

Research Focus

Issue No. 39

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PROMOTING THE APPLICATION OF RESEARCH IN BUILDING AND CIVIL ENGINEERING

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Egan demonstration at Cardington

Why is the construction industry not more innovative? This question is often asked when the industry is compared with the car, aircraft or IT industries. One answer is that you cannot usually construct a prototype of a new building – the finished building is the prototype. When developing a new model of car or a piece of software, the designers create a prototype on which their ideas are tested and refined before going into production. This opportunity seldom arises in the construction industry: an exception is the 7-storey, in-situ concrete frame building at BRE Cardington, part of the European Concrete Building Project (ECBP).

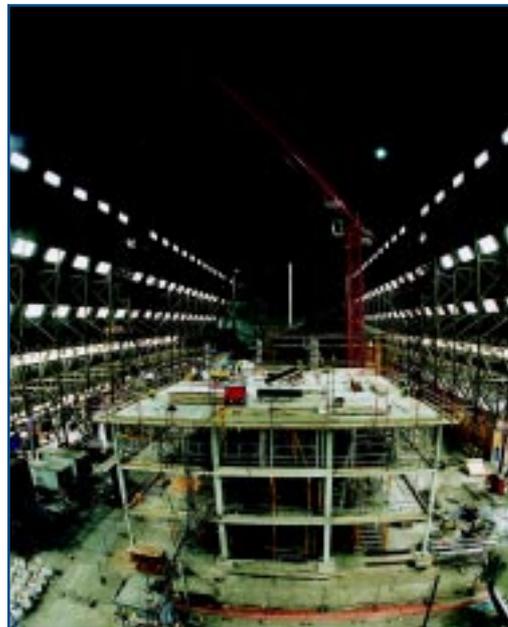
The opportunity to try new innovations in the building process and in the design and construction of building elements arose because the ECBP building was never going to be used conventionally. These opportunities have been recognised by the Movement for Innovation – the group taking forward the recommendations in Sir John Egan's *Re-thinking Construction* – which has designated the ECBP building a demonstration project.

This will provide many avenues and opportunities for disseminating to the industry the lessons learned from the construction of the building and the ongoing programme of research, for example on:

- saving up to 28% of cycle times and 42% of manhours through a re-design of the concrete frame business process;
- early striking of formwork and certainty of loading in backprops;
- the use of LOK and/or CAPO tests instead of temperature-matched cubes for the early-age acceptance of concrete.

The results are being worked up into a series of Best Practice Guides. The guides, and CONSTRUCT's *Guide to Flat Slab Formwork and Falsework*, will help the construction industry to deliver better value and achieve the targets advocated in *Re-thinking construction*.

The collective design experience on the ECBP has allowed a constructive criticism of



The in-situ concrete frame building at BRE Cardington has been designated an Egan demonstration project

the design code Eurocode 2. This discusses many aspects, including depth of floor, maximising span whilst minimising column size, achieving a balance between structure and building services distribution, non-regular grid layouts, ease of construction and maintenance, and use of prefabrication.

In addition to donating the frame's reinforcement and to close involvement throughout the project, the Reinforced Concrete Council has experimented with a

variety of analyses and reinforcement patterns to improve efficiency. The BCA funded the cement used.

Research on the performance of the structure is now looking at deflections, whole building behaviour, brickwork cladding, slab-column interaction, innovation, and dynamics.

The ECBP team would welcome suggestions for implementing lessons learnt from the Project or indeed proposals for further research on this unique facility.

For an update on the project see the M4I website (<http://www.m4i.org.uk>). For details of the RCC's and BCA's involvement in the project, please contact Martin Southcott, Project Director, RCC (01344 725733; E-mail: msouthcott@bca.org.uk).

For further information please contact

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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.

Distribution

If you receive *Research Focus* by direct mail (i.e. not with *Civil Engineering*) and the address it is sent to is incorrect, if you would like additional copies for circulation within your organisation or if you would like to be added to the direct mail list, please contact Lesley Wilson at the Institution of Civil Engineers, 1 Great George Street, London SW1P 3AA (020 7655 2242; fax 020 7799 1325; Email wilson_l@ice.org.uk).

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Using unprotected steel in buildings

Methods of demonstrating the safety of unprotected steel in buildings are being developed following recent fire tests at Cardington. These tests demonstrated that a conventional composite steel framed building could withstand severe fires with many beams unprotected. Following the fire test programme, further research has been started, to try to understand the observed behaviour at Cardington and to develop design guidance.

