Research Focus

Issue No. 33 MAY 1998

PROMOTING THE APPLICATION OF RESEARCH IN BUILDING AND CIVIL ENGINEERING

IN THIS ISSUE

Safer ports from a new guide

The safety of ship-to-shore ramps and walkways has been the subject of recent publicity with extensive coverage of the fatal Ramsgate accident. The ports industry – represented by the Ports Safety Organisation (PSO) and Professor Jack Chapman, a renowned expert in this field – approached CIRIA in 1996 with a request to prepare and publish best practice guidance on the two areas that the industry considered would make maximum impact on safety: Procurement, and Operation & Maintenance.

To ensure a truly collaborative approach, CIRIA brought together representatives from all parts of the ports industry to contribute to the development of the project. The project now enjoys substantial support from over 200 Ports (through the PSO), HSE, DETR, Lloyds Register, the Safety Assessment Federation and the TT Club. CIRIA is grateful for this financial support, and for the in-kind technical contributions of members of the project steering group, which enabled work on the project to start in December 1997.

CIRIA's research contractors are Posford Duvivier, who have continued CIRIA's efforts to ensure maximum involvement and input from industry. The first step was to carry out an industry survey of all linkspans and walkways in the UK, Ireland and North West Europe. 115 consultees responded (a 43% return rate and more are still arriving) which resulted in the identification of 430 shore ramps and 135 walkways. Posford Duvivier are now gathering detailed information on all of these facilities from port operators, owners, designers, classification societies, installation contractors, trade associations, statutory authorities, insurers, inspection companies, ship owners and maintenance organisations. This information will all be put into a database which will then be interrogated for information throughout the rest of the research.

Establishing best practice in the procurement, operation and maintenance of these facilities will be through analysis of the data gathered and discussions by the experienced and industry-representative project steering group. A consultative workshop will also be held in June 1998 to which industry experts will be invited to comment on the findings and initial recommendations.

Publication of best practice should not only result in safer facilities but also enable the production of clearer functional specifications, better communications and more efficient and cost-effective operation and maintenance.

The research is scheduled to finish in September 1998, with open publication by the end of the year.

For further details on the research, or if you would like to be considered for invitation to the June workshop, please contact Dr Ghazwa M. Alwani-Starr, Head of Process Group, CIRIA, 6 Storey's Gate, Westminster, London, SW1P 3AU (0171 222 8891; fax: 0171 222 1708; E-mail: ghazwa.starr@ciria.org.uk).

CONSPEC: towards improved ready-mixed concrete specifications

Under a DETR-funded Partners in Technology project, the Ready-mixed Concrete Bureau has developed software called CONSPEC, a CD-rom-based guide to the ready-mixed concrete standard BS5328. Significant efficiencies are expected to accrue to specifiers and their clients as CONSPEC is launched on to the market. The DETR hope that the concept can now be replicated in other market sectors.

Ambiguities and inaccuracies in specifying concrete can be very costly. To reduce the chances of such errors, the very difficult and time consuming process of specifying concrete mixes has been completely computerised. In developing CONSPEC, the Concrete Research and Innovation Centre at Imperial College and the Consulting Engineers, Posford Duvivier, have used the database software Microsoft Access to ensure that the requirements of BS5328 are fully met.

Twelve consulting engineers and all the major ready-mixed concrete producers have been trialing the system over the last six months. Users can set up their own standard library or use the one built into the system. Designed, designated, prescribed and standard mixes are all handled and there is no limit to the number of construction projects or mixes. The concrete can be reinforced or unreinforced and various factors such as exposure to metals, sulphates, acids and the environment are all catered for.

If users wish to reduce the number of mix specifications within a project, either to minimise potential ambiguities or to improve economies of scale, a rationalisation process is available.

The requirements of BS5328 are fully observed using forms which set out all the information relating to the mixes specified. However CONSPEC also produces an 'invitation to tender' document which can be transmitted by post or e-mail to potential suppliers, thereby achieving a more efficient supply chain.

To ensure that the standards are being properly applied, a specification log can be printed at any time. This sets out the detailed steps and decisions taken by the software so that these can be examined and checked by the user. Any changes made by the user are also logged so that an audit trail is available.

CONSPEC runs on any computer with Windows 3.1 or above and requires about 15MB of hard-disc space. When the new European Standard EN206 is available, this will be dealt with by an updated CONSPEC. It is hoped that all users will be keen to sign up for the European version because EN206 will be extremely complicated for specifiers and producers to interpret by conventional manual methods.

CONSPEC is available to all users free of charge for the first six months. Thereafter modest charges will be made to cover any costs incurred in maintaining and updating the system. Authorised users will be able to download any updates direct from the internet and there are plans to export the system.

For further information please contact:
Den Dover at BCA (01344-725732;
fax: 01344 761214;
E-mail: ddover@bca.org.uk).

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, lively 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 or, in the case of EPSRC's research programme, from Catherine Coates at EPSRC (01793 444176).

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 tp the direct mail list, please contact Lesley Wilson at the Institution of Civil Engineers, 1 Great George Street, London SW1P 3AA (0171-665 2242; fax 0171-799 1325; Email wilson_@ice.org.uk).

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Port environmental management

Researchers at HR Wallingford are preparing guidelines on the environmental management of ports to help managers tackle the environmental issues arising from routine port operation and longer-term development planning. The Manual[1], part-funded by the DETR, will outline the issues that should be addressed within an environmental management plan, give recommendations and cite examples of management systems in practice.

UK legislation and EC Directives already aim to protect environmental resources. BS 7750[2], the European Eco-Management and Audit Scheme (EMAS) and the more recent International Standard on environmental management[3] have clear relevance to port operations. 'The protection of environmental resources should be addressed by every port, as it may significantly influence future development plans,' stresses Eleni Paipai, who leads the project at HR. 'Some port authorities have already set up environmental management systems and we hope that this study will help others to do so.'

During the first two phases of research Mrs Paipai and her colleagues aim to contact port authorities around the UK and overseas, starting a dialogue with them to find out more about their operating procedures. 'It is important to look at ways of safeguarding environmental resources whilst allowing development plans to proceed,' she explains. Researchers consider the type of port (container or bulk cargo) and try to identify potential problems both at the quayside and in the hinterland. They then explore possible environmental management solutions in consultation with the port authorities.

