# Research Focus

Issue No. 43 NOVEMBER 2000

PROMOTING THE APPLICATION OF RESEARCH IN BUILDING AND CIVIL ENGINEERING


IN THIS ISSUE



# Guide to construction risk ...

A new manual has been written for the identification and management of risks in river and estuary construction. The guide has been prepared by HR Wallingford, as a result of work funded by the DETR.

The manual focuses on construction projects in rivers and estuaries and the risks open to contractors in this environment. Typical risks include scour, poor ground conditions, site drainage, plant operation, site access, tidal impact and flooding. The manual also discusses the impact the construction works may have on the river. Construction works could affect flood water levels, cause changes to the local river regime, induce scour or siltation, affect navigation or perhaps pollute the environment.

The new manual will be useful for contractors, project funders, consulting engineers, clients, insurers and others interested in the risks associated with river and estuary engineering. It provides a step-by-step guide to the identification, assessment and management of typical risks in a river or estuarine environment.

Throughout the manual, examples of real projects are used to demonstrate the practical issues of risk management. As a result, the manual assists the development of more efficient and cost-effective designs and construction works.

*Construction Risk in River and Estuary Engineering* (edited by Mark Morris and Jonathan Simm of HR Wallingford) is available from Thomas Telford Publishing *(tel: 01892 832299; fax: 01892 837272; E-mail: orders@combook.co.uk.).*

*For further general information please contact Jonathan Simm, HR Wallingford (01491 835381; fax: 01491 825428; E-mail: j.simm@hrwallingford.co.uk).*

*Temporary works at Welmore Lake Sluice, construction of which also required a river diversion (courtesy of Lewin, Fryer & Partners).*

# ... and Successful river diversions

River diversions are artificial channels used to divert all or part of a river's flow. They may be required for a range of civil engineering projects including flood alleviation schemes, developments near watercourses or new roads.

The planning and design of river diversions can be extremely complex. Planners and designers must consider the impact of the engineering works on the ecology, fisheries and pollution within rivers, as well as the engineering and design features.

Recent DETR-funded work at HR Wallingford has resulted in a new guide on the planning, design and construction of river diversions. Coverage includes data requirements, environmental considerations, design, construction, operation and maintenance, and legislation. The guide is mainly intended for application in the UK but the basic principles are applicable overseas.

The manual will be of particular value to planners, designers and contractors working on projects involving temporary and permanent river diversions. It will also be of interest to local authorities and planning organisations involved in the design of river diversions.

*For further information please contact Paolo Negri, HR Wallingford (01491 822249; fax: 01491 825916; E-mail: pao@hrwallingford.co.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 articles on current research are written for practising engineers, architects, surveyors and their clients with the objective of disseminating research news as widely as possible. Its sponsors wish to promote the benefits of research, improve contacts between industry and researchers, encourage investment by industry in research and the use of research in practice, and facilitate collaboration between all the parties involved.

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

**Enquiries and Comments**

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

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

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(tel: 020 7655 2242; fax 020 7799 1325;
Email: wilson_l@ice.org.uk).

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

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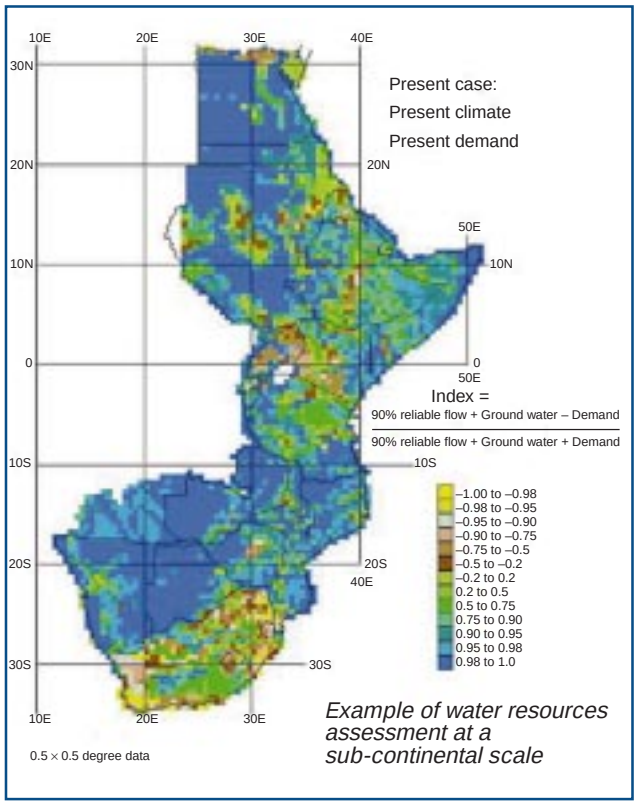
# Multi-scale water resources assessment