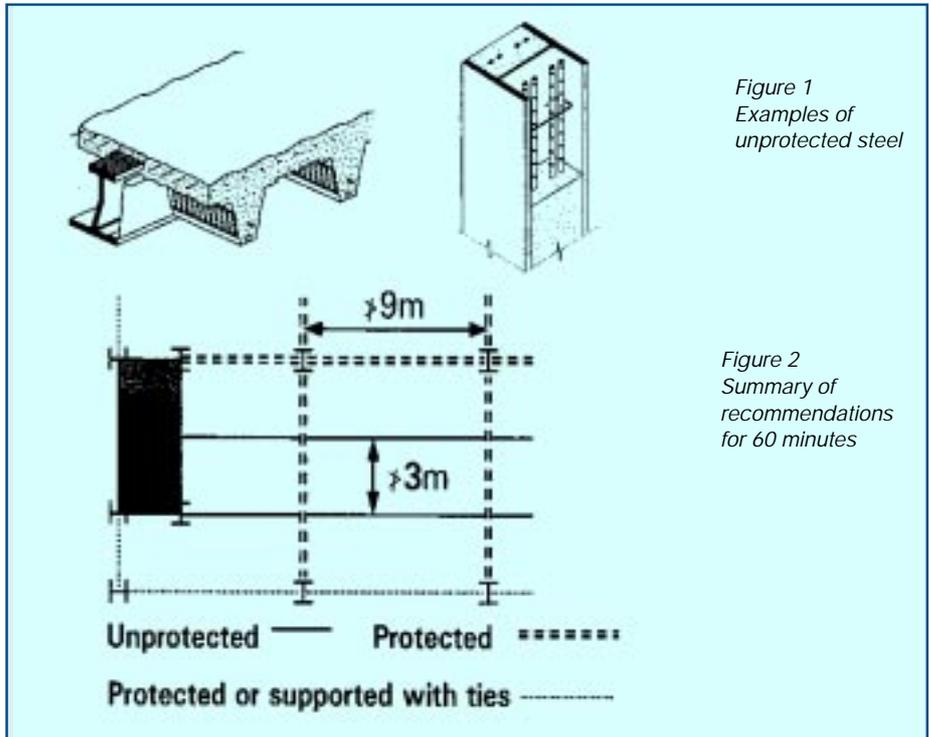


Figure 1
Examples of
unprotected steel

Figure 2
Summary of
recommendations
for 60 minutes

Building regulations often require steel structural members to have a specific fire resistance. To achieve this fire resistance the steel will, in most cases, be fire protected. However, building regulations do not specify that steel must be fire protected, and fire resistance may often be achieved without applied fire protection. In some buildings, cost savings through faster construction may be made as the application of fire protection is often on the critical path.

The fire safety of unprotected steel can be achieved in two ways. The first way is based on the building regulation approach of performance in a standard test. The second way is by some form of 'fire engineering'. Methods of achieving fire resistance are described in the new SCI publication *The design of steel framed buildings without applied fire protection*.

Many types of beams and columns can achieve at least 60 minutes' fire resistance without applied fire protection. In most cases, the steel is partially encased in concrete or masonry. (See Figure 1). Most engineers will be familiar with the asymmetric beam and *Slimflor* construction and partially encased beams and columns are commonly used in Europe. Concrete filled structural hollow sections are architecturally pleasing and are useful when an applied

protection may be damaged.

The fire performance of steel used in these ways is very reliable. The performance after 20 years will be the same as on day one, as there is no fire protection to be damaged or removed.

In the Cardington tests, a major influence on the performance was the floor slab. This carried most of the vertical loads when the beams, which often reached 1000°C, lost strength. Generally, columns were protected to limit damage to higher floors.

Initially, simple guidance is being prepared, based largely on observations, and great importance is being placed on human safety. This will cover buildings normally requiring 30 or 60 minutes' fire resistance. In addition it is hoped to be able to recommend that, for 30 minutes, all beams may be left unprotected and, for 60 minutes, all secondary beams may be unprotected – see Figure 2. However, column protection will still be required and the floor slab must have at least A142 mesh.

For further information please contact Gerald Newman, Manager, Fire Engineering, The Steel Construction Institute (01344 623345; fax: 01344 622944, E-mail: g.newman@steel-sci.com; Web site: <http://www.steel-sci.org>).



Data handling – a key to coastal management

The coastal zone faces a barrage of competing demands, and coastal managers require data inputs from many different areas to help them in decision making. There is plenty of information available, but it is held by different organisations, in many different formats. Researchers at HR Wallingford are involved in collaborative European projects that examine how best to handle data as well as how to make it more accessible. Three initiatives funded by the European Union – DESIMA, ENVALDAT and AVID – are recent examples.

DESIMA – A prototype information tool for coastal managers

Today's coastal managers need access to a wide range of environmental data in order to make appropriate planning decisions. Technology can help, and the EC has recently funded work to develop the concept of a decision support system for coastal management (DESIMA). The project was awarded to a consortium involving Matra Systems and Information (France), ACRI (France), HR Wallingford Ltd and Satellite Observing Systems (UK), which has developed a prototype tool capable of integrating information sources such as satellite data, in-situ measurements and numerical models to simulate events in two specific locations.

'Working in collaboration with the Environment Agency, HR concentrated on coastal defence issues around West Bay in Dorset, a region that illustrates many of the features common to all coastal management situations,' explains Kieran Millard, HR's project leader.

'Our partners at ACRI simulated an oil spillage scenario in the Gulf of Lyon.' Researchers considered which data sets were needed, how these could be called up remotely from different providers across Europe and whether they could then be meshed together into a single real-time system for use by coastal engineers. The DESIMA project was coordinated by the Marine Environment Unit of the Space Applications Institute of the Commissions Joint Research Centre. (Readers may be interested to look at the West Bay simulation on <http://desima.jrc.it>).

DESIMA shows that it is theoretically possible to build integrated tools for use in coastal management. Further inputs are needed, however, especially on legal and business aspects of the sale or licensing of coastal information. EC-funded research programmes such as ENVALDAT and AVID should help to supply this information, as well as opening up new data resources to those who need them.

ENVALDAT – Establishing the value of environmental data products

Many organisations hold environmental data and the aim of ENVALDAT was to see how this might be commercially valued as a prelude to sale or licensing. ENVALDAT developed out of the need to find ways of



Waves, tides, bathymetry and topography – some of the parameters required for effective coastal management.

trading satellite data and involved seven European organisations. Three workshops were held between November 1997 and June 1998 and a Working Document has been produced to summarise findings. Keiran Millard, who edited the final report, explains: 'We looked at the types of organisation that held, supplied and pur-

Separate research, this time funded by CIRIA, will result in publication of a manual entitled 'Maximising the use and exchange of coastal data – Developing best practice'. Many organisations operating in the coastal zone find they are hampered by a shortage of high quality data. This information often exists, but it is hard to track down and use. 'Effective sharing of data offers real cost savings,' says Daniel Legget, CIRIA's manager of the project. The Manual will include input from coastal managers, mapping organisations, District and County councils, harbour authorities, conservation organisations, government departments, industry and academia. Production is being coordinated by HR Wallingford and the final publication is expected to be available towards the end of 1999.

For further information about this work and the Manual please contact Daniel Legget (0171 828 4441; fax: 0171 828 4055; E-mail: daniel.legget@ciria.org.uk).



chased environmental data as well as data formats.'

Workshop participants focused on five aspects of coastal management: shellfish water quality, bathymetry, wave data, meteorological data and information on sea level rise. 'In each case we tried to identify what the data product was, who produced it, who might use it and how much they would pay for it,' explains Millard. The Workshops also examined current data pricing policies within organisations (such as the UK's NERC and the Irish Marine Data Centre) and flagged up issues that could affect pricing in the future. A full report of the project is available at www.hrwallingford.co.uk/projects/ENVALDAT.

AVID – Added Value Information Dissemination of hydrographic data

Much environmental data is held by publicly funded organisations. Under the terms of a Green Paper on Public Sector information, the European Commission is funding projects to examine how government information might be made accessible to other users. This could also help institutions to recoup some of their investment in data collection.

One such project, AVID, aims to gather, interpret and disseminate information held by European hydrographic offices such as SHOM (France), BSH (Germany) and the Portuguese Navy Hydrographic Institute.

The hope is that outputs will lead to the creation of a 'shop window' for port authorities and other organisations wishing to access data (for example on sediment transport, tides and currents) for a specific location. Eight European partners are involved including Matra and HR Wallingford.

'HR is providing value-added data sets from hydrographic office data and Matra is researching ways of fitting this together into one system for easy access,' explains Millard. Such data sharing carries with it business and legal implications. 'HR will be looking at the business aspects of the system – including suitable charging structures,' he continues. Spanish-based legal experts Consultaria Garcia Olaya will investigate current industrial data purchase and licensing arrangements and look at the whole question of IPR.

For further information on any of this work please contact Kieran Millard at HR Wallingford (01491 835381; fax: 01491 825743; E-mail: keiran@hrwallingford.co.uk).