Problems might include the handling and

storage of hazardous substances and land contamination. 'Oil from leaking barrels can seep into surrounding soil, but correct storage will prevent the problem from occurring and help to protect land values as well as the wider environment. Good storage and recycling practice safeguards the environment and can have positive economic benefits,' says Paipai. Also important to the development of a successful environmental management plan is the early identification of potential conflicts between a port and other relevant authorities.

The study will continue into 1999 and Eleni Paipai is keen to talk to port authorities who are setting up an Environmental Management Plan as well as those who already have one in place. 'We are interested to hear about people's experiences in establishing and implementing these procedures,' she explains. 'What difficulties did they encounter in preparing for an Environmental Management Plan and what corrective action have they taken?'

Guideline development is a consultative, two-way process. Researchers appreciate the operational and development needs of port authorities as well as the importance of safeguarding environmental resources. Eleni Paipai stresses that the final publication will be practical and pragmatic. 'Our emphasis is very much on dialogue and continuous communication. We aim to compile a document 'which will help the industry to carry out its day-to-day operations and implement port development plans in an environmentally acceptable way.'

[1] To be called 'Guidelines for Port Environmental Management'
[2] Specification for environmental management systems (now superseded by ISO14001)
[3] ISO 14001: Environmental Management Systems: Specification with Guidance for use

For more information about this work, or if you are able to contribute in any way, please contact Eleni Paipai at HR Wallingford (01491 835381; fax: 01491 832233; E-mail: epp@hrwallingford.co.uk).

Breaking down barriers to natural ventilation

A soon-to-be-completed EC project NatVent™ has been aimed at overcoming technical barriers to low-energy natural ventilation in office-type buildings in moderate and cold climates. It has found that natural ventilation is an effective design strategy for office buildings in the UK or other moderate or cold climate countries in Western Europe.

Misconceptions surrounding natural ventilation are impeding its take-up by architects and developers in and around Europe. Many building owners and occupants are thus missing out on the benefits that it provides – from the financial to those concerning health, comfort, productivity and the environment. NatVent is a project designed to correct these misconceptions by convincing the market of the viability of natural ventilation and that generalised and tested solutions to technological barriers are available.

In-depth structured interviews identified perceived commercial, institutional and technical barriers. Key technical barriers identified were the issues of air and noise pollution in urban and city centres, variability of weather, attempting to recover heat from natural ventilation systems, combating summer overheating, and integrating and maintaining natural ventilation systems.

BRE's award-winning Environmental Building which formed part of the NatVent studies.

NatVent aims to provide the market with practical solutions to these issues.in the form of 'smart' technology systems and component solutions. A guide-book and an interactive CD-ROM will describe them and show how they can be applied in an integrated manner for year-round occupant comfort.

NatVent also recognises that natural ventilation is a building-integrated design concept. Design is centred on using passive ventilation, based on 'stack' temperature effects and wind pressures to supply fresh air to building interiors even when the windows are closed. NatVent, for which a 7-nation consortium is being led and coordinated by BRE, has established a pan-European network of some of the key low-energy architects within the participating countries, and monitored exemplar buildings. A national seminar is planned for June to describe the completed work and establish a dialogue to take the issue forward.

For further information please contact Dr Earle Perera at BRE (01923 664877; fax: 01923 664796; E-mail: pererae@bre.co.uk).

An innovative approach to design management

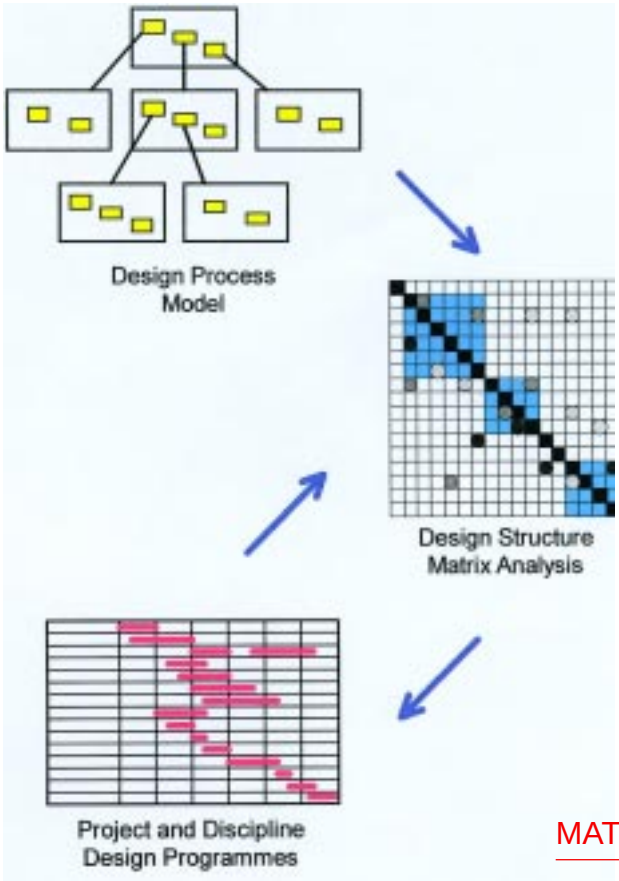
Significant improvements in design management are now possible through the introduction of new techniques that model and analyse design processes to produce co-ordinated design programmes based on information flow rather than deliverables. A research programme at Loughborough University, operating under the EPSRC and DETR-funded Integrated Design and Construction LINK Programme, is addressing these issues in collaboration with AMEC Design and Management, Ove Arup & Partners, Sheppard Robson, Laing Management, Boots and BAA. The team is developing models of the detailed design phase of building design and has created a prototype software tool to optimise design task order and analyse the effects of change.

The new methods are being developed in three stages. Firstly, a generic model of the detailed building design process has been produced showing the relationship between design activities based on the flow of information in the process. Secondly, design structure matrix (DSM) analysis of a schedule of activities identifies an optimum sequence of tasks based upon the dependency and availability of design information as defined in the design process model. Finally, the matrix analysis is linked to a planning and scheduling package so that design programmes can be produced when resources and duration of tasks are allocated to the re-sequenced activity schedule. The complete methodology is referred to as ADePT (Analytical Design Planning Technique).

The model has been produced using a variation of the IDEF0 technique (termed IDEF0v) which recognises the cross-disciplinary information exchanges, which are more difficult to manage. The generic model has approximately 750 activities at the lowest level of the hierarchy and 4000 information inputs. For the generic model to be useful, it must be made project-specific, in which sections not relevant to the project are discarded along with corresponding information. There must also be scope to add new sections to allow for special features of a building.

The use of DSM techniques has yet to be proven to be workable on a process of such magnitude as detailed building design. A manipulated matrix gives the optimum design sequence in a process that contains iteration. Feedback loops of tasks are indicated, where either work must be undertaken in an iterative manner or estimates of unavailable information must be made. In the building design process, these feedback loops correspond to areas of the building containing the need for close co-ordination. The DSM tool can indicate the most important information estimates to be made, and the most effective way to reduce design iterations.

Following the DSM analysis, resources and durations are allocated to produce the optimal design programme. Once the initial scheduling of tasks is complete, further manipulation of the DSM is undertaken to move specific design activities to more suitable locations, taking into account the timing of information release required, say, to suit construction (e.g. early completion of the foundation design). A co-ordinated design plan is thus produced.



Analytical Design Planning Technique (ADePT)

Discussions with design planners and managers have highlighted a range of issues that have a bearing on the detailed building design process such as the scheduling of work into packages to meet a procurement strategy and construction programme. One of the aims of this research is to use the methodology to fully analyse the effect of scheduling the design process to satisfy procurement and construction. The methodology may thus reveal more appropriate work packaging that will better suit the entire design and construction process.

Current design planning practice takes little account of the interdisciplinary, iterative nature of the process (largely due to its inherent complexity). The result is that, combined with work packaging devised to suit construction, this leads to a severely compromised design process containing inevitable cycles of redesign with associated time and cost penalties. The ADePT methodology may offer an opportunity to design managers similar to that given to construction planners with the introduction of the critical path method, by providing a logical, structured approach to planning that takes full account of the design process's iterative nature (which CPM itself cannot do).

For further information, including details of the project report 'Development of the ADePT Methodology', please contact Dr Simon Austin, Department of Civil and Building Engineering, Loughborough University. (01509 222608; fax: 01509 223981; E-mail: s.a.austin@lboro.ac.uk).

EPSRC

MATERIALS

Recycled concrete aggregate results

The University of Dundee work on testing recycled concrete aggregate (see *Research Focus* No 32), is now complete.

Professor R K Dhir of the University intends to publish papers and arrange some seminars in May 1998 to present the final report and disseminate the output of this research.

For further information please contact Professor Dhir at Dundee University (01382 344347; fax 01382 344816, E-mail: r.k.dhir@dundee.ac.uk).

Re-assessing reservoir sedimentation

Researchers and engineers at HR Wallingford's Overseas Development Unit, supported by the UK's Department for International Development, have developed new software to help reservoir operators simulate and predict patterns of sedimentation. The software is known as RESSASS (REServoir Survey Analysis and Sedimentation Simulation).

Reservoirs play a vital part in water supply, irrigation and hydropower schemes. Reservoir capacity is declining by about 50km^3 a year worldwide, due to the deposition of sediment by incoming rivers. A project larger than the Three Gorges Dam would need to be completed each year to offset this storage loss. It is therefore important that engineers are able to predict likely siltation patterns so that they can adjust reservoir operating procedures to minimise impacts on irrigation, water and energy supply.

ODU's Phil Lawrence stresses that RESSASS can be applied by non-specialists. 'The software is user friendly and combines three functions in a single package – reservoir volume analysis, volume prediction and a simulation model'. The first function is carried out using the Stage Width Modification Method. 'The software processes data from pre- and post-empoundment surveys and calculates changes in reservoir volume caused by sedimentation. Users can also plot sediment distribution through a reservoir,' he explains. Depending on the amount of data available, RESSASS can then be used to carry out empirical volume prediction calculations based on methods developed by Borland and Miller (1958) or steered towards a more detailed numerical simulation of future events.

Much of the development effort behind RESSASS has concentrated on improving the way in which fine sediment is modelled within

reservoirs. Sediment settling velocities are heavily influenced by turbulence and this in turn depends on factors such as reservoir shape, bed friction and inflow rates. RESSASS includes routines to represent the effects of turbulence throughout a reservoir – provided that users can input data on water level variation, incoming sediment concentration and grain size. Ed Atkinson, who developed the program, explains: 'It is capable of predicting both the extent of sedimentation and its composition over time. The main benefit of the new software is that it brings together several capabilities within a single, user-friendly package and each is able to 'talk' to the others'.

REASASS has already been used to look at sediment distribution in Sri Lanka, Zimbabwe and India, and has proved particularly valuable during a study at Tarbela Dam on the River Indus in Pakistan. Since it was constructed in 1976, sediment build-up has reduced reservoir capacity by about 20%, and threatens to block the power intakes. During the study, RESSASS was calibrated using existing data, verified against observed sedimentation patterns at Tarbela and then run to simulate possible management options – including flushing, and reducing sediment inflows to the reservoir. Dr Rodney White, project manager for the Tarbela study, confirms the central key role that RESSASS played in the work.

Siltation poses a serious problem worldwide, with the potential to reduce the life expectancy of strategic infrastructure. RESSASS should prove to be a useful weapon in the war against reservoir sedimentation, helping engineers to plan management regimes more effectively.

For further information please contact Ed Atkinson at HR Wallingford Ltd (01491 835381; fax 01491 832233; E-mail E.Atkinson@hrwallingford.co.uk).

Safety of structures under dance-type loads

Practising engineers find it difficult to predict structural response to dynamic crowd loads and there is a general lack of understanding of these loads. Research at UMIST, sponsored by EPSRC and supported by BRE, has led to a better understanding of the loads and to methods of determining structural response to them.

Dance is movement with rhythmic steps and actions, usually to accompanying music. Similar movements include jumping, stamping and aerobics. The loads are thus related to the dance frequency, are periodical, and are termed *dance-type* loads. Maximum response occurs when jumping is involved.

The safety of structures subject to dance-type loads relates not only to the loads but also the structure itself. Using pre-or post-stressing techniques and high-strength materials, long-span structures can be built to accommodate static loads and thereby provide clear space and good viewing. This leads to structures which have relatively low natural frequencies and which are dynamically sensitive, such as cantilevered grandstands which are desirable for

Students testing floors at BRE Cardington

watching sports matches but are particularly vulnerable to dynamic loads.

