)).*

## Infrastructure research priorities identified

Infrastructure users and their needs were recognized as the key source of inspiration guiding efforts to develop an industry-owned research and innovation strategy for infrastructure, the Institution of Civil Engineers' Infrastructure Research Priorities Project found.

The Project Report, prepared to identify a set of industry-wide research priorities for infrastructure on behalf of nCRISP (the New Construction Research and Innovation Strategy Panel), identified sustainability, future proofing and policy & planning, which collectively represented over 70% of the issues raised, as the priority areas for future research. They were closely followed by transport and flood protection.

The findings in the Report, compiled through a combination of workshops and a questionnaire, clearly underpin the belief that 'infrastructure is crucial to the development of the UK built environment and economy in its broadest sense' and that the focus of future research should be to:

- protect ourselves from hazards (natural and human);
- provide and maintain the security of supply of the services that we need;
- better utilize evidence-based policy and planning to enable this to be achieved in more efficient, robust and sustainable ways.

While the main drivers for change, such as climate change and the need to move forward sustainably, are often outside the control of the construction industry, it was concluded that reactive and supportive strategies to predict and respond to such change can be adopted.

The benefits of these measures would not only be felt by the principal users of infrastructure, society at large, but also by service providers, including central Government and local authorities, and there was a strong case for Government funding to support the proposed research.

The report concludes that, ultimately, responsibility must be borne by all and that the research agenda needs to be owned by a range of stakeholders including government, industry and wider society.

For further information please contact Andrew Crudgington at the ICE (020 7665 2219; fax: 020 7799 1325; E-mail [Andrew.crudgington@ice.org.uk](mailto:Andrew.crudgington@ice.org.uk)).



## Ground storage of building energy dti

Arup has led a team researching the potential of ground storage of building energy as a means of heating and cooling buildings in the UK. As lead partner in a DTI-sponsored, Partners in Innovation project, Arup has coordinated the project in conjunction with Cementation Foundations Skanska, the University of Birmingham, the University of Newcastle and the Environment Agency. A client review panel was established to enable input of ideas and dissemination of findings.