Market study of building services consultants

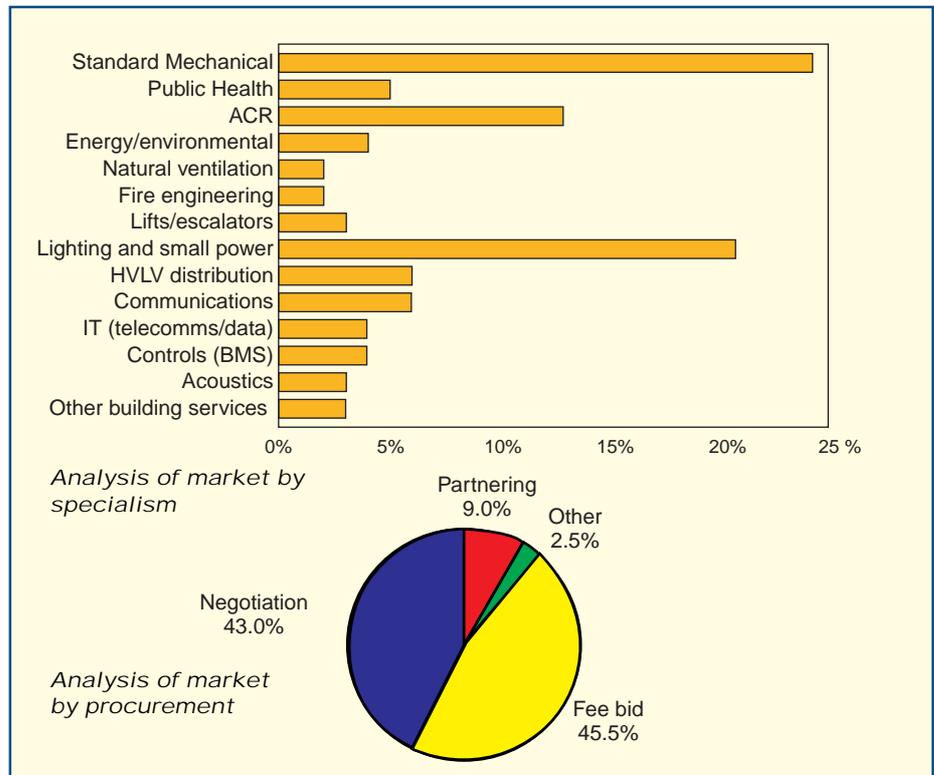
A project being undertaken jointly by BSRIA and CIBSE is aiming to provide much needed information on the size, structure and role of building services consultants within the UK construction industry.

This new project complements earlier research undertaken by the Construction Industry Council on UK professionals but concentrates on the building services sector. The research covers a wide range of building services consultancies, ranging from SMEs to some of the larger, well-known firms. DETR is providing part funding under the Partners in Innovation scheme.

The objective of the research is to enable companies to benchmark their activities against the industry norm and to promote the wide range of specialisms encompassed within building services. As well as the traditional M&E services, the firms surveyed provide a wide range of services, including acoustics, air conditioning and refrigeration, energy, fire engineering, IT and controls, lifts, natural ventilation, public health services (including water) and thermal storage.

The results of the research will be published at the end of 1999 and will be available from both BSRIA and CIBSE.

For further information please contact Gerry Samuelsson-Brown at BSRIA, Old Bracknell Lane West, Bracknell, Berks, RG12 7AH (01344 426511; fax: 01344 487575; E-mail: gerry.samuelsson-brown@bsria.co.uk).



MANAGEMENT

Measuring performance in design organisations

A group of twelve CIRIA Core Programme Members are participating in a new research project on performance measures in design organisations. The work follows earlier work on the management of technical excellence in design organisations and the benchmarking of good practice.

The aims of all this work are to:

- gather information and experience on current practice in performance measurement in design offices of leading consulting and contracting firms in the UK;
- develop, and report upon, a framework for performance measurement and a set of performance indicators that may be adopted by design organisations.

Following the commissioning of a cross-industry study on performance measurement in design activities, CIRIA designed and developed a three-stage project programme.

1 The development of a set of generic performance measures

To simplify the performance measurement of design, CIRIA developed a model that separates the process of design from the outcome of design. One of the reasons for adopting this distinction is to differentiate between indicators that measure the cost of

design against those that measure the value of the product designed.

The process of design is considered to consist of two distinct activities:

- conception activities, and
- development activities.

The outcome of design is also thought to consist of two distinct elements:

- realisation of the design
- satisfaction with the product.

The next stage of this work is a 2-day workshop aimed at generating a wish-list of generic performance indicators.

2 Benchmarking

The wish-list of generic indicators will be assessed by the group in order to select a number that may be used by the participants to benchmark their performance on a limited number of projects. The selection will be influenced by availability of data,

types of projects being undertaken by participants and other current constraints.