One of the main aims of the project is to investigate the dynamic crowd effect when a crowd of people is involved, ie attenuation of loading due to the lack of synchronisation of the crowd. This is required to deal with practical situations and is important for the calibration of calculation methods with full-scale measurements. Large-scale, controlled experiments, with crowds of up to 64 students, were conducted at the BRE's Cardington steel test building in October 1997, and these tests produced a significant amount of useful information.

For further information please contact Dr Tiankian Ji at UMIST (0161 200 4604; fax: 0161 200 4646; E-mail: tji@umist.ac.uk; web page at: http://www.umist.ac.uk/UMIST_CIVENG/staff/ji/grants.htm).

EPSRC

Sealant movement in cladding and curtain walling

Oxford Brookes University's Joining Technology Research Centre has recently completed an EPSRC project in the Materials for Better Construction Programme. The rates and amplitudes of movements from actual building joints were translated to novel laboratory-based rigs, which were used to cycle a variety of sealed joint systems during the early stages of cure. The test procedure developed represents a rapid method of screening candidate sealant systems.

Structures and buildings comprise many component parts, giving rise to joints or 'gaps' between different materials and panels, and around openings. Modern construction methods based on curtain walling rely on obtaining an adequate seal between the joints – often in the form of a wet-applied gunnable sealant.

The cost of new sealing is only about 3% of the value of the curtain walling, but the cost of resealing is nearer 15%.The occurrence of wet-applied sealed joint failure can, in part, be attributed to the movements that occur in the external envelope. Such movements can be both large and rapid if it involves large lightweight cladding panels that are also heavily insulated.

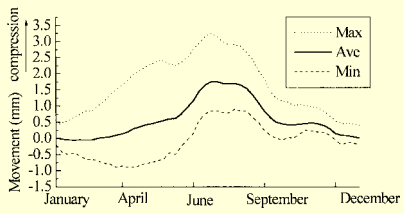
A detailed understanding of joint behaviour was developed from measurements taken on the predominantly south-facing aspects of two modern office blocks in London. One was concrete-clad, the other aluminium-clad. Detailed weather records for the period were collected so that joint movements could be related to panel surface temperatures, air temperatures, solar gain and precipitation.

Laboratory cyclic movement rigs were developed that could simulate the measured rates and amplitudes of real joint movements, imposed on experimental joints made with and without backer rod. Crucialto the simulation of reality was the ability to subject test joints to movement immediately after fabrication, since early movement during cure may be a very significant factor in contributing to premature sealed joint failure.

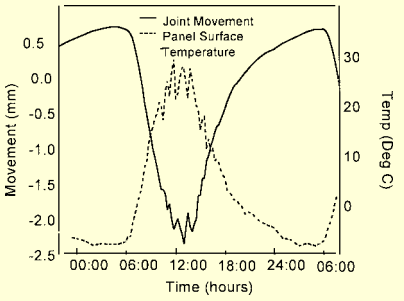
In general, the one-part sealant systems investigated were affected far more by movement during cure than the two-part products, particularly in test joints made with 'standard' polyethylene backer rod. The effect of movement was to actually increase the rate of cure of the one-part systems. However, the overall joint performance was reduced because of voiding and deformation of the sealant bead, as well as a loss of adhesion. Reductions in modulus and extension were broadly in proportion to the rates and magnitudes of imposed movement.

These results will feature in a RILEM publication on the Durability of Building Sealants to be published later this year. In the meantime, further work is being directed at developing movement monitoring techniques for buildings so that a larger database on real joint behaviour can be assembled. Future research will also address the critical role of backer rods in sealed joint performance.

For further information please contact Dr Allan Hutchinson, School of Engineering, Oxford Brookes University, Oxford OX3 0BP (01865 483504; fax: 01865 484179; E-mail: arhutchinson@brookes.ac.uk).



Annual pattern of joint movement for aluminium-clad building



Springtime temperature and movement for aluminium cladding

Improving design & performance of flexible composite pavements

The Highways Agency recently commissioned TRL to review the performance history of flexible composite pavements by tracing the construction, major maintenance and traffic history of nearly 650km of roads of this type.

Flexible composite pavements (20% of the UK trunk road network) are constructed with upper layers of asphalt over a cement-bound base. Both the asphalt and the cement-bound layers contribute to the structural strength of the road. The asphalt also insulates the cement-bound material from daily temperature cycles and limits the movement of transverse thermal shrinkage cracks that form in this layer as a result. Current Highways Agency designs for heavily-trafficked flexible composite pavements are based upon layer thicknesses and strengths which combine to be able to withstand both traffic and thermally-induced stresses. The oldest and most heavily trafficked of these pavements have carried about 100 million standard axles, sometimes with little or no major maintenance. While these pavements have been constructed to previous standards, a comparison with today's designs has validated the current design method.

Equipment for inducing cracks in a cement-bound base.

The cost of flexible composite pavements could be reduced by using thinner asphalt layers. However, where no preventative measures are employed, this could lead to large thermal movements in the shrinkage cracks in the cement-bound base such that cracks could then form in the asphalt, above those in the base, and lead to accelerated deterioration of the pavement.

Inducing thin, closely-spaced cracks in the cement-bound layer during construction can reduce this risk. The induced cracks accommodate thermal movement and limit the production of natural shrinkage cracks. This will reduce the risk of cracks developing in the asphalt without producing a significant reduction in the strength of the cement-bound layer.

Trials of pavements built with thinner asphalt layers and induced cracks in the cement-bound base are currently being monitored by TRL, for the Highways Agency.

For further information please contact Tony Parry, TRL (01344 770154; fax: 01344 770356; E-mail: Tonyp@h.trl.co.uk).

Addressing buildability problems of structural frames and cladding

Lack of understanding of, and hence allowance for, construction tolerances is a major source of conflict on site. This increases construction costs, can compromise integrity, performance or appearance, or can lead to building failures if corrective measures to allow fit are ill-conceived. There is also a lack of up-to-date information on the accuracy characteristic of typical construction processes, making specifying and designing for buildability more difficult.

The 3-year, DETR-funded project *Structural frame & cladding buildability assessment method* addresses the problems that occur with the fitting of cladding systems to building frames as a result of the level of accuracy to which structures are built and the tolerances specified. The partners in the project are Taywood Engineering Ltd (the lead researcher), CWCT, BRE and Building Envelopes Ltd.

Variability exists in all production processes due to the impossibility of machines, instruments and humans to make or measure with absolute precision. Variabilities must be controlled so that a cladding system will fit together on a structure as intended, and be fit for its purpose. In terms of appearance, this means panels, corners and features, particularly for reflective surfaces, should appear in line and plane and that joints are of a consistent width. British and industry standards state the variability allowed in cladding components, and in the construction and erection of most cladding systems such as masonry, profiled metal, composite, concrete and stone cladding, and curtain walling.

Initial research indicates that the incidence of cladding buildability problems varies between cladding contractors and depends on the inherent and designed adjustability of the cladding type and the process by which frame and opening tolerances are addressed at the design stage. For example, is a British Standard merely specified, without due consideration of the tolerances, or are tolerances discussed and agreed, based on the frame type and the requirements and adjustability of the cladding type?

The variability allowed by British Standards in a brickwork window opening can result in unsightly or unsealable joints at the interface. Best practice is to agree more moderate tolerances, which are marked on drawings and adhered to on site. However, one contractor estimated that 50 per cent of structures and/or openings failed to comply with the specified accuracy. Cast-in connections, out-of-position or omitted, cause more problems than the frame being out-of-tolerance. Moreover, cladding units frequently need to be re-positioned or cut to allow window installation within the formed opening because of inadequate allowance for the combined tolerances at the interface.

Common design and construction process deficiencies that affect buildability have been identified, and four examples follow.

- Building elements may be poorly co-ordinated due to inadequate communication between the architect and engineer, the late involvement of the cladding contractor and/or insufficient time generally to address buildability problems.
- The benefits of optimising edge beams of structural frames to suit the span and load conditions of each bay in order to save material are often out-weighed by the consequences of the variable and complicated cladding fixings which may be required as a result. The consequences include increased cost, delays in release of information to the cladding contractor and increased risk of clashes between elements. The edge detail of the structural frame to which the cladding will be attached should be standardised.
- Surveys of the structure commonly do not agree because of variabilities in equipment and operators, and inherent deviations in the frame, although (the little used) BS 5964 *Building Setting Out and Measurement* could help to reduce discrepancies.
- Lack of accountability can mean trades are asked to check and overcome problems arising from the work of previous contractors.

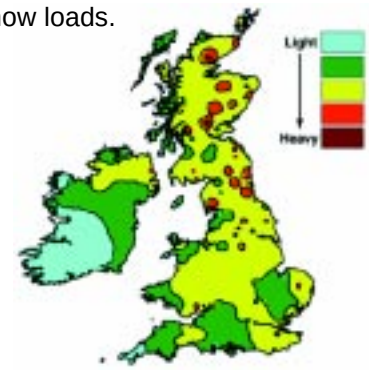
The aims of this project are to gather sufficient, reliable and up-to-date data on accuracy actually achieved in construction as well as to prepare guidance on good design and good practice in agreeing, allowing for and achieving the required accuracy. Companies who have survey data recording accuracy of construction are invited to contact Taywood Engineering. The information will be used to develop a buildability assessment method to assist all parties in the design, specification and erection of building and cladding systems and in overcoming the problems of lack of fit.

For further information please contact Jeremy Layzell at the Centre for Window and Cladding Technology (01225 826541; Fax: 01225 826556; E-mail: cwct@bath.ac.uk), or Martin Wilson at Taywood Engineering (0181-575 4826; Fax: 0181-575 4547; E-mail: martin.wilson@taywood.co.uk).

CENTRE FOR WINDOW AND CLADDING TECHNOLOGY

Snow load maps

Work is under way in BRE's Centre for Structural Performance on the development of a European map of snow loads.



The study forms the first phase of a large programme of prenormative research on the definition of snow loads appropriate for the design of structures. Funded by the EC, the research supports the development of the Eurocode on Actions on Structures. Due to the timescales involved, it was not possible to produce a unified European snow load map for the Development Draft of the Eurocode. The Prestandard available for trial use has therefore had to adopt national snow load information as an interim measure.

Such information is not in a common format and significant differences result from application of these national procedures. A unified European snow load map based on a consistent analysis of meteorological records is therefore required so that design snow loads can reflect geographic and climatic considerations not national boundaries.

BRE has joined with seven scientific institutions with appropriate expertise to carry out this work: project co-ordinator University of Pisa (Italy), CSTB (France), Ecole Polytechnique Federale de Laussane (Switzerland), ISMES (Italy), JRC (CEC), SINTEF (Norway) and the University of Leipzig (Germany). Contacts with the national meteorological services have also been established.

A geographical information system is being used to generate the snow load map, based on the results of the analysis of meteorological data. The map (see figure), which will be used to determine characteristic snow loads to be considered in the design of roofs throughout Europe, will be submitted to the Project team developing the Eurocode on Actions on Structures.

Future phases of the project will investigate the specification and treatment of serviceability snow loads in design and include a study on the snow load distributions on roofs of different geometries.

For more information please contact at BRE: PaulSims(01923 664626, E-mail: simsp@bre.co.uk) or Diana Currie (01923 664537; E-mail: curriedm@ bre.co.uk).

BRE

Re-engineering building procurement

In the fast moving world of the 1990s, every industry is subject to pressures of satisfying increased customer expectation from products whilst remaining viable financially. Increased 'responsiveness' to customer demand – 'agility' in manufacturing parlance – has become one of the most critical factors at the point of sale, more so than cost according to many. This is equally true for the construction industry where, in the climate of 'post-Latham' research, great effort is dedicated to the improvement of management processes and techniques in order to achieve the performance levels envisaged in that watershed '*Constructing the Team*' report.

Commonly, as with other industries, the overwhelming imperatives for construction become satisfying or exceeding client expectations of quality, cost and time. The current best practice approach to tackling this has been to maximise client input at the design phase, so that all the client 'wants' are translated into process criteria at the outset. Paradoxically, however, clients are often not sufficiently experienced in procuring construction to articulate their requirements efficiently during 'up front' design. Frequently, clients simply do not know what they want from a project beyond such intangibles as 'high quality' and 'prestigious'.