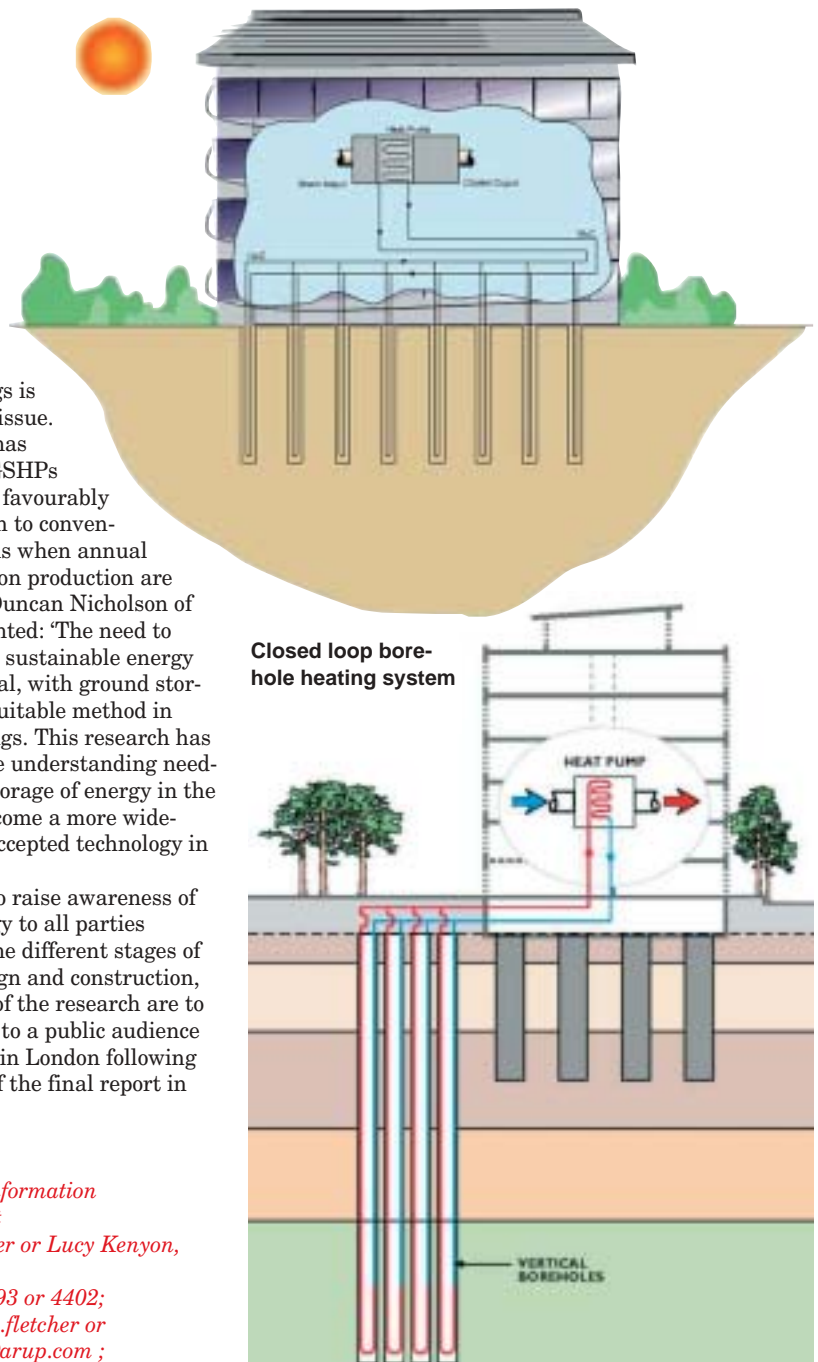
Ground Sourced Heat Pump systems (GSHPs) work by utilising the relatively constant temperature of the ground or groundwater to provide either cooling or heating to a building according to seasonal requirements. The research has shown that, if properly designed for the available ground conditions, GSHPs can be a successful energy source for the UK in the long term.

The research suggests that, in the UK, GSHPs do not currently compare favourably to conventional systems in financial terms – in most cases the high capital costs lead to long pay-back periods. However, the financial drawback must be weighed up against environmental and social benefits.

Carbon production from buildings is a significant issue. This project has shown that GSHPs perform very favourably in comparison to conventional systems when annual levels of carbon production are considered. Duncan Nicholson of Arup commented: 'The need to develop more sustainable energy sources is vital, with ground storage being a suitable method in many buildings. This research has developed the understanding needed to allow storage of energy in the ground to become a more widespread and accepted technology in the UK.'

In order to raise awareness of the technology to all parties involved in the different stages of building design and construction, the findings of the research are to be circulated to a public audience at a seminar in London following publication of the final report in April 2005.

For further information please contact Karen Fletcher or Lucy Kenyon, at Arup (020 7755 2793 or 4402; E-Mail [karen.fletcher](mailto:karen.fletcher) or [lucy.kenyon@arup.com](mailto:lucy.kenyon@arup.com); website: <http://www.arup.com/geotechnics/feature.cfm?pageid=662>).



# Composite insulated beams (CIBs)

Mr Ali Bahadori Jahromi, Research Fellow, School of the Built Environment, Napier University, spent 7 months at The New Zealand Forest Research Institute, partly funded under the Royal Academy of Engineering's Global Research Awards Scheme. It provided him with the opportunity to continue his research for developing new engineered wood products, including CIBs, at a world-class research centre and to establish extensive links with leading scientists in the field.

The current worldwide demand for wood has doubled in the last 30 years to approximately 3.5 billion m<sup>3</sup> per annum, fuelled by the increase in world population and improvements in general living standards. The combined effects of changing timber resource and increased demand for the use of structural wood products have led to the development of Engineered Wood Products (EWP).

Ali Bahadori's research examines the development and performance of a new engineered wood product in the form of the Composite Insulated Beam (CIB). The idea of the CIB is to combine the efficiency of a sandwich panel with existing EWPs, to produce new, competitive and cost-effective EWPs with improved structural qualities and long-term durability.