3 Recommendations

The benchmarking exercise will highlight areas where participating organisations need to improve their performance. In addressing recommendations for improved performance, a set of generic issues having a direct impact on the performance of design will be developed.

The output from all of this work is expected to be a short report presenting a framework for performance measurement of design activities. Key performance indicators will be recommended, with guidance on how to apply them. Recommendations for improving performance based on the experience gained from the study will also be made.

For further information please contact James Milne at CIRIA (020 7222 8891; fax: 020 7222 1708; e-mail: james.milne@ciria.org.uk).



Assessing construction and demolition waste

A reliable, cost-effective method of assessing the contamination risk of construction and demolition waste is needed to help increase levels of waste re-use and recycling, and to encourage the redevelopment of brownfield land.

Construction and demolition waste is normally of low value, so sophisticated methods of assessing the risk of contamination are rarely justified. The current guidelines for making initial assessments were not designed to be applied directly to construction and demolition waste, and are therefore not strictly appropriate.

The lack of suitable assessment methods is inhibiting the re-use of waste because, without reliable information, it is difficult to gauge the level of contamination. To be on the safe side, therefore, materials that could be re-used are often sent to landfill.

A project aiming to solve this problem has recently started. Its objectives are to:

- develop a method of risk assessment for contaminants in C&D waste;
- develop standard guidelines for soil and waste sampling to monitor and assess contamination risk;

- ensure that these methodologies are clear, adaptable and usable by SMEs, as well as larger construction and waste management organisations.

The project is being funded by the Engineering and Physical Sciences Research Council, and managed by BRE and the University of Manchester. Industrial partners include Kier Construction, Carillion plc, Leck Construction, the Environment Agency, Masons Partners and Greater Manchester Waste.

For further information please contact Stephen Garvin, at BRE Scotlab (01355 576200; fax: 01355 576210; E-mail: garvins@bre.co.uk).



Only a small proportion of construction and demolition waste is currently reclaimed or recycled

MATERIALS & ENVIRONMENT

Sustainable use of aggregates

TRL is currently undertaking a range of activities that will result in the more sustainable use of aggregates and reflects the increasing emphasis on sustainable development resulting from the Egan report *Rethinking Construction*. DETR has identified the prudent use of natural resources as an objective for sustainable development because aggregate use generates impacts on the environment whilst being important for economic growth and employment.

One major area of aggregate use is in road construction. There is particular concern about the use, in road surfaces, of scarce, polish-resistant aggregates, which can maintain adequate levels of wet skidding resistance under heavy traffic. Over-specification of these materials is neither sustainable nor economic, while under specification could lead to increased accident risk. A Highways Agency programme of work has led to changes in the specification of these materials (TRL Report 322) and is continuing with the additional support of the Quarry Products Association (QPA) and the County Surveyors' Society.

TRL, in partnership with QPA and Carillion, has recently been commissioned to produce indicators and auditing procedures for the use of quarry products in building construction, under the DETR Partners in Innovation scheme. This is in response to the need to develop measures of sustainable construction for individual products and discrete supply chains. The project is due to be completed in early 2002 and will produce a tool-kit designed to provide a common platform by which clients can request the use of the indicators, and contractors and suppliers can adopt them.

Another major use of aggregates is in bridge construction. TRL has undertaken a programme of work for the Highways

Agency to assess the use of lightweight aggregate manufactured from waste materials as an alternative to natural aggregates in concrete. The purpose of this work is to encourage the use of lightweight aggregates in bridge construction. The specific aims were to examine the properties of lightweight aggregate concrete, review its application in the design and construction of bridges, compare the design rules currently used in different countries, and recommend improved design rules where applicable.

An experimental programme was undertaken in which two types of aggregate were studied: Lytag, which is manufactured from pulverised fuel ash, and Pellite, which is manufactured from blast furnace slag. Tests were carried out to investigate a range of properties of beams cast using lightweight aggregate, including shear

capacity and corrosion resistance.

For further details on roads and indicators contact Tony Parry (01344 770154; fax: 01344 770356; E-mail: aparry@trl.co.uk) and on bridges, Albert Daly (01344 770449; fax: 01344-770356; E-mail: adaly@trl.co.uk).



Aggregates for road surfacings.



New initiative on dam modelling

Dambreak analysis is the investigation of catastrophic flooding following the uncontrolled release of water from a dam, and it plays an important role in reservoir safety studies. The EC is funding a 2-year project to foster links between researchers and end-users (such as dam operators) with the aim of improving modelling techniques and the understanding of dam safety issues.



Intense flooding of downstream land follows almost all dam breaks.

CADAM (Concerted Action on Dam Break Modelling) started in February 1998 and builds on studies by a Working Group of the International Association for Hydraulics Research, led by Electricité de France (EDF). It brings together participants from universities, research establishments and industry across Europe, with Mark Morris of HR Wallingford as the Project Coordinator (supported by DETR). Technical direction is provided by EDF. Links with the US Bureau of Reclamation have provided valuable information on current practice in the US.

'CADAM provides a framework within which we can share information, and compare existing models and understanding against field and laboratory data,' explains Morris. These aims are achieved through a series of Experts' Meetings and Workshops, covering issues such as modelling methods for catastrophic floods, structure failure, breach formation mechanisms, insurance issues, loss of life, and social and economic consequences. Debris and sediment transport are also key areas of investigation.

'Various approaches have been taken,' says Morris. 'Models and understanding have been reviewed through consideration of basic theory, use of physical models, field test data and information from past failures. The project has started with simple test cases and progressed to more complex ones. At each stage we have considered our understanding of processes and our ability to predict impacts and conditions.'

The final CADAM meeting will be held in Zaragoza (Spain) in November 1999. Final outputs from the project will include guidelines for modelling this

challenging topic and identification of future research and technology needs.

Communication is a vital part of the project. Through CADAM, the international research community has found a network of contacts with industry and the project has provided coordination to existing national research efforts in various EU member states. Participants keep in touch through meetings, informal contact, newsletters, e-

mail and the Internet. New inputs and contacts from those involved in dam assessment are always welcome.

*For further information please contact Mark Morris at HR Wallingford
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fax: 01491 825539; E-mail:
m.morris@hrwallingford.co.uk).*



BUILDINGS & ENVIRONMENT

Development of a new energy assessment method

The government has signalled its intention to introduce an industrial energy tax from April 2001. Whilst the exact scope of the tax has yet to be determined, it will inevitably place an even greater incentive on building managers to improve their organisation's energy efficiency. The Chartered Institution of Building Services Engineers (CIBSE) have published a new tool to help energy managers, building designers and facilities managers to assess the energy performance of their buildings.

The package, CIBSE Technical Memoranda 22, is the product of a CIBSE-led DETR Partners in Innovation project, funded by the DETR and CIBSE, and describes the *Energy Assessment and Reporting Methodology* (EARMTM) (originally developed by BRE) which can be used for assessing the energy performance of buildings and systems. Initially developed for the assessment of office buildings, the procedure has now been extended to include hotels, banks and agency buildings, and mixed-use light industrial buildings.

The method provides the user with a simple overall view of the energy performance of a building's systems. This can be used in greater detail to obtain an improved understanding of system performance and to identify poor performance, operational problems and possible savings. Information on the building, such as its size and type and its fuel consumption, is entered into the spreadsheet provided. These figures are then compared with existing benchmarks, to enable performance to be rated against comparable buildings.

Because the approach provides feedback on plant sizing, service provision, occupancy, operating hours, and control and management, it is a valuable tool for designers, and it can help feed back operating performance to designers.

The procedure has been carefully developed

and has been extensively tested – it was used as a basis for Energy Consumption Guide 19, *Energy Use in Offices*, and also for the PROBE post-occupancy review investigations published in Building Services Journal. A 'soft-entry' approach avoids prohibitive learning curves or costs by providing a simple initial assessment stage, which also judges whether a more-detailed assessment is needed.

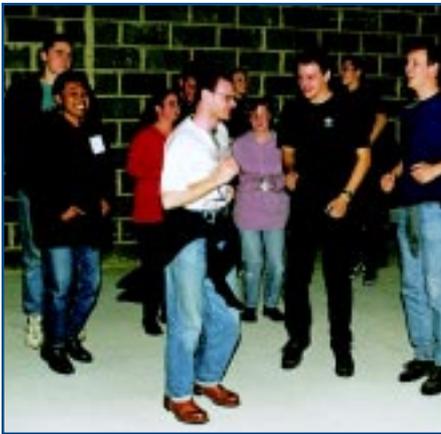
The analysis is presented in a graphical form. Data entry completion and accuracy are monitored, allowing the assessment to proceed with the data available and improving the reliability of the conclusions. The workbook formulae are visible, allowing calculations to be followed and understood, reducing mistakes and further enhancing reliability. New system and component benchmarks have been developed from existing benchmarks for whole-building energy use, and verified against surveys of representative premises. The method can assist with the development of custom benchmarks.

CIBSE Technical Memoranda TM22:1999 comes complete with the necessary spreadsheets on disk and is available from Ken Butcher, CIBSE Publications, (020 7675 5211; fax 020 8675 5449; E-mail kbutter@cibse.org) price £28.20 to members and £42.30 to non-members.