In line with Agenda 21 principles, the UK Department for International Development supports improved assessment of available water. Past support has revealed a range of assessment scales, from global to local, as demonstrated by the following examples.

**Global** – Global assessments of average per capita availability of water provide a benchmark of the state of a global shortage, against which actions can be mobilised. Comparisons of water availability and demand highlight areas of present and future scarcity, and pressures arising from particular uses.




*Example of water resources assessment at a sub-continental scale*

**Regional** – Shared watercourses create dependence in downstream countries upon the actions of upstream states. Regional assessments that share information and technologies across borders promote mutual understanding and trust. Expressed in terms relevant to international treaties, regional assessments can reduce the risk of potential conflict.

**National** – Comprehensive national water policies require knowledge of the available resource. This influences the planning of water resources development, allocation and investment to attain equity in access to water. Different countries have evolved unique assessment methods, all relying on well-managed hydrological data.

**Catchment** – Catchment planning requires more-detailed assessment in support of optimal allocation of water for the social and economic development, and environmental protection, of the catchment population. Operating within a national legislative framework, catchment assessments are expressed in terms that support operationalisation of water policies, laws and regulations.

**Engineering schemes** – Engineering schemes – for example dams, direct abstraction, and hydropower generation – demand a more-precise knowledge of the amounts, timing and reliability of water resources at a specific location. These assessments maximise local information to derive the requirements for the design and operation of the particular scheme, or may rely on standard design statistics from regionalised flow estimation.

**Community** – Community decisions that improve access to water for individuals in the community require an understanding of localised availability of water, linked to the specific ways in which that community uses water. Generalisation becomes difficult because of the variety of uses and variability of hydrological processes. Arguably, this is the most critical – yet the least advanced – scale of assessment.

**Experimental** – At this scale, hydrologists endeavour to understand the processes by which water moves through the landscape. Scaling-up that understanding advances the precision of larger-scale assessments.

Different purposes at different scales have dictated different information outputs and methods of assessment. There remains scope for improved transferability of information and methods across different scales, and for improving the contribution of assessments to real-world social and economic development.

*For further information on this DFID sponsored work please contact Andy Bullock at CEH Wallingford (01491 838800; fax: 01491 692424; E-mail: anb@ceh.ac.uk).*

DFID Department for International Development

# Sustainable construction and the Highways Agency's civil engineering standards

The Highways Agency is committed to sustainable development. However, its standards and specifications are mostly older documents that were written before sustainable development became a policy objective, so updating is needed.

TRL have recently completed a review of the Highways Agency's strategic plans and of their civil engineering standards and specifications for highway construction and maintenance. The aim was to establish their impact on sustainable construction and the potential for improvement in this area. The study identified areas where the Highways Agency is well in advance of other construction clients although, generally, it was found that there is still more that could be done.

TRL is continuing with development of plans to translate the strategic sustainability commitments into route- or scheme-level actions.

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

*Highways Agency procedures now insist on whole-life costing of roadworks and permit the use of recycled materials.*



# Design guidelines for overcladding systems to maintain durability of the building fabric

The repair and refurbishment of concrete frame buildings accounts for a significant portion of the UK building repair budget. In particular, a large number of tower blocks erected in the late 1950s and 1960s display advanced deterioration. Typical problems include spalling of reinforced concrete, decay of metal frame windows, poor insulation leading to severe condensation and mould growth, and deteriorating external appearance.

Refurbishment can prove a viable alternative to demolition, particularly where local demand for housing remains high. A popular option is the installation of a rainscreen cladding system in tower blocks, the primