Research Focus

Issue No. 31 NOVEMBER 1997

PROMOTING THE APPLICATION OF RESEARCH IN BUILDING AND CIVIL ENGINEERING

IN THIS ISSUE

New DETR Research Priorities

The Department of the Environment, Transport and the Regions (DETR) has revised priorities for its annual £23m construction research programme. The result is the Construction Research and Innovation Business Plan, supported by five individual plans which reflect each business area within the programme.

Construction Minister Nick Raynsford announced the revamped programme at a meeting of industry representatives at the Institution of Civil Engineers. Mr Raynsford said 'I emphasised the importance I attach to research and innovation when I spoke to the Construction Industry Board. I reiterate that I want to see an industry which is competitive at home and abroad, gives proper training and places value on its workforce, has a strong quality ethos, builds safely and sustainably, is looking to innovate and is receptive to change'.

The Minister announced the publication of five DETR business plans for construction research. Research Focus Issue 28 (February '97) reported on the development of the business plans and these have now been finalised following wide consultation with the industry. The five plans, which divide funding into priority and secondary research objectives, are shown below.

Mr Raynsford emphasised that decisions on research funding would be strongly influenced by the priorities identified in the business plans but confirmed that genuinely innovative proposals which could not be aligned to any of the plans' priorities would not be ruled out.

A new initiative to promote the application of research was also announced. Mr Raynsford said, 'There is no point in doing research unless it is likely to be of practical value. Yet, one of the most resonant criticisms I hear of the industry is that it fails to make best use of the substantial fund of research outputs, technical advice and best practice which already exists. I propose to take steps to address this issue by developing a best practice programme'. DETR and the Construction Industry Board have begun discussions to develop proposals in detail.

For further information and copies of the business plans please contact Robert Crangle at DETR's Construction Sponsorship Directorate (0171-890-5704; fax: 0171-890-5759; E-mail rcrangle@detr-cirm.demon.co.uk).

THE FIVE PLANS

- **Environment**: promoting sustainable development and improvements in the environmental performance of buildings

- **Safety and Health in Buildings**: supporting the Building Regulations for safety, health and security, including the suitability of buildings for disabled people

- **Technology & Performance**: including the interaction of materials, components and systems, new technologies and techniques to improve product performance

- **Construction Process**: to bring about greater efficiency through improvements in quality, productivity, value to clients and/or users, and management of the process

- **Motivation**: promoting a culture of change by encouraging a climate of innovation and exploitation of new ideas.

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, or if you would like additional copies for circulation within your organisation, 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_l@ice.org.uk).

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Intelligent labelling of construction components

Bar coding is now commonplace in retailing and manufacture. In its most simple form, the bar code provides a code which is used as a means of accessing a record in a computer database. However, within the construction process, access to such a data source is frequently not practical. One possible solution to this problem would be to build *intelligence* into the label itself, requiring the ability to store much more information than has previously been the case.

Research is currently being undertaken by the University of Reading and Taylor Woodrow to determine the feasibility of using 2D bar coding for storing and transmitting information relating to building components throughout their various life cycle stages, including manufacture, distribution, construction and operation. This technology allows up to 2,500 characters of information to be stored within a single label, acting as a *portable* database.

The research team is considering a variety of components and processes. However, the results of an initial pilot study have already demonstrated advantages of using intelligent labels during building maintenance. 2D bar codes could be originated during the manufacture of plant and other building components, detailing the specification, and operation and maintenance requirements. Following installation, the label would be scanned to determine information to be transferred to the asset register.

During each maintenance operation, the label would be scanned to ensure the identity of the item. Finally, the label would be updated with a portable printer to provide a completely localised maintenance history database. Such a system has three key advantages.

- **Increased value to the client** is providing by enabling direct access to information in the field. The majority of major clients audit maintenance periodically by visual inspection. Intelligent labels would allow direct access to information without recourse to a central database or paper records.
- **Significant cost savings** could arise by automating the generation (and maintenance) of the asset register, given the ability of the client to stipulate the labelling of items during manufacture. Common problems associated with gathering this information manually are the high cost and frequency of inaccurate and incomplete data.
- **Instant access to information.** During both planned and unplanned maintenance, engineers periodically require access to O&M manuals in order to carry out a variety of procedures. Although these are usually comprehensive at hand over, information is frequently lost or not updated. The ability to gain instant access to such information in the field could yield significant advantages.

Figure 1 – Steel member intelligent label.

Member	P1
Location	Roof Purlin – Ozone Generator Building
Length	8409
Size	p145/155
number	14
TWCE drawing no.	A13452
K&B drawing no.	5687A/10, 5687A/2
Source	Wards
Certificate no.	34983
Welding certificate no.	234r3
Delivery date	28/10/97
Grade	BS1763

The ability to capture and update large quantities of information could lead to many more applications for intelligent labelling within the construction process. Materials and components could be labelled with component ID references, COSHH (Control of Substances Hazardous to Health) information, works test data, and other physical and performance data. Figure 1 shows an example of a label used to transfer traceability information between manufacturer and contractor relating to prefabricated steel members. The research team will recommend standard label formats for a variety of components including structural steelwork, architectural details and M&E services, as well as providing guidance for organisations wishing to implement intelligent labelling.

An evaluation of the potential of bar coding is given in *Enabling Technologies: a Primer on Bar Coding for Construction* by Laurence Marsh et al, published by The Chartered Institute of Building (ISBN 1 85380 081 3).

For further information please contact Laurence Marsh at The University of Reading (0118 931 8201; E-mail: kcsmarla@reading.ac.uk; World Wide Web address: http://www.rdg.ac.uk/~kcsmarla/).

Focus on flooding – RIBAMOD

Floods in several European states have highlighted the need for broadly-based research into river flood management and prompted the EC Directorate General of Research and Development (DG XII) to convene an expert workshop on the subject in May 1995. A Concerted Action known as RIBAMOD (River Basin Modelling, Management and Flood Mitigation) emerged as a result. The UK's Environment Agency is also supporting RIBAMOD as part of its commitment to international policy development within its areas of expertise.

Dr Paul Samuels of HR Wallingford is coordinator for the Concerted Action. 'RIBAMOD aims to take an overview of current EC flood research projects, highlighting further research needs,' he explains. 'It will also examine difficulties arising from past management methods and identify best practice.' Partners include the Danish Hydraulics Institute, Delft Hydraulics, Potsdam Institute of Climate Impact Research, the National Technical University of Athens and the University of Padua. Researchers and river managers involved in the Concerted Action will benefit by sharing experiences, problems and new data. So far, the RIBAMOD partners have organised an Expert Meeting at the Danish Hydraulics Institute and a Workshop at Delft Hydraulics in the Netherlands.

The Expert Meeting involved more than 20 specialists and covered subjects such as risk assessment, standards, scaling, and the links between meteorological and hydrological models. A major discussion area was that of integrated modelling. 'Models already exist to help assess and manage flood risk but, for greater benefit, they should be linked,' says Dr Samuels. 'We need open systems that can accommodate different software packages.' Flood defence planning should also take environmental change into account, since timescales for planning can extend over 20–50 years.

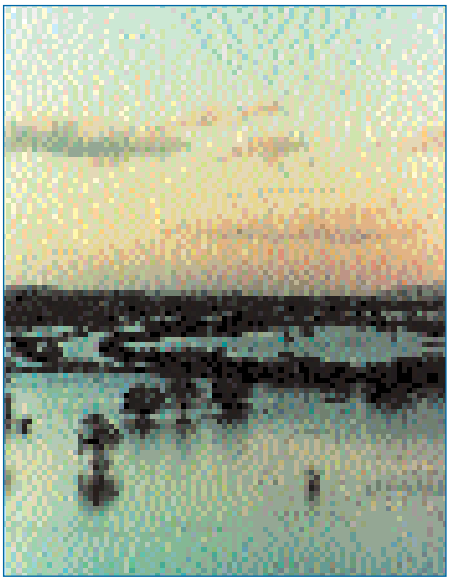
The Workshop attracted over 80 delegates – including river managers, engineers, hydrologists and researchers. It included sessions on recent flood events, risk, coping with future floods, operational management and integrated flood protection, as well as a summary of current EC research projects on flood hazard.

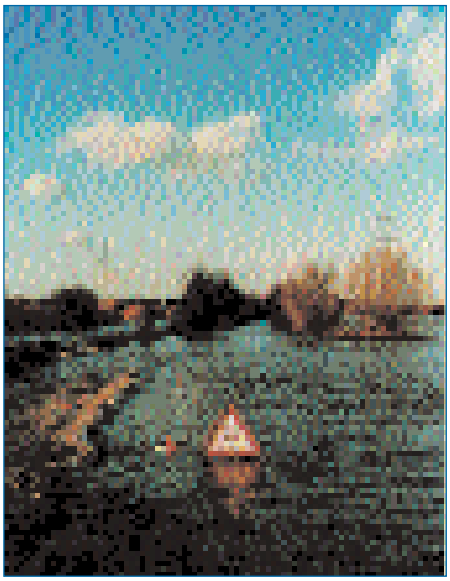
As a result of its activity so far, RIBAMOD has crystallised four main areas for future research: policy, procedure, operation and scientific issues. 'Operational management of flooding could be improved, for example, if real-time information were available on meteorological conditions within a catchment along with its hydrological response,' explains Dr Samuels.

Further Workshops and Expert Meetings are planned for the rest of 1997 and into 1998. 'We aim to promote information transfer between research groups and develop best practice,' says Samuels. In the longer term this approach should help to improve flood defence planning and management Europe-wide.

For further information please contact Dr Paul Samuels at HR Wallingford Ltd (01491 835381; fax: 01491 825916; E-mail: pgs@hrwallingford.co.uk). You can visit the RIBAMOD web site on: http://www.hrwallingford.co.uk/RIBAMOD/ribamod1.htm.

River flooding can cause major disruption. RIBAMOD links researchers and specialists across Europe to share experience and information.





Simulating innovation using multi-media

To promote an organisation culture more favourable to innovation, a better understanding of the innovation process is required. An educational tool is currently being built to simulate the management of innovation which is based on four case studies within the UK construction industry.

The collaborative research programme aims to design and construct a simulator that will replicate the management of change and the function of interactions within an organisation. It will illustrate the differences and similarities in organisations specialising in different product markets, enabling the end-user to learn in real time.

It is intended that the simulator will capture the innovation process and the evolution of risks and their assessment, and the necessary conditions which are vital within an innovative culture will also be explored. Team dynamics and the re-formation of different functions will be an integral component, along with decision-making under uncertainty.

Data is currently being collected and analysed from interviews with employees from the four industrial case studies, each providing a unique set of perspectives of the innovation process. These are:

- the Royal Opera House, a live project using information technology and concepts of integration and teamwork (BDP);
- National Westminster Bank, Broadgate, using novel solutions for access systems (Technitube Ltd);
- a high-tech powder products plant, involving organisational design and management of change (Sbd Ltd);
- innovation in social housing using new concepts and techniques for the mass market (Roger Bullivant Ltd).

The prototype simulator will be tested independently on a number of organisations and will subsequently be refined before being launched as a formal multi-media, educational tool. It will be aimed at companies who wish to heighten or improve their managers' awareness of the innovation process.

For further information please contact at BRE – Dr Barbara Young, Director of Innovation (01923 664251; E-mail: youngba@bre.co.uk), or Dr Charles Egbu, Senior Research Fellow (01923 664267; E-mail: egbuc@bre.co.uk; fax for both: 01923 664089).

Blast loading on cladding fixing assemblies

There is an urgent need to protect people from debris, both within and outside a building, that has been subjected to explosive blast pressure, and also to avoid potentially damaging loads upon the building structure. Blast resistance of external cladding and fixing assemblies is critical but there is insufficient data on the resistance of fixings and supports. Work carried out at Sheffield University in collaboration with Teeside University and Messrs. Sandberg, a member of the Centre for Window and Cladding Technology, and funded by EPSRC, has shown that it is not sufficient to study the fixing element alone, but that the interaction between the panel and fixing response requires a study of the integrated assembly.

A fixing was idealised into three constituents: the cladding panel connection, the fixing element itself and the main structure connection. The failure of a fixing assembly can occur at any of these three locations and involve local failure of the cladding panel or of the main structure.

The pilot study undertaken so far has concentrated on methods for determining the blast loads on cladding panels, the transfer mechanisms of this load to the fixings (using a dynamic finite element analysis computer program), and the determination of the magnitude of loads in the fixings.

Finite element analyses were carried out to show how blast loading on reinforced concrete cladding panels, rigidly supported by idealised steel rod fixings at each corner, was transferred to the fixings and how interaction between different forms of cladding panel and the fixings influences the transfer of blast loading.

It was seen that the largest bending moments in the panel, when the blast pressure first hit, occurred at the corners of the panel around the supports and, at the same time, the axial force in the fixing increases rapidly to a peak. If yielding occurs in the panel around the fixing, then the bending moment remains constant and the axial force in the fixing decreases as moments increase in the centre of the panel. As the deformation of the panel increases, bending moment and shear increase in the fixings. Ultimate failure of the cladding panel-fixing assembly is then interactive and depends upon the resistance and relative stiffness of the fixing and the cladding panel. It was also demonstrated that the flexural stiffness of fixings has a major effect on the deflection of the cladding panel.

A small number of impact experiments were carried out to validate the theoretical predictions of the dynamic forces in cladding panel fixing assemblies. To carry out as many tests as possible with the minimum number of specimens, the whole system was limited to elastic response. Used as an alternative to blast tests, the impact tests involved a drop hammer impacting a pressure bar in contact with a steel plate, representing a cladding panel, which was supported on four rods giving out-of-plane restraint.

Wooden blocks were placed on top of the pressure bar to produce a soft impact with a pressure-time history as close as possible to that of an explosive blast load and the results were compared with those from a numerical analysis.

With the pressure distributed uniformly over an area equal to that of the pressure bar and varied according to a half sine curve, the peak load and duration are similar to that measured in the impact test. The test results had a quite significant variation in the forces transferred to each fixing, so the total force and total bending moment transferred to all fixings was compared to the predicted results from the finite element analysis.

The axial force prediction agreed very well with the measured results but the bending moment predicted is higher than the test results. This is thought to be due to the difficulties in modelling the restraint conditions of the test.

Further analysis and experiment is required to determine the ultimate capacity of fixings, with regard to modes of failure determined by bond and pull-out characteristics under blast loading. At present there is little blast design guidance available for cladding fixings and whether peak over-pressure, impulse or a combination of both is used for design depends on the dynamic characteristics of the panel-fixing structural assembly and the interaction with the characteristics of the blast loading function.

Considering the nature of an explosion and the complexity of the many factors involved, there is an urgent need, using theoretical and numerical analyses and further experimentation, to optimise a design procedure. There is also a need to establish whether residual deformations in frames and cladding panels that have been damaged by blast loading can be related to fixing damage.

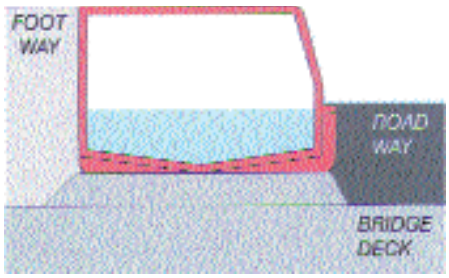
For further information please contact Dr A J Watson, Department of Civil & Structural Engineering, University of Sheffield (0114 222 5055; fax: 0114 222 5700; Email: A.J.Watson@sheffield.ac.uk).

CENTRE FOR WINDOW AND CLADDING TECHNOLOGY

Improved bridge deck drainage

Deficiencies in the drainage system for bridge decks are often a major cause of water ingress. Under the EPSRC/DOT-sponsored LINK Transport Infrastructure & Operation Programme, a research project undertaken by the University of Birmingham has been examining, with industrial partner CIS Construction Products, the hydraulic performance characteristics of combined kerb drainage units for effective drainage of bridge decks

Areas studied were discharge capacity, resistance characteristics, sedimentation and outfall efficiency. The load-bearing capacity of units and leakage reduction between units were also considered.



Cross-section of a typical combined kerb drainage unit.

Two flumes (9m & 15m long) were used to simulate uniform and spatially varied flow and to examine sediment build up and outfall efficiency. In tests in an environmental chamber, various methods of sealing between units were examined, for temperature cycles between -10°C and +50°C.

The results have highlighted 5 key issues and the final report makes recommendations for each:

- structural load performance;
- conveyance capacity;
- leakage between units;
- sedimentation;
- outfalls and diversions.

This practical project has shown conclusively that different manufacturers' units with similar dimensions can have significantly different hydraulic characteristics. Effective sealing between units can also be achieved. The result of this work should be correctly designed bridge deck drainage that removes water efficiently and with minimal leakage.

For further information please contact Dr D W Knight, School of Civil Engineering, University of Birmingham (0121-414 5049; fax 0121-414 3675).

EPSRC

Standardisation and pre-assembly: providing better value for money

'The last place to build anything is on a construction site!' The reasons are obvious: construction sites tend to be dirty, dangerous, difficult and, above all, unpredictable. Thus not only is time lost to the weather and supply chain problems, but high standards of workmanship are usually achieved despite conditions that are hardly conducive to accuracy and finesse.

A recent CIRIA project has identified how standardisation, pre-assembly and modularisation can be used to optimise production conditions, minimise on-site work and use standard products and systems to achieve unique projects more efficiently. In addition to data gleaned from interviews, workshops of experts and site visits, lessons have been identified from other industry cultures such as vehicle manufacturer, electronics, power and aerospace and from other countries such as Japan, USA and the Netherlands.

Correct timing of decisions on standardisation and/or pre-assembly is critical to achieving the benefits. Ideally, a standardisation and pre-assembly strategy should start at the inception of the project. Various options should be investigated during the feasibility and concept design stage, with detail decisions on the use of standardisation and/or pre-assembly being made during scheme design. Once detail design starts, it is likely to be too late and any new standardisation and pre-assembly decisions made later than this will almost certainly be counter-productive.

Improved value can take many forms and is rarely reflected in a first-cost analysis based on a bill of quantities. However, while standardisation can result in reduced initial cost, standardisation and pre-assembly, particularly in combination, can result in improved quality and durability thus reducing maintenance costs. Better whole-life value is therefore obtained.

The speed and predictability of using standardised products and systems, pre-assembly and modularisation can make highly significant reductions in construction time, bringing facilities into early operation and thus early revenue generation. In many cases this results in greatly improved value for money. An example is the MacDonalds Drive-Thru Restaurant (see illustration), where the time from availability of the site to completion and revenue generation is typically 9 days.

Standardisation, pre-assembly and modularisation are not new concepts. However, they could be used to a much greater extent. A new CIRIA report contains 14 case studies from the UK and overseas varying from the historical to the present day. It has been targeted at clients and their principal advisors because a cultural change is needed for this approach to be widely adopted.

For further information contact Barry Staynes at CIRIA (0171 222 8891; fax: 0171 222 1708; E-Mail:bws@ciria.org.uk).

CIRIA

MacDonalds Drive-Thru Restaurant manufactured by Yorkon Ltd

INNOVATION

Just time to respond to calls for research proposals

Three research programmes directly relevant to building and civil engineering are seeking proposals for collaborative research projects. All have an open call, so proposals may be submitted at any time until the deadline of 31 December 1997.

The three programmes are:

- the LINK Programme on *Integration in Design and Construction* (IDAC);
- the LINK Programme on *Meeting Clients' Needs though Standardisation* (MCNS);
- the *Construction as a Manufacturing Process* (CMP) which is a sector of the Innovative Manufacturing Initiative.

Proposals can arise from any relevant part of the industry or academia. In all three cases, anyone contemplating making a proposal is strongly advised to secure the appropriate guidance notes on the coverage of the relevant programme and to discuss their ideas informally with the appropriate Programme Coordinator or Manager before making any further commitment.

The contact points are:

- *the IDAC Programme Co-ordinator: Peter Pullar-Strecker, Pullar-Strecker Consultancy Ltd, 15 Woodland Rise, Oxted, Surrey, RH8 9HW (01883 730883; fax: 01883 712468)*
- *the MCNS Programme Co-ordinator: Tony Trinick, TriTone Partnership, 64 Towncourt Crescent, Petts Wood, Orpington, Kent, BR5 1PJ (01689 820838; fax: 01689 890488)*
- *the CMP Programme Manager: John Findlay, BBSHD, Osborn Way, Hook, Hampshire, RG27 9HX (01256 763161; fax: 01256 768614)*
- *for overall guidance: Ms Jacqui Williams, EPSRC (01793 444068; fax: 01793 444187; E-mail: jacqui.williams@epsrc.ac.uk).*

EPSRC

Structural Safety: research needs and communicating results

The important role of communication in maintaining structural safety – including communicating research findings – has been highlighted in the Eleventh Report of SCOSS, the Standing Committee on Structural Safety.