Clients of the 1990s are faced with a range of contractors that try to please, but can only be employed efficiently given a level of knowledge of projects most clients do not possess. Probably the most difficult problem that clients must face is the selection of the procurement system to use during the project – all of which have been shown to have both potential benefits and pitfalls for those unfamiliar with the workings of the sector.

From the four main systems used, traditional open tendering is currently in decline, and Design and Build is becoming much more popular. However, studies have also shown that the procurement system selected by clients does not tend to follow any logical process. The system, when selected, is very often inappropriate to the requirements that the client has of the project. The relative merits of procurement systems have been the subject of much debate and numerous reports, including Emmerson (1962), Banwell (1964), various reports from NEDO (1974, 1983, 1988) and, notably, Latham (1994).

Professor Dave Langford and Professor Cliff Hardcastle (Strathclyde University and Glasgow Caledonian University respectively) have recently teamed up to look at this problem. Funded by the EPSRC[1], work is in progress at both institutions seeking to identify client requirements of projects, procurement routes used, project success and organisational structures adopted. The aim is to provide clients with a 'one-stop' guide to effective procurement choice in construction. Further additions to the team include a number of high profile industrial collaborators whose experience will inform and influence the research plus researchers with construction and aerospace supply chain experience.

The research seeks to develop a 'route map' drawn from the varied experience of the participants allied to a rigorous research method. It is intended that clients be able to identify their project according to defined requirements, from which they will be able to select both a procurement route and an organisational structure that is most likely to deliver project success.

High quality, low cost or rapid acquisition: are clients selecting optimum procurement methods?

Commented Professor Hardcastle: 'It's early days on the project yet. However, the background of the team members drawn from two universities and the quality of industrial partners we have attracted leads me to think that this project will be of great use to a large number of less experienced or occasional clients of the construction industry – and ultimately for the industry as a whole'.

For further information please contact John Tookey at Glasgow Caledonian University (0141 331 3659; fax: 0141331 3696; E-mail: J.E.Tookey@gcal.ac.uk).

EPSRC

The future of national building research organisations

A recent special issue of the journal *Building Research and Information (BRI)* has reviewed the pressures on construction research & technology organisations in the light of privatisations and commercialisations around the world.

Of interest to customers of research organisations as well as their leaders, the issue raises such fundamental questions as 'should governments find construction research?' and the impact of privatisations and commercialisations on the research community.

Although BRI is normally available only on subscription, this issue is available for £35 on a one-off basis.

For further information contact the Editor, Richard Lorch, 43 St.George's Avenue, London N7 0AJ (Phone & Fax: 0171-609 4311). Internet access to BRI is at http://bri.thomsonprofessional.com.

Putting the elderly and disabled back in control of windows and doors

A guide for specifiers of automatic controls for windows and doors for use by elderly and disabled people has been produced as part of project undertaken by BRE. The work (previously reported in *Research Focus Issue 29*, May 1997) has been funded by the Department of the Environment, Transport and the Regions Partners in Technology programme and by industrial partners.

The guide, *Domestic automatic doors and windows for use by elderly and disabled people:*

- emphasises the importance of having controls that meet the individual needs of users;
- provides specifiers with information on a range of windows and/or doors that will give sufficient choice of automatic control systems, and doors and windows to satisfy the varying needs of those individuals using them;
- advises on achieving the necessary dialogue between specifiers, manufacturers, suppliers and clients (both landlord and resident) to fully meet the needs of the disabled or elderly person;
- describes the tailoring of window or door control systems to the needs of the individual person – there is no system that provides a universal solution – and advises on adapting controls to the requirements of new residents;
- emphasises the importance of preventing control systems from making the windows and doors look different or institutional;
- gives guidance on avoiding compromise on performance, particularly safety and security, but also weathertightness, and thermal and acoustic performance.

Field testing is continuing and will provide long-term feedback on the usefulness of the controls to users, as well as data on costs, durability and the maintenance requirements.

Three field trial sites have been set up with the assistance of control manufacturers and housing associations.

1 Anchor Housing Trust at Cramlington – three sets of window controls installed by Velux in January 1997 in flats occupied by frail elderly people.

2 Habinteg Housing Association at Middlesborough – one set of window controls installed by GEZE in January 1998 in a flat occupied by wheelchair users.

3 Hanover Housing Association at Longbenton – two sets of window controls and one door control were installed by Titon (windows) and by NT Dor-o-Matic (door), both in January 1998.

(Left) *A metal and glass swing door used in laboratory tests: outward opening, with side panel, fully automated with electric lock, push plate internally and externally a coded key pad, closes automatically after a delay period, this was a commercial type door but could be used at the entrance to a communal block.*
(Right) *Roof window system used in laboratory tests: top and horizontal pivot, chain operator works in top hung outward opening mode, remote control or key pad activators, linked insystem to timber.*

The flats in the first trial have timber double-glazed top hung windows retrofitted with chain box operators. These can be operated by individual keypads or a remote control device. The windows function individually from the keypads, but can work either as a system or individually from the remote control which has different channels for each operator. All of the residents are elderly ladies with varying degrees of disability from poor eyesight to mobility problems – none could previously open their windows.

BRE's initial visit to the flats took place less than a week after the installation of the window controls. The residents were pleased with the window operators and their rediscovered ability to open and close the windows whenever they wanted. Subsequent visits over a course of the year have indicated a similar high level of satisfaction. No problems were reported in using the remote control or the key pads. The windows were no more prone to weather penetration or loss of heat than before fitting the automatic controls.

The only problem was that the residents had forgotten the full range of options available and had to be reminded about them as necessary.

The first visit to the Middlesborough site found that the residents were satisfied with their window controls. A scissor stay operator has been installed and is activated via a wall mounted switch – the system is very simple to use. The Longbenton site is a new build scheme and the residents only moved in as recently as February 1998.

Domestic automatic doors and windows for use by elderly and disabled people (ref BR334) is available from CRC Ltd,151 Rosebery Avenue, London EC1R 4QX.

For further information on the research project please contact Dr Stephen Garvin at BRE Scottish Laboratory (01355 233001, fax: 01355 241895, E-mail garvins@bre.co.uk).