Damping out floor vibrations

Modern building materials allow architects to design buildings with longer floor spans than was once possible. The problem with medium and long span floors is that people walking on them cause vibrations that can be an annoying distraction to other occupants of the building. As there is little guidance for engineers on what to do about this, BRE and the Tun Abdul Razak Research Centre have been developing and testing a means of controlling floor vibrations as part of a DETR Partners in Innovation project.



Synchronised jumping on the test floor by students from UMIST

Vibration produced during walking has two main components – that generated by the impact of each footfall, and the build up of resonant vibrations (which happens when the walking frequency is a integer fraction of the floor's natural frequency). In modern floors, with relatively low damping values, it is the resonant vibrations that dominate the response and are the source of the problem. (See Research Focus No.33, page 5 for details of earlier related work).

An obvious solution to this problem is to increase the level of damping. The key questions are: How can this be done? and How effective is it likely to be?

As part of the project, a constrained damping layer was designed and installed in BRE's steel framed building at Cardington, on a modern composite floor that was relatively lively – that is, it was easy to feel the vibrations generated by others walking across the floor.

The effect of the damping layer was to completely change the feel of the floor, making it 'dead' to heel-drop and walking loads. Before any scientific tests were undertaken, it was clear that the damping layer had reduced vibration to a fully acceptable level.

While this work was concerned with adding damping to an existing floor, the concepts could easily be adapted for the construction of new floors. Further work will aim to establish guidelines allowing designers to specify the stiffness, mass and damping of a floor, so selecting its dynamic characteristics and avoiding the vibration problem.

For further information please contact Brian Ellis at BRE (01923 664566; fax: 01923 664786; E-mail: ellisb@bre.co.uk).



BUILDINGS

Trialling of proposed standard European watertightness test for cladding

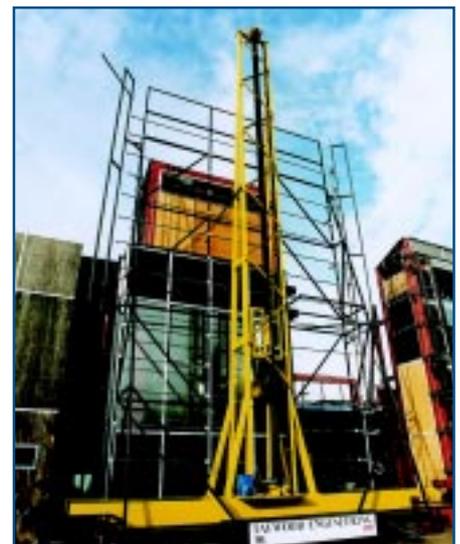
The cladding industry has been given three years in which to comment upon recommendations for a new European standard dynamic watertightness test for curtain walling. The Centre for Window and Cladding Technology (CWCT) is advising architects, specifiers and manufacturers to trial the proposed test during the probationary period, when it is a provisional Standard, so that any comments that the UK cladding industry may have can then be considered for inclusion in the final European Standard.

This is a prime opportunity for the UK construction industry to exert its influence on the European standards that are set. Trialling of the proposed test on a much broader scale, and further development, will help to provide the cladding industry with the data it requires for future product development and quality improvement. CWCT recommends that the new test is used only for research purposes, until it has been verified, and that it is undertaken after the prescribed CWCT dynamic test has been completed in the normal sequence of commercial testing.

Currently, there are at least eight recognised dynamic tests in use worldwide – but all raise problems with regard to test conditions and their reproducibility. A European-funded development programme was established to develop a standard test that is both practical and cost-effective, with good repeatability. The two-year study was led by Taywood Engineering, a founder member of the CWCT and operator of the largest independent cladding test facility in Europe. Their pan-European research partners included the Building Research Establishment and PF Consultants in the UK, the Institut Für Fenstertechnik, Germany, and Permasteelisa SpA, Italy.

To develop a scientifically sound and repeatable test, the European research team went back to first principles. Based on the meteorological data they collated, the team derived a range of exposure conditions appropriate to vertical facades and evaluated a number of test parameters for their significance in watertightness tests. The outputs from this task determined the principles for the new test.

The method preferred by the European standards body, CEN, was a dynamic test that could simulate real conditions using existing test apparatus as far as possible.



New European Test Rig

The proposed test retains the use of a pressure chamber and water spray rig to simulate internal pressure and rainfall.

The main difference is the use of a mobile wind generator, which can be tracked horizontally and vertically across the external face of the test sample to apply a controlled turbulent airflow to the outside surface of the specimen.