CIB beams consist of a composite frame with T or rectangular cross sections. A beam frame is constructed by bonding at least two webs to the top and bottom flanges. Inside, the beam frame may be filled with, for example,

injected polyurethane, to enhance the structural performance and long term durability of the beam, as well as providing sound insulation. A 23% increase in bearing capacity was seen in compression tests of CIBs with infill compared with the equivalent hollow designs. Research continues toward commercialization of the product.

The Academy's Global Research Awards scheme funded Ali Bahadori's visit to the New Zealand Forest Research Institute. The

scheme provides funding for UK-based engineers to undertake research projects at centres of excellence overseas, for 3 to 12 months. The award covers up to 50% of the costs of the secondment, up to £35,000.

*For further information please contact Rob Barrett, Manager, Research Support, RAEng (0207 227 0500; E-mail: robert.barrett@raeng.org.uk; website: www.raeng.org.uk).*

## ENVIRONMENT & RISK

### A climate of risk

CIRIA is examining some of the challenges that face, or may face, the construction industry as a result of climate change.



(Top): Mr Ali Bahadori Jahromi at the New Zealand Forest Research Institute.  
(Above): CIB Cross Sections Tested

Construction developments are exposed to a wide range of climate-related risks, such as subsidence and heave, slope instability, mould growth, flooding, degradation of building fabric (particularly cladding) and damage from wind-related events. As the UK's built environment stock is generally expected to last between 50 to 100 years, it is essential for the construction industry to understand how projects can be designed today to allow for uncertain future climatic conditions.

Despite the availability of information on the scale of impacts that can be expected from climate change, there is little evidence of mainstream UK construction companies implementing (or even considering) possible adaptation techniques or mitigation measures to reduce impacts. Construction industry professionals and developers who ignore the risks posed by climate change do so at their financial peril. They could face higher insurance premiums, greater maintenance costs, indirect costs associated with reputation, and costs relating to contractual arrangements with buildings and infrastruc-



Courtesy of the Environment Agency

ture not meeting the design life.

A method for assessing risk is needed to help designers and constructors make rational decisions about whether to incorporate climate change consequences in their project planning.

Two new CIRIA publications have been released to help industry deal with the risk-related challenges. *Implications of climate change for the construction industry* (C638) explains how to assess and manage the risks to

projects, such as those associated with ground movement, rain penetration and wind loading. *Development and flood risk* (C624) provides practical guidance on assessing flood risk as part of the development process. CIRIA has also been involved in project FD2320, sponsored by Defra and the Environment Agency, to deliver a national framework for flood risk assessments. To buy a copy of either these publications, visit [www.ciriabooks.com](http://www.ciriabooks.com).

*For further information on the project that led to these publications, and on related work, please contact CIRIA (020 7549 3300; fax: 020 7253 0523; E-mail enquiries@ciria.org).*

# Motorway roadworks delays: how bad are they?

The Highways Agency is committed to providing reliable journeys for our customers and improving the management of roadworks on our network. In order to deliver these objectives, it is critical that the delay to drivers, and the subsequent economic impact, is fully accounted for when planning major maintenance work, particularly on the busiest parts of the motorway network.

The Agency has used QUADRO for many years to forecast these delays but there were concerns that the software might not adequately model the economic impact for the busiest motorways on the network. The objective of this research project was therefore to develop an improved understanding of the effects of major motorway roadworks and then to provide advice on the best methods for assessing delays and diversions.

The research, undertaken by Faber Maunsell, had two strands of analysis: an investigation into perceptions and attitudes of drivers to roadworks; and a detailed quantitative analysis of flows and speeds. The attitudinal analysis was based on interviews with around 650 drivers over a six-month period, as part of the rolling Road User Satisfaction Survey (RUSS) undertaken by the Agency. The quantitative element consisted of flow and speed data collection at major roadwork sites on the M25 (2 sites), M62, M4, M1 and M42.

As the behavioural response to roadworks was of particular interest, a key finding of the RUSS was the choices that drivers made when faced with roadworks on their normal route.

- 90% decided to drive through the roadwork and accept the delay.
- 9% chose an alternate route.
- 1% decided not to travel.
- None chose an alternate mode.

A more-detailed breakdown of the responses is provided in Figure 1 (see below).

The quantitative analysis showed a good correlation with the attitudinal surveys, with an average flow reduction of between 7 and 8% during the period of roadworks compared with normal operation. The delays experienced by drivers during the roadworks were typically of the order of 4 minutes, although it should be remembered that this is in the context of a motorway link which is probably already experiencing congestion in normal conditions. This finding does, however, reflect positively on the way in which the Agency and its contractors are managing roadworks on these very busy stretches of the network.

An example of the sort of speed data collected is shown in Figure 2 (see below).

The research has provided an objective view of the real impact of motorway roadworks on driver behaviour, and the consequent economic impact of that work. It has also enabled the Agency to develop advice that will help engineers to forecast with increased accuracy the likely impact of roadworks on the busiest sections of the motorway network.

*For further information please contact Frank Mohan, Highways Agency, Manchester (0161 930 5694; E-mail: frank.mohan@highways.gsi.gov.uk).*

## STRUCTURES

### IKEA store uses Quicon®



The IKEA store in Croydon is being extended to provide more extensive retail space. Bourne Steel won the contract to supply and erect 240 tonnes of steel for mezzanine floors to achieve this expansion within the existing envelope and has used Quicon connections to speed up construction.

The project is being executed in three phases, with the first and second phases currently under construction. Speed and minimum disruption have been and remain of the essence, as the store had to remain open during the busy post-Christmas sales period. The project's main contractor is RG Group and the third phase will commence in August 2005.

Over the past two years, an extensive test programme on the Quicon® connection and has led to the development of an SCI design guide, available from SCI (see IRF 60) covering the range of sections and connections for which Quicon® is an effective solution. In addition, RAM International has incorporated the SCI Quicon® design checks into the recent release of the RAM software and a detailing facility for Quicon® has been incorporated into Xsteel by Tekla. A European version of the design guide is currently in preparation.

Supply chain issues have also been addressed by ensuring that a stock of components is available on the market through Andrews Fasteners Ltd.

*For further details contact Bassam Burgan, at the Steel Construction Institute (E-mail: b.burgan@steel-sci.com, visit the Quicon® website www.quicon.com or the Bourne website www.bournesteel.co.uk).*

Figure 1: Behavioural response to roadwork

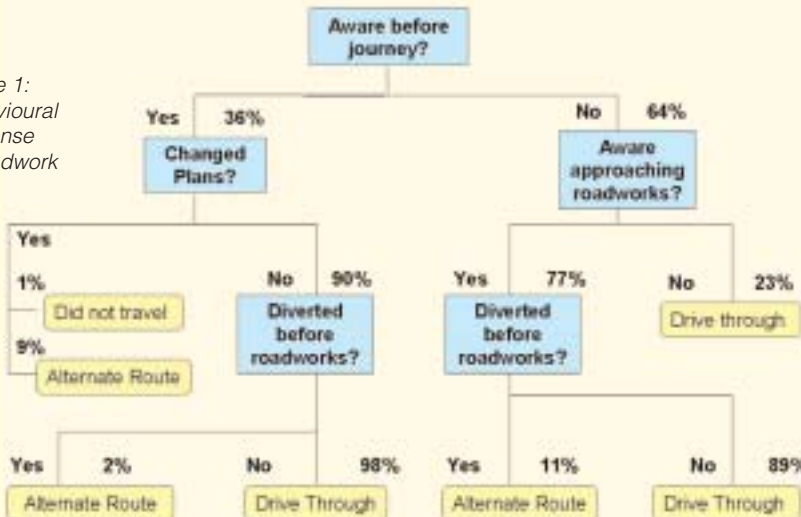
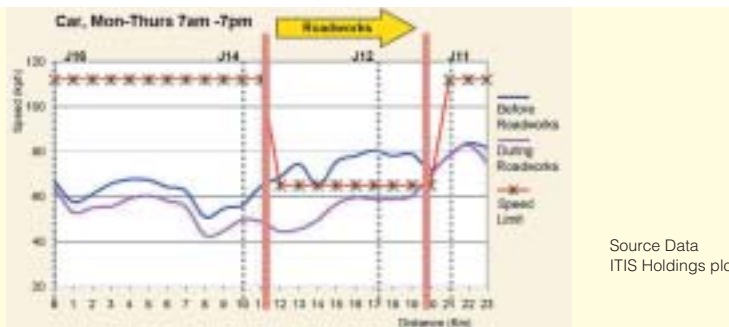


Figure 2: Example of speed data



Typical Quicon connections

# Corporate Social Responsibility (CSR) and the construction industry

The latest report from Sir John Egan, *Skills for Sustainable Communities*, highlights the need for construction industry firms to learn to listen to the communities where they work, and to develop and sell them appropriate solutions. Construction is mainly a project-based industry, which forms teams for one-off developments and individual clients. The emergence of Public Private Partnerships is changing this attitude, and is expected to have a significant effect on the longevity of construction organisations' involvement with the community. The skills shortage in construction, with staff retention playing a major part, is an important factor to consider when assessing the reasons for adopting a Corporate Social Responsibility approach.

Initial research by CICE within the industry has provided what was considered to be the barriers to adopting CSR. These include:

- the cyclical nature of the work;
- short-term priorities and the problems of securing continuity of work;
- gaining buy-in from the Directors and Chief Executive;
- lack of resources;
- lack of control over the form of contract, only control over performance; and
- a lack of feedback or chance to voice opinions with Government agencies over protective measures adopted.

Many construction companies are adopting policies that are wholly compatible with CSR practices, but they are not harmonizing these various initiatives, nor developing a coherent and comprehensive long-term CSR strategy. The need to focus on long-term goals whilst operating in what is traditionally a short-term operating arena is one barrier that will have to be overcome.

GRI seeks to harmonize and integrate



The GRI Framework

The fact that larger construction companies are starting to ask for CSR policies from their suppliers and sub-contractors, in response to requests from their customers, is

one more and more companies will be facing.

CSR is still in its infancy in UK construction. There is a good base to build upon, with many companies having the desire to be better corporate citizens, but expertise needs to be provided in an accessible, understandable and usable form.

Fortunately, construction is accomplished in developing innovative solutions within the iterative design process; some of this in-built knowledge could be successfully applied to the iterative CSR process. However, construction companies need to recognise that, unless they adopt socially responsible working practices, then their business will suffer. In many other sectors, companies are coming to recognise the clear business case for adopting CSR-friendly working practices – the construction sector must now make similar adaptations.

*For further information, please contact Louise Randles (E-mail: [louiserandles@aol.com](mailto:louiserandles@aol.com)) or contact CICE, Loughborough University (01509 228549; E-mail [j.c.brewin@lboro.ac.uk](mailto:j.c.brewin@lboro.ac.uk)).*

## ENERGY INNOVATION & HOUSING

# Fuel cells for combined heat and power

A DTI-sponsored Partners in Innovation partnership led by the Black Country Housing Group Ltd (BCH) has pioneered domestic, fuel-cell-based combined heat and power systems. Already known for successful innovation, BCH can claim a world first in demonstrating that hydrogen can safely replace carbon-based fuels like coal, oil and gas when those fuels become too scarce or too expensive.

The system provides an ordinary household with power and domestic hot water. The house has virtually no space heating load.

Three key areas of research have been undertaken:

- selection and assembly of components to produce a combined heat and power system fuelled by hydrogen;
- safe supply of hydrogen in a densely developed housing estate;
- minimisation of the dwellings fuel consumption rates.

BCH Group Chief Executive, Sandra Spence, said, 'We need to do this kind of ground-breaking R&D to future-proof our housing stock. Doing so without wrecking the environment is what makes us a truly sustainable business.'