Light steel framing in residential housing

Research is being carried out at the University of the West of England, Oxford Brookes University, the Steel Construction Institute and British Steel research centres involving the integration of the whole supply chain in housing and similar low rise construction with greater potential for the use of standardised products in design, production and erection.

The research team is responding to government targets which demand a reduction in costs and improvements in quality as well as addressing issues of standardisation in construction in the residential building sector. The importance lies in the nature of Light Steel Framing (LSF), coming from an industrialised manufacturing sector which is used to providing standardised components and has traditionally been proactive in the supply chain.

The current collaborative research work is already producing flow charts, process development and some standards and procedures. Initial modelling indicates the potential to build up to 50% more houses with the same cash flow. Research has shown that by using LSF in housing, a 50 house development, which could have been expected to take 18 months, can be built in 13 months without increasing site resources.

A cost model has been developed in partnership with a quantity surveying firm who have good data on the performance of light steel framing and conventional blockwork. The table shows how the cost model can be used for a typical detached house in a major housing project.

The University of the West of England, in partnership with the SCI and British Steel, has recently made an application for funding through the IMI Link programme to further the work by developing a system model for LSF.

The development of a systems model of procedures and actions is expected to lead to greater use of LSF in housing and low rise buildings of light steel construction in the UK. The potential growth of light steel construction in the UK and elsewhere in Europe could mirror its dramatic increase in the US and Australia where the market share for steel is close to 15%.

In the UK, Ayrshire Metal, Metsec, Speedframe and Surebuild (a trademark of British Steel Framing) are the key players, building over 200 houses between them last year.

A Light Steel Framing Residential Housing Group has been set up as part of the Light Steel Framing (LSF) Group. It will provide general support to the users of LSF in housing development and will address the production of standards and procedures, technical support and marketing, as well as creating a financial and value engineering model for residential housing.

There are further benefits of LSF which can be quantified as part of a value assessment, but are often not obvious to potential users.

- One of the oldest steel-framed houses in USA, built in 1928, is still not showing any signs of degradation.
- Steel does not warp or shrink and is of consistent quality.
- Many people spend eight hours a day in what is considered a superior structure, their office, which is predominately made of steel.
- 45% of all material needed in steel construction worldwide is already available through recycled scrap. All redundant steel is recyclable and steel is the most recycled material in the world. It can also be re-used at the end of a building's life.
- Galvanised steel is durable and is, in effect, permanent in internal applications.
- LSF can be extended easily and adapted to meet future requirements.
- LSF buildings are dimensionally accurate.
- Light steel frames, because of their dimensional accuracy, can help promote standardisation and prefabrication of secondary fittings.

The technical aspects of light steel framing are covered by a series of SCI publications for Architects, Structural Engineers and Developers.

For further information contact Alan Lewis Rogan at the University of the West of England (0117 9656261 ext. 3372: E-mail: al-rogan@UWE.ac.uk or Dr Mark Lawson at SCI (O1344 623345; fax: 01344 622944; E-mail: mlawson@steel-sci.com).

Element of the work	Blockwork	Light Steel Frame	Difference
	£ p	£ p	£ p
Prelims	2905.00	2098.00	807.00 less
Foundations	5110.40	5228.37	117.97 extra
External Walls	9217.20	9231.40	14.20 extra
Upper floors	1006.00	1000.00	6.00 less
Roof-windows	4281.60	4245.20	36.40 less
Stairs	530.00	545.00	15.00 extra
Window & External Doors	1240.00	1257.00	17.00 extra
Internal Walls & Doors	1927.00	2017.50	90.50 extra
Finishes	4900.45	4582.85	317.60 less
Ceiling Finishes	1593.50	1768.40	174.90 extra
Fittings	6116.00	6126.00	10.00 extra
Services	2720.00	2650.00	70.00 less
Heat/Vent	1130.00	1230.00	100.00 extra
Summary	**£42677.15**	**£41979.72**	**£697.43 less**

Saving on Construction Time	5 months shorter	35.71% faster
Earlier Sales Start	2 months earlier	33.33% sooner
Increased Profitability	£ 30,979 more profit	4.76% higher
Peak Cash required	£17,716 less	1.17% lower
Average cash requirement	£59,716 less	9.22%
Internal rate of return	47.36% Higher	

Cost model used to compare light steel framing and conventional blockwork for a typical detached house. Source: Poole Stokes Wood & University of the West of England.

Waste minimisation through increased re-use & recycling

There is increasing pressure to minimise waste, resulting from environmental, legislative and fiscal measures. The construction industry has a clear need to develop a greater awareness of the current and potential uses for reclaimed and recycled materials. The industry needs authoritative information on this topic.

Although some materials, such as crushed concrete, have been recycled for many years, this has generally been for low-grade uses, for example in access roads. There is a significant potential for reclaiming and recycling materials for higher grade uses. This will reduce the demand for primary, non-renewable resources and the amount of Landfill Tax that has to be paid by contractors and others.

In July 1997, CIRIA commenced a project focusing on the use of reclaimed and recycled materials in construction, sponsored by DETR, other government agencies and industry. A related project, Waste Minimisation and Recycling in Construction (which has recently been completed) identified several barriers to reuse and recycling.

The aims of the current project are to increase awareness of the opportunities that exist for using reclaimed and recycled materials, and to provide good practice guidance on how to use such materials, particularly in higher grade uses.

The work, being undertaken by a consortium led by Scott Wilson, includes collecting and consolidating data through a literature review, consultation with clients, designers, specifiers, material manufacturers and others involved in waste minimisation and recycling. They are also holding four project Workshops to gather the views of the industry on the development of the project. Scott Wilson's work is being carried out in close collaboration with the Aggregates Advisory Service who are providing an information service on the efficient use of aggregates.

BRE's new Environment Building contains much re-used and recycled material.

The main output from the project will be a handbook that will include:

- an introduction addressing 'Why bother using reclaimed or recycled materials?';
- a discussion of the barriers that designers and specifiers may face in using reclaimed or recycled materials, and how to overcome them;
- coverage of the building and civil engineering applications in which reclaimed or recycled materials may be used;
- for each of the materials identified, information on properties and performance, sources and availability, current applications, case studies, relevant specifications, constraints and potential future uses.

The structure and presentation will enable a reader who is involved in designing a particular building or facility to obtain information on which reclaimed and recycled materials they can use. Alternatively, a reader that has a particular material that they would like to use will be able to identify what options there are for using that material in a construction application.