The team's full recommendations are now included in the proposed European standard. Taywood Engineering and CWCT predict that, within five years, dynamic watertightness tests will be standardised and will be commonly used throughout Europe.

For further information please contact Dr Stephen Ledbetter, CWCT (01225 826541; fax: 01225 826556; E-mail: cwct@bath.ac.uk).



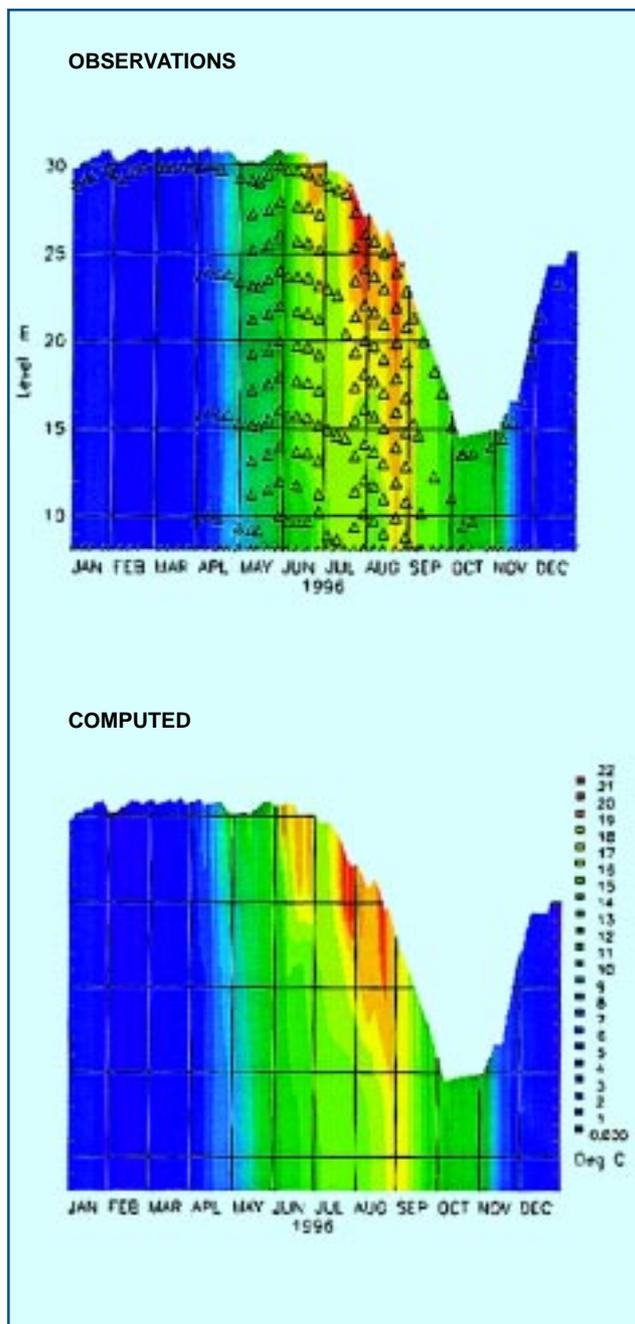
Modelling water quality

Water quality in lakes, reservoirs and estuaries is a vital concern, particularly where growing populations and intensive farming methods put pressure on resources. Excessive inflows of nutrients, for example, can result in weed overgrowth and algal blooms. HR Wallingford has developed a powerful, 3D numerical model (SULIS) capable of following more than 20 aspects of water quality (including biological oxygen demand and algal growth) over long time periods, including annual cycles.

SULIS is based on an earlier finite difference model first developed at Wallingford during the 1980s and has three modules, covering hydrodynamic flow, thermal processes and water quality, linked together to save storage and make the model easier to run. 'Both models share the same multi-layered, irregular, quadrilateral grid but the physics behind SULIS has been upgraded and its hydrodynamic module is based on an advanced new technique,' explains Num. Ir. Sebastien Bourban of HR.

Bourban has modified the hydrodynamic module so that it is fully implicit. 'The generalised Navier-Stokes equations are now coupled with the mass conservation equation,' he explains. This means that water depth is part of the 3D flow field rather than being deduced from averaged velocities (as is the case with most shallow water numerical models). SULIS can therefore deal with sources and sinks of water in any grid cell, giving a more accurate simulation of mixing patterns in test zones. Bourban has also included full thermal balance amongst other physical processes.

The model has been applied to data from lakes and reservoirs in various parts of the world, including Africa. It has been found to give accurate simulations of annual temperature variation across a UK reservoir and is capable of simulating progressive changes in a lake over timescales of up to 10 years.



Observed (above) and computed (below) water temperature profile in Wraysbury reservoir

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