The role of the partners in this project has been crucial to its success. Alternative Fuel Systems Ltd (AFS) built the CHP system and

the British Oxygen Company Ltd (BOC) provided a safe hydrogen supply system. The Health & Safety Executive and West Midlands' Fire Service worked together to



The Mayor of Sandwell, Cllr Linda Turton about to have a cup of tea using power produced by the system

complete a successful hazard and operability (HAZOP) study that has led to the definitive risk assessment, now available to every fire tender in the country. Public liability and property insurers have assessed and approved the project.

The 3-year project is now nearing completion, gathering operational data in winter, spring and summer conditions with field trials well under way. It has received media coverage from television companies, and from housing and specialist industry magazines. Much more significant, however, is the interest in follow-on projects expressed by several manufacturers seeking both test-bed and manufacturing facilities in the British Midlands.

*For further information please contact Richard Baines, Black Country Housing and Community Services Ltd (0121 561 1969; E-mail: [bainesr@bcha.co.uk](mailto:bainesr@bcha.co.uk)).*

# Landslide risk assessment **DFID** Department for International Development

In hilly and mountainous areas, landslides regularly lead to fatalities, injuries, loss of livelihood and economic disruption. These effects are probably most acutely felt along mountain road corridors in developing countries, where roadside populations are high, where the physical geography places greater emphasis on a small number of key road corridors in the national road network, and where there are limited resources to combat landslide hazards.

**T**hese problems are probably nowhere more severe than they are in the Himalayas, where extensive floods and landslides have caused considerable damage and loss of life in recent years. In 2000, Scott Wilson, assisted by the University of Durham, began a research project aimed at developing low-cost methods of landslide mapping, for use by planning authorities and road departments in developing countries, making maximum use of remote sensing sources of data.

The research was carried out in Nepal and Bhutan. Three study areas were selected in

each country, covering a total of over 2,000 km<sup>2</sup>. In excess of 1300 landslides were mapped from a combination of satellite imagery, aerial photograph interpretation and field mapping. Methods of terrain evaluation and landslide recognition were tested for a range of small and large scale satellite images, and a set of best practice guidelines were developed.

Having established the landslide database, the distribution of landslides was correlated against a number of geological, geomorphological and land use factors to identify those factors most significant in determining the location of landslides. Landslide susceptibility maps were produced and were tested independently. New landslides occurring during the course of the study were also mapped and correlated against the susceptibility model. Prototype landslide hazard and risk maps were also produced, which enabled assessment of landslide runoff and total potential landslide losses.

The study was carried out in association with the Ministry of Local Development in Nepal and the Department of Roads in Bhutan. It was sponsored by the Department for International Development and won the 2003 BCCB Award for International Expertise (Large Firm Category B).

Government staff were trained in the use and application of the techniques, and workshops were held for over 300 delegates in the public and private sectors. A set of guidelines has been produced covering remote sensing, landslide hazard mapping and rural road corridor management for landslide mitigation.

*For further information, contact Gareth Hearn of Scott Wilson Kirkpatrick & Co Ltd (01256 461161; E-mail: gareth.hearn@scottwilson.com).*



(Top) Developing GIS models and training of staff from the Bhutan Department of Roads (Above) Road blockage and loss of carriage-way at Jumbla on the Phuentsoling-Thimphu Highway, Bhutan

## ABOUT INNOVATION & RESEARCH FOCUS

also on the web at [www.innovationandresearchfocus.org.uk](http://www.innovationandresearchfocus.org.uk)

**Aims** – The aim of *Innovation & Research Focus* is to promote the application of innovation and research in building, civil engineering and the built environment by disseminating new information as widely as possible. Its articles on current research and innovation are written for a wide-ranging audience, including practising engineers, architects, surveyors, environment specialists and their clients. Its sponsors wish to promote the benefits of research and innovation, improve contacts between industry and researchers, encourage investment by industry in research and innovation and the use of results in practice, and facilitate collaboration between all the parties involved. Articles may be reproduced, provided the source is acknowledged.

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