The handbook is due to be completed in August 1998.

For further information please contact Ann Alderson, Research Manager at CIRIA (0171 222 8891; fax: 0171 222 1708; E-mail: ann.alderson@ciria.org.uk).

CIRIA

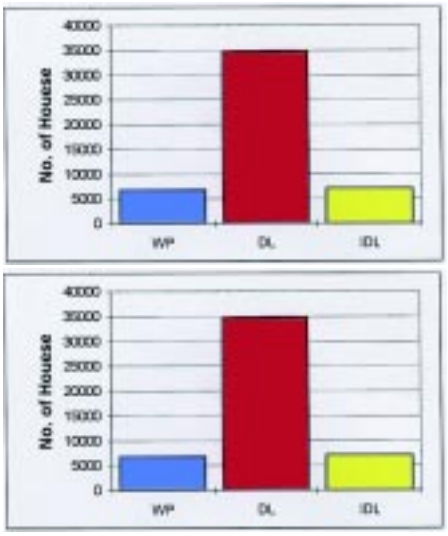
Responding to changes in thermal insulation standards

Following the July 1995 amendments to the Building Regulations, CERAM Building Technology (CBT) (supported by DETR and a range of industrial sponsors) sought to identify current trends in external wall constructions within the housebuilding market.

Changes to Part L of the Building Regulations are leading to an ever increasing thickness of thermal insulation in external walls. Past experience has shown that using the cavity as a convenient insulation space often causes rain penetration. This project aims to determine and encourage the use of wall forms which drastically reduce this risk and also:

- retain the designer's flexibility of choice of structural form;
- ensure wall thicknesses are economic;
- enable improved levels of thermal insulation to be achieved;
- are practical, buildable and tolerant of site skill levels;
- use readily available local resources;
- are acceptable to house-purchasers and insurers;
- show genuine benefits on life-cycle costs, energy usage and CO_2 emissions.

A survey of internal finishes to walls, pre- and post-July 1995, indicates the changing trends in wall insulation techniques (see charts). A threefold increase in the use of insulated dry lining (IDL) at the expense of wet plastering (WP) and dry lining (DL) is evident, reflecting the apparent concern of house builders to maintain a clear cavity wherever possible. The result has been thicker walls with wider cavities and increased thicknesses of partial fill.



Long-term pressures to reduce CO_2 levels will maintain the impetus for increasing insulation standards. Construction methods and insulation systems will be affected as a consequence. CBT are developing standard details for a range of wall forms to meet current and projected requirements. Laboratory testing is aimed at identifying the most critical features of poor workmanship which cause walls to leak.

For further information please contact Geoff Edgell at CERAM Building Technology, Queens Road, Penkhull, Stoke-on-Trent, ST4 7LQ (01782 746 476; fax: 01782-412-331).

DETR Environment Transport Regions

Building equality in construction

Virtually every sector of the construction industry has a poor image in terms of providing equal opportunities. Even at a professional level, women are seriously under-represented. A research team based at the University of Manchester Institute of Science and Technology (UMIST) has been developing a management tool for supporting equality in construction.

There is no question that the construction industry has remained largely a male preserve. Figures from the Construction Industry Board show that, in 1995, women comprised less than 10% of the 1.8 million employees in the industry. Whilst it may be argued that most young women simply have little interest in choosing a career in construction, the image of the industry and negative attitudes of employees are perhaps the prime factors behind their lack of enthusiasm in the first place.

Previous research has shown that women who do pursue a career in construction encounter a series of barriers to full participation. Whatever the truth of the matter, the effective exclusion of some 50% of the workforce represents a major source of untapped talent and prevents the industry from performing to its full potential.

The Latham Report and subsequent Working Group No.8 (Equal Opportunities) Report 'Tomorrow's Team: Women and Men in Construction' called for practical action in promoting and mainstreaming equality of opportunity in the construction industry. A project undertaken by UMIST, and funded by DETR under Partners in Technology, aims to develop effective and measurable procedures for promoting and maintaining equal opportunities in the construction industry.

The main objectives of the project are:

- to investigate and develop the optimum methodology for partnering between construction industry clients, in the form of Housing Associations, and their contractors;
- to develop effective and measurable procedures for promoting and maintaining equal opportunities policies in the construction industry;
- to develop, publish and disseminate good practice guidelines;
- to develop a transferable model for action-research-based intervention.

The research has gathered data on barriers to women entering and working in construction. It has also pointed to practical steps that building contractors can take to ensure equality and the role Housing Associations can play in promoting good practice. Focus groups were an important factor in the successful evolution of the action-research methodology. Feedback from participants resulted in the groups being used to disseminate findings from previous project activities.

A process of action research has been one of the project's hallmarks; this has prompted representatives from several agencies to discuss training and equal

opportunities issues with the research team. Moreover, several contractors have used the project as a source of information and practical help in aiding recruitment and forming links with education. The research team has, as a result, identified a number of contractors genuinely committed to equal opportunities who might act as role models for the construction industry.

The project has developed a network with significant contacts across the construction industry, Housing Associations, academia and other players in a position to help with building equality in construction.

An industry forum is planned for 6th May 1998 at which Construction Minister Nick Raynsford aims to launch the Good Practice Guidelines produced following the research. Raynsford quickly noticed the industry's gender imbalance on taking office and has placed equality of opportunity firmly on his agenda.

The project recommendations are likely to suggest a number of pilot initiatives involving partnerships between Housing Associations and contractors. Proposals for continued dialogue between interested parties through a permanent industry forum will also be set out in detail.

The report's authors are A W Gale, M Davidson, C Davey, A Hopley and S Rhys Jones.

For further details please contact Dr Andrew Gale, Department Building Engineering, UMIST (0161 200 4236; E-Mail: Andrew.Gale@umist.ac.uk) or Dr M Davidson, School of Management, UMIST (0161 200 3449; E-Mail: (Marilyn.Davidson@umist.ac.uk).

DETR
Environment Transport Regions

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Centre for Window and Cladding Technology,
University of Bath, Claverton Down, Bath, BA2 7AY (01225 826541, fax 01225 826556)

Construction Industry Research and Information Association,
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Englemere, King's Ride, Ascot, Berkshire, SL5 8BJ, (01344 630700, fax 01344 630777)

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