SCOSS is an independent body established by the Institution of Civil Engineers (ICE) and the Institution of Structural Engineers (IStructE) to continually review matters in building and civil engineering affecting the safety of structures. It is also supported by the Health and Safety Executive and reports every two years on the significant events and developments in the field of structural safety. It makes recommendations to the profession, government and standards-making bodies about changes in practice and research needs arising from the Committee's discussions.

Only through effective research, together with effective application of its findings in practice, can the benefits of research be fully realised. Communication of research findings to application in practice is however a far from simple process. Although research provides the basis for much innovation and development in structures, research results pass through several stages – generation, distillation, comparison and interpretation – before bringing about a change in practice.

SCOSS welcomes the emphasis now being placed by the Engineering and Physical Sciences Research Council (EPSRC) on supporting research serving the needs of industry and regards it as especially important. For research sponsored by the Construction Sponsorship Directorate of the DETR, in particular in its Partners in Technology programme, SCOSS has also welcomed the requirement on research teams to put suitable emphasis on disseminating the results of their research.

Alongside public and legislative pressures for greater health and safety, clients are demanding substantial improvements in quality and costs. These demands may lead to adverse trends in structural safety and it is important for the construction industry response to the pressures to be balanced and sound. Continuing support by EPSRC, government departments and official agencies for research on structural safety is needed so that industry can achieve acceptable safety and structural performance at economic cost.

In reviewing specific topics over the last two years, SCOSS has highlighted some important areas for research or studies to assist structural safety, including:

- a review of codes of practice relating to structural design;
- structural concepts and forms with low sensitivity to damage and with appropriate capacity to resist disproportionate collapse;
- criteria and methods for assessment and strengthening of existing edge barriers in multi-storey car parks;
- design of edge barriers in multi-storey car parks to restrain vehicles and safeguard small children;
- standards for structural assessment of rail bridges;
- pin connections in bridges and buildings;
- design against fatigue in steel structures.

Any researcher wishing to receive further details of these research recommendations, or practitioners with relevant experience that they wish to share on these issues (in confidence if needs be) is invited to contact the Committee at the address given below.

The 11th SCOSS Report, Structural Safety 1994-96: Review and Recommendations, is available from the IStructE, (0171-235 4535, fax: 0171-235 4294) and from the Thomas Telford Bookshop at the ICE (0171-222 7722), price £25.00.

For further information on the report or the work of SCOSS please contact Nick Clarke (0171-235 4535; fax: 0171-235 4294; E-mail: istructe.lon@bogo.co.uk).

THE INSTITUTION OF CIVIL ENGINEERS

SCOSS

'Greening' of structural steelwork coatings

Every year, it is estimated that 16.5 million litres of paint are used on structural steelwork in the UK: this equates to 8,000 tonnes of solvent being discharged into the environment. A transition from solvent-based coatings to low-VOC coatings could reduce this discharge by 5–10%, saving on pollution of the environment. This in turn would lessen global warming, reduce the health risk to users and lead to long-term cost savings.

Government environmental protection initiatives, for example the Environmental Protection Act 1990 (EPA), health and safety legislation, and the Construction Design and Management Regulations, as well as EC Ecolabelling regulations, focus on the need to reduce volatile organic compounds (VOC) emitted into the environment. These regulations have led paint manufacturers to develop low-VOC (ie low solvent content) coatings.

Designers, specifiers and users are confused about their use and are reluctant to change from conventional coatings, leaving the manufacturers with the dilemma of complying with the legislation or providing conventional coatings to satisfy their clients. There is therefore a need to provide information to the industry gained through practical experience of low-VOC coatings and to compare them with conventional, solvent-based systems.

However, at present there is no independent guidance available on the performance of low-VOC primers and/or coatings on steelwork. To assist in filling this gap, BRE is undertaking a three-year project – with industry partners and with support from the DETR Partners in Technology scheme – which addresses these issues and aims to provide solutions to the technical uncertainties.

The project entails:

- carrying out a literature critique of low-VOC primers and coating systems;
- artificially weathering a broad range of primers (conventional solvent-based systems and low-VOC systems that are either water-borne or have high solids with low-solvent emissions) and assessing their performance;
- assessing a range of properties of the primers and/or complete coating systems and comparing them with conventional, solvent-based products including weldability, durability and over-coating capability both before and after natural exposure.

For further information please contact Dr John Kempster at BRE (01923 664153; fax: 01923 664786; E-mail: kempsterj@bre.co.uk).

BRE

Realising greater use of pfa in concrete

Pulverized-fuel ash (PFA), a by-product of coal-fired electric power generation, has for some years been used as a component of the cement in concrete. In the UK, this use was accepted with the adoption of BS3892: Part 1 in 1982 for PFA within a narrow range of fineness and permissible loss-on-ignition (LOI*). However, the situation changed in 1995 with the publication of the European standard for PFA, BS EN 450. This broadens the material quality limits and has potential to promote increased use of PFA in concrete and provide a number of environmental, technical and economic benefits.

There are two main differences in the property requirements of the new BS EN 450:

- in the fineness, with permitted levels of up to 40% retained on a 45mm sieve, compared to 12% in BS3892 Part 1;
- in the control of material quality, with the requirement that PFA fineness should be within ±10 of the suppliers' declared mean fineness, subject to an overall limit of 40%.

A project been undertaken by the Concrete Technology Unit (CTU) of the University of Dundee to examine the impact of PFA to this new standard on the full range of concrete properties. The work was funded by DETR and industry under the Partners in Technology (PiT) scheme.

The study considered a wide range of material variables, including the effect of fineness on strength, where PFAs from single and multiple sources were studied, and the effect of Portland cement (PC) variability when combined with different fineness PFAs.

Overall, the results indicated an approximately linear reduction in the strength of concrete, as the PFA became coarser. A single relationship was maintained over the BS EN 450 fineness range (which also includes BS 3892-quality PFA), see figure. In contrast, loss-on-ignition* of up to 8% was found to have no significant effect on strength, although increased admixture dosage was necessary to achieve specified air entrainment as LOI increased.

A mix design method was developed to take account of the effects of PFA quality to enable the production of equal strength concrete. This followed simple adjustment to either the water content, binder content, or both, of the mix and the use of a water-reducing admixture. An example is given in Table 1 for 30% PFA replacement mixes.

The implications of the limits on PFA fineness to control material quality have also been evaluated. Given the relationship identified in the Figure, for a design strength of 40 N/mm², a strength variation of 0–3 N/mm² may occur. This may add to the strength standard deviation beyond that of other operational factors, and tighter limits as a commercial condition of concrete supply may be necessary. Alternatively, PFA suppliers may decide or be required to reduce the permitted variability and introduce grades for PFA over the BS EN 450 range, such as those shown in Table 2.

Concrete mixes of equal strength produced with PFA quality varying within the BS EN 450 range were all found to posses similar durability properties in terms of permeation, carbonation rates, chloride diffusion, sulphate attack, abrasion resistance and freeze/thaw resistance, as illustrated in the figure. Thus, the durability provisions in BS 5328 for the specification of concrete also apply to those containing PFA to BS EN 450.

Other work has demonstrated that equivalency of engineering properties, including modulus of elasticity, creep and shrinkage at equal strength is also achievable with BS EN 450 PFA.

The full impact of this new standard for PFA will be felt by the construction industry in 1999, when the European Standard for concrete BS EN 206 (which recognises PFA to BS EN 450) will be adopted as a full standard, making it possible for engineers to specify PFA to this standard. The UK construction industry now has an ideal opportunity to further exploit PFA as a valuable resource, with consequent environmental protection and cost benefits.

A technology transfer programme funded by DETR/Industry under PIT scheme to ensure that the use of BS EN 450 PFA is known and understood by potential users is being developed, and a series of seminars and workshops will be held at different UK venues during 1997/98.

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

Table 1: Typical mix proportions using 30% PFA cement replacement for 28-day design strength of 35 N/mm²

CONCRETE PRODUCTION	W/B RATIO	CONCRETE MIX PROPORTIONS, kg/m³								SLUMP
		Free Water	Binder			Aggregate				
			PC	PFA	Total	Fine	10mm	20mm		mm
1. PFA fineness = 3·5% (45µm sieve retention), LOI = 3·0%										
Normal	0·51	165	230	95	325	715	395	800		65
2. PFA fineness = 38.0% (45µm sieve retention), LOI = 5.2%										
Water adjusted	0·47	155	230	95	325	715	410	810		70
Binder adjusted	0·47	165	245	105	350	715	370	740		75

Fig 1: Relationship between PFA fineness and concrete strength and the achievement of equivalent concrete performance in terms of bulk engineering properties and durability

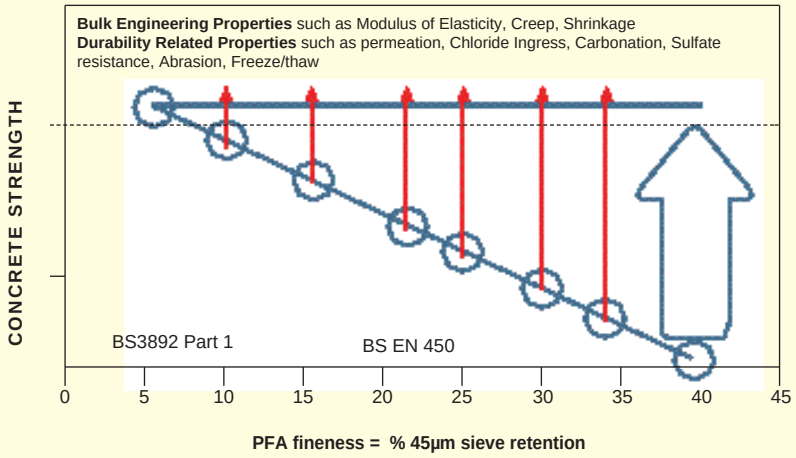


Table 2: Possible grades of PFA

PFA Grade	Target Fineness	Fineness Range
	% Passing 45 um sieve	% Passing 45 um sieve
I	5	0–10
II	15	10–20
III	25	20–30
IV	35	30–40

* LOI is a measure of unburnt carbon in ash.

Timber Frame 2000 project moves to construction stage

Until a few years ago, the number of storeys in timber-framed buildings in the UK was limited by fire regulations, with several differences between the Scottish and English & Welsh regulations. This restriction was recently lifted in the English & Welsh regulations, allowing the number of storeys potentially to reach eight without additional fire resistance. BRE is involved in a major project with the main commercial, industrial and technical objectives of ensuring and balancing the safety and economy of such buildings following the regulatory change and which involves the construction and testing of a six-storey timber-framed building.

The timber-frame building project, or TF2000 as it is known, was established by DOE (now DETR), the UK timber frame industry, TRADA Technology Ltd and BRE in October 1995. This followed the production of a feasibility report, *Disproportionate Collapse and Other Design Requirements* which concluded that to ensure a sound basis for the design and construction of medium-rise buildings, further investigations into such buildings were necessary.

Management and technical committees were set up within TF2000 to consider the design and construction requirements of medium-rise timber-framed buildings in the UK. The process was divided into two phases.

- Phase I identified areas in need of investigation and approved a core programme of work and the detailed design of a full-scale test building.
- Phase II – the construction and testing of the building at the Cardington Large Building Test Facility (LBTF) – is due to begin this year. It has seven main objectives, to:
  - increase the design/construction process value to the client;
  - reduce construction time;
  - reduce cost in use;
  - achieve greater regulatory harmonisation;
  - improve quality through off-site prefabrication and manufacture;
  - provide market comfort through full-scale testing and research data;
  - produce authoritative national guidance documents.

The six-storey timber building, the second in a series of full-scale test buildings at the LBTF, will be of typical timber-framed construction, designed as a multi-occupancy residential block, with four flats per floor around a service core. The large panel platform frame will be constructed of C16 timber (12% moisture content for floors and 18% for walls), and will extend to the communal staircases and lift shafts. All four external elevations will be clad with a single brick leaf. Two flats on the fifth storey and two on the sixth will be fitted out to notional 'show flat' standard.

The TF2000 research team aims to investigate many design principles and bring together all aspects of the construction process – from regulations, research, design and construction, through to whole building evaluation. Eight Task Groups are being established to cover the following areas: Regulatory, Architectural & Client, Structural, Construction Process, Differential Movement and Cladding, Performance Testing, Fire, and Acoustics.

The project partners, although competitors, have co-operated well, resulting in the effective promotion of the timber industry and their own organisations. The existing management and technical arrangements can be expanded to accommodate other organisations and professions without interfering with the overall aims of the project.

The outcome of the work is intended to provide authoratitve guidance and enhanced design techniques, manufacturing and construction techniques, and enhanced use of home-grown timber.

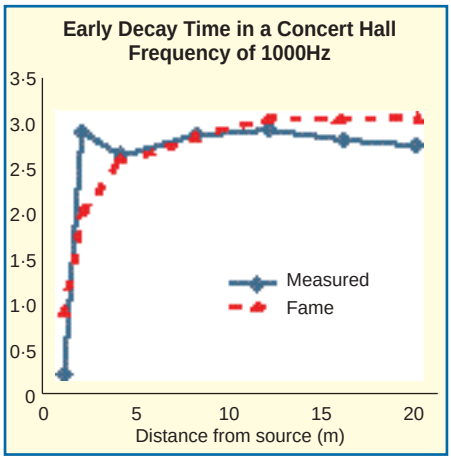
For further information please contact Dr Vahik Enjily, Head of Timber Engineering at the Structural Design Division, BRE (01923 664392; fax: 01923 4096; E-mail: enjillyv@bre.co.uk).

BRE

Predicting sound in enclosed spaces

In 1992, a European Community directive aimed at protecting the hearing of workers was enacted in the UK in the form of the Noise at Work Regulations. An EPSRC-funded project developed computer models to predict noise levels in factories, so that the buildings could be designed or configured to ensure that sound levels would comply with the new regulations. It was found that other types of enclosed space could also be modelled, so EPSRC funded a broader investigation, in collaboration with the Applied Acoustics Department of Salford University, into the prediction of sound fields in other types of enclosed space.

Computer models were developed, adapted and extended to predict the sound field in enclosed spaces such as atria, concert halls, churches, lecture rooms and recording studios. In these types of space listening pleasure is of primary importance and hence it was necessary to predict temporal acoustics parameters, as well as steady state sound. Two of the mathematical models developed were fully validated in the above spaces using generally available acoustic data and it was found that the predictions were close to measured values across the frequency range. A graph showing good agreement between predicted and measured values of early decay time in a concert hall is shown in the figure.



To allow one of the models to be commercially exploitable optimisations were performed enabling the program to run twenty-five times faster than the research model. The optimised model was then integrated into the commercial version of the model FAME (Factory Acoustics Modelling and Evaluation) which has been developed in collaboration with ISVR Consultancy Services of Southampton University.

For further information please contact Dr Stephen Dance, South Bank University, SESD, Borough Road, London SE1 OAA (0171-815 7662; fax: 0171-815 7699; E-mail: dances@sbu.ac.uk).

EPSRC

Selecting water sources in emergencies: Linking research to practice

Water is essential for life and during an emergency must be made available within a short time frame, often during periods of intense confusion. In conflict situations or areas with complex socio-political environments the task of water source selection becomes increasingly difficult. Water and sanitation engineers therefore not only have to have knowledge of appropriate technologies for source abstraction, treatment, transmission and supply but also to understand the wider constraints to, and the consequences of, decisions on these issues.

The Water, Engineering and Development Centre has been undertaking research to develop management tools to improve the procedures for the selection of water sources and potable water treatment processes in emergencies. The research is being funded by the UK Department for International Development.

Working closely with a range of international relief organisations including the United Nations High Commissioner for Refugees, the International Committee of the Red Cross and Medecins sans Frontieres, the research team has combined an academic assessment of current procedures and literature with the realities and constraints of the field situation.

An assessment based on interviews and field study was undertaken of the present field procedures for selecting water sources and treatment processes to make the water potable in emergencies. The skills required to undertake this task were identified together with the skills and weaknesses of the personnel involved.

On the basis of these findings and a comprehensive literature review, draft field tools and guidelines were developed, field tested in Zaire (for Burundi and Rwandan refugees), Burundi and Ethiopia (for Sudanese and Somali refugees), peer reviewed and revised. The guidelines include information-gathering checklists, survey sheets, selection tools and a range of supporting information.

It is hoped that these materials will help engineers and other personnel to take a holistic approach to the selection of water sources and treatment processes in emergencies, thus limiting the negative impacts on the affected and local populations, and on the environment.

For further information or to obtain a free copy of the guidelines or training modules, please contact Bob Reed or Sarah House at the Water, Engineering and Development Centre (WEDC), Loughborough University (01509 222 885; fax: 01509 211 079; E-mail: r.a.reed@lboro.ac.uk).

Surface water source in Kurdistan

Research-based manual on marine sands

A new research-based Manual 'Dynamics of Marine Sands – A Manual for Practical Applications' summarises the main processes influencing the behaviour of sand and gravel at sea and provides guidance to engineers involved in coastal defence and construction projects where sand transport is an important concern.

Richard Soulsby of HR Wallingford compiled the book. 'The Manual is very much a bridge between mathematical theory and practical engineering needs,' he explains. `It sets out methods for calculating the hydrodynamic and sediment dynamic quantities which engineers require and makes recommendations about the most appropriate ones to use.'

The Manual arises from a strategic research programme on sand transport processes, part funded by the DETR. 'It covers existing methods and equations but it also includes new formulae, derived during recent research programmes,' says Soulsby. Chapters provide or deal with:

- marine sand behaviour;
- a general procedure for solving sediment-related problems;
- errors and sensitivity;
- the properties of sand and water;
- hydrodynamics;
- sand transport.

A software package (*SandCalc*) has also been developed for use with the book and which allows users to calculate values for over 70 of the equations and procedures cited in the Manual. '*SandCalc* speeds up calculations and enables engineers to compare values obtained using different methods simply and quickly,' explains Soulsby.

The behaviour of sand and gravel can have a major impact on coastal defence schemes, harbour viability and offshore construction, so engineers need access to current information and methodologies during planning stages. This new Manual provides a valuable summary of theory and practice and should prove a useful tool for those involved in such projects.

Dynamics of Marine Sands, (£60.00), is available from Thomas Telford, 1 Heron Quay, London E14 4JD (0171 665 2464; fax: 0171 537 3631).
For further information please contact Richard Soulsby at HR Wallingford (E-mail, the preferred means of contact: rls@hrwallingford.co.uk; tel: 01491 835381; fax: 01491 832233).

Assessing the properties of dredged material

Material dredged from harbours and navigation channels is disposed of at approved sites following a careful assessment and licensing procedure. But what happens to it once it has been placed offshore? Does the material behave as predicted? This is the question being tackled by researchers from HR Wallingford and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in a research project funded by the Ministry of Agriculture, Fisheries and Food (MAFF). This project will help to underpin the assessment that CEFAS makes of each application to dispose of dredgings at sea and of the associated monitoring programme.

Throughout the project, HR researchers are working closely with staff from CEFAS, port authorities and dredging companies. 'We wanted to study the physical properties of bed material through three stages of the dredging process: in-situ at the berth, in the dredger hopper and at the disposal site,' says Mike Dearnaley who leads to the HR team. Researchers had originally thought that much of their work would be carried out in the laboratory, but preliminary studies aboard MAFF's research vessel RV Cirolana showed it was possible to measure sediment stability in a direct and novel way. `We took bed samples with a NIOZ corer (see photograph) and used the recently developed ISIS* instrument to measure its erodability,' explains Dearnaley.

ISIS was developed jointly by HR and the Energy Technology Support Unit (ETSU) to study mud-sand mixtures in estuaries. It consists of an inverted bell-shaped funnel (84mm across) inside a cylindrical perspex tube, with a small space around the circumference. The bell is positioned so that there is a 3–8mm gap between it and the test surface (in this case the surface of a NIOZ core). Water is then pumped down the outside of the bell, producing a smooth radial flow across the test surface, returning up through the central funnel. Applied shear stress can be calculated as a function of flow rate and gap size. Critical shear stress (the point at which the surface starts to erode) is reached when monitors in the water feed reservoir detect a sudden increase in turbidity.

'So far, we have taken core samples from Teesside and Felixstowe. We have also worked at the respective disposal grounds,' explains Dearnaley. Small samples from each test surface are returned to Wallingford for characterisation and analysis. ISIS has been used successfully on samples containing between 20% and 80% mud.

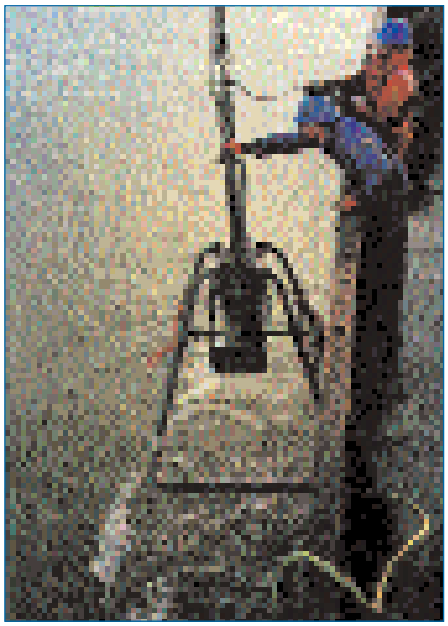
Besides measuring the erodability of bed deposits, researchers have also deployed Minipods, special equipment developed by CEFAS to log wave and current activity as well as suspended sediment concentrations over longer periods in test areas. 'Minipods allow us to characterise the natural conditions at each site,' says Dearnaley. 'This is crucial for understanding the natural forces acting to disperse material after it has left the dredger.'

Further work to sample material on dredgers is planned for the rest of 1997 and results from all parts of the study will then be analysed. This work should help towards better understanding of how disposal of dredged material influences the marine environment and will provide a wealth of information about the type and distribution of bed sediment during dredging cycles. There is scope to include data in new predictive modelling tools and results should also be valuable to those interested in developing beneficial uses for dredged material.

For further information about this work please contact Dr Mike Dearnaley at HR (01491 835381; fax: 01491832233; E-mail: mpd@hrwallingford.co.uk).

* ISIS stands for 'Instrument for measuring Shear stresses In Situ'. This instrument has been further developed for inter-tidal work and the new instrument is referred to as Sederode.

Deploying a NIOZ cover during a research survey



Exports project calls on suppliers

As part of the Technology for Exports Project (see *Research Focus* Issue 29 for details), the ICE's Project Team is now seeking to broaden the input from materials and components suppliers, and from suppliers of other technology-based products used in and by the civil engineering industry.

If you are from one of those sectors of the industry, it would be most helpful to the Project Team you could spare a few minutes to respond to the questions below and write, fax or email your response, with full address, telephone, fax and email numbers, to Dr John Bennett at the ICE at the address below.

1 Into which of the market areas below are you supplying?
- Transportation planning and infrastructure;
- Water & wastewater engineering;
- Coastal and river engineering;
- Infrastructure for urban development and megacities;
- Environmental improvement, remediation and sustainable development;
- Other – please specify.

2 Please indicate the main materials and/or products you supply to the civil engineering industry.

3 Please list the issues, technologies and strategies which you believe are critical to success in materials or component supply to civil engineering exports, and where further research & development could be of major benefit.

Items can relate to any aspect of civil engineering – materials, components, or supporting services or technologies.

Please send your responses by post, fax or email to Dr John Bennett, Assistant Director of Engineering, the Institution of Civil Engineers, 1 Great George Street, London SW1P 3AA (Fax: 0171-799 1325, Email: bennett_j@ice.org.uk)

For further information about the project, please contact Roger Venables, Project Manager, Venables Consultancy, ICE Technology for Exports Project, 12 Cranes Drive, Surbiton, Surrey, KT5 8AL (0181-399 4389; fax 0181-390 9368; E-mail: 101722.374@compuserve.com).

THE INSTITUTION OF CIVIL ENGINEERS

Co-ordinating concrete-related R&D

The review of research funding in the construction industry in 1990–1994 presented in Research Focus Issue 26 showed a small drop in real terms, and a lower level of investment compared with other countries. It is also generally accepted that we do not co-ordinate well what research is done, nor make the best use of the results – technology transfer is poor and take-up is low. An attempt to rectify some of these deficiencies is now being made in the concrete sector.

Under the banner of the Concrete Industry Al liance (CIA) and with the Concrete Society as the lead organisation, a R&D Task Group has been set up, with strong support and encouragement from DETR. The basic objectives are to co-ordinate submissions to the DETR's Partners in Technology scheme (PiT) and to advise on how best the results can be taken into practice. Broader objectives are to produce an implementation plan for the Concrete 2005 strategy, and to develop effective systems for technology transfer and validation.

To date, the following actions have been taken.

1 Support for the Concrete 2005 Strategy and the DETR's Business Plans

Together, these documents create a framework for the future, and define priority needs for the industry as a whole. However, action is required: the Task Group has formulated an Implementation Plan for the Strategy (submitted to DETR in May 1997), which takes account of the need both to improve competitiveness and to create new opportunities in the concrete industry.

2 Collaboration, Co-operation, Consistency, Continuity, Contacts and Communication

The work of the Task Group was initiated via the DETR and focused on the PiT Scheme. However, research on concrete is funded by other sources, and there is commonality (perhaps even duplication) in the work. Contact has been made with the EPSRC and the Highways Agency initially, with the intention of creating a comprehensive UK database, giving easy access to R&D projects. That database is now extensive – if not yet complete – and located at the Concrete Society. As part of this exercise, the BCA's register of research facilities is being integrated into the Society's bank of research projects.

3 Technology transfer

The reality of poor take-up is now receiving recognition, and is a major concern of the R&D Task Group. As a first step, a workshop was organised on 5 June 1997, with invited contributions from organisations known to be working on different aspects of technology transfer, including Atkins R&D, BCA, BRE, CIRIA, the Concrete Society, Taywood Engineering and the Universities of Dundee, Kingston, Luton and Queen's Belfast. Key points which emerged included:

- user demand for authoritative consensus guidance;
- a too-conservative industry (thus low demand for research results);
- lack of validation of results;
- inadequate collaboration between researchers and users;
- insufficient appraisal of the benefits of research;
- poorly focused research i.e. no defined objective;
- the existence of too much unprocessed information;
- lack of motivation e.g. users unwilling to take risks and researchers unwillingly to follow through into practice;
- little positive collaboration between researchers in the same field, making consensus difficult;
- little awareness of the need to positively and consciously translate R&D into practice;
- the need to co-ordinate and modernise the dissemination processes.

Plainly, there is room for improvement! After discussion within its Steering Committee, the Task Group plan to:

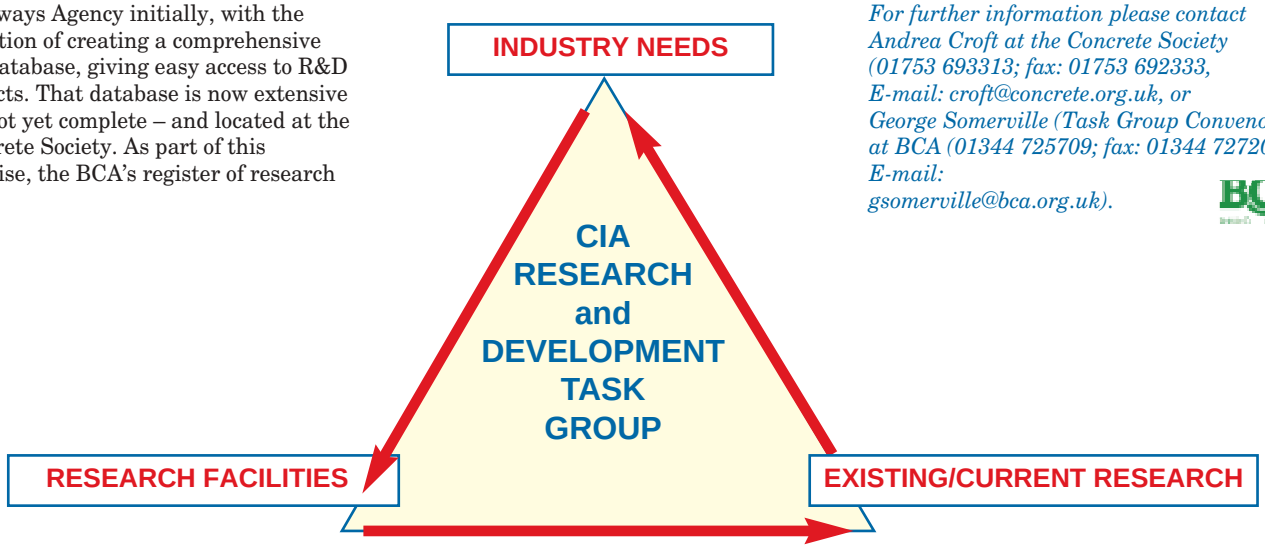
a) develop the notes from the workshop into general guidance for publication in *Concrete*;

b) formulate and carry through a technology transfer project, in accordance with the general guidance, on a priority topic ripe for development, useful in itself, and a possible model for other topics.

In addition to the individual activities described above, an important function for the Task Group is to act as a focal point for the concrete industry in bringing together researchers and practitioners. The role of the Task Group is perceived as operating within a research triangle (see illustration). Industry needs and priorities are identified via the Concrete 2005 Strategy. The database of research facilities and current projects also exists and will be developed to make it more accessible.

Operating within the triangle, the Task Group vets new proposals against the database but, more importantly, it plays a key role in co-ordinating results, and taking positive steps to ensure application in practice.

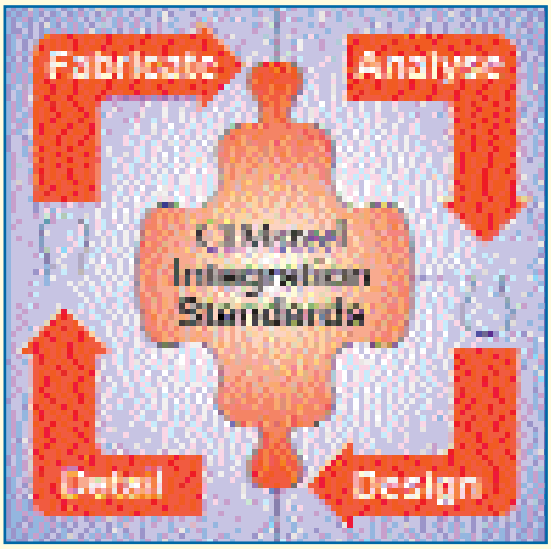
For further information please contact Andrea Croft at the Concrete Society (01753 693313; fax: 01753 692333, E-mail: croft@concrete.org.uk, or George Somerville (Task Group Convenor) at BCA (01344 725709; fax: 01344 727203; E-mail: gsomerville@bca.org.uk).



The concrete industry research triangle

CIMsteel – taking structural steelwork into the 21st century

The CIMsteel project (Computer Integrated Manufacture of Constructional Steelwork) was conceived in 1987 with the vision to improve the competitiveness of the European constructional steelwork industry in world markets. The project, which is drawing to a close at the end of this year, has involved over 50 collaborating organisations in eight European countries. Within the UK, this collaboration has involved steel fabrication companies, consulting engineers, academics, research organisations, software houses, contractors and clients. Two kinds of output have been produced: software developments and guides to assist designers.



In addition to the key objective of producing CIMsteel integration standards (CIS) to facilitate the exchange of data between different software applications, principle achievements in software development have been:

- fully integrated analysis and design software;
- software for moment-connection design embedded within a portal frame design program;
- prototype software to demonstrate the possibility of combining analysis and design with expert advice and cost information;
- 3D-solid-modelling software with interfaces to analysis and design packages, capable of producing fabrication drawings and other production and manufacturing information;
- an electronic calculation pad, to produce computer calculations with a hand calculation format for the input and output;
- software for fabrication workshop scheduling (currently under development).

Among the guides which have been produced to help designers in steel, the following titles give an indication of the extensive scope of the work:

- design to EC3 and EC4 – numerous publications have been produced to help designers use these new European codes;
- design of semi-continuous braced frames;
- design-for-manufacture guidelines;
- design-for-construction guidelines;
- modelling of steel structures for computer analysis.

Activities in the latter half of 1997 have concentrated on disseminating results of the project. A highly successful seminar *Improve your steelwork design* has been held in Nottingham, Ascot and Manchester. A seminar dedicated to portal frames was also held in Nottingham, and still to come is a one-day seminar to mark the end of the project, to be held in Ascot on the 18th November. Additional seminars have been held outside the UK.

For further information on the output from the project, and dates of any forthcoming events, please contact David Brown or Graham Couchman at The Steel Construction Institute (01344 23345; fax: 01344 22944; E-mail: couchman@steel.sci.com).

SPONSORING ORGANISATIONS

GOVERNMENT

Department of the Environment, Transport and the Regions,
Eland House, Bressenden Place, London SW1E 5DU
(0171 890 5704, fax 0171 890 5759)

RESEARCH ORGANISATIONS

British Cement Association,
Century House, Telford Avenue, Crowthorne, Berkshire, RG11 6YS
(01344 762676, fax 01344 761214)

BRE,
Garston, Watford, Hertfordshire, WD2 7JR
(01923 894040, fax 01923 664010)

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,
6 Storey's Gate, Westminster, London, SW1P 3AU (0171 222 8891, fax 0171 222 1708)

Engineering and Physical Sciences Research Council,
Polaris House, North Star Avenue, Swindon, Wiltshire, SN2 1ET
(01793 444000, fax 01793 444010)

HR Wallingford Ltd,
Wallingford, Oxfordshire, OX10 8BA
(01491 835381, fax 01491 832233)

The Steel Construction Institute,
Silwood Park, Ascot, Berkshire, SL5 7QN
(01344 23345, fax 01344 22944)

Transport Research Laboratory,
Old Wokingham Road, Crowthorne, Berkshire, RG45 6AU (01344 773131, fax 01344 770356)

PROFESSIONAL INSTITUTIONS

The Chartered Institute of Building,
Englemere, King's Ride, Ascot, Berkshire, SL5 8BJ, (01344 23355, fax 01344 23467)

Institution of Civil Engineers,
1 Great George Street, Westminster, London, SW1P 3AA, (0171 222 7722, fax 0171 222 7500)

Institution of Structural Engineers,
11 Upper Belgrave Street, London SW1X 8BH
(0171 235 4535, fax 0171 235 4294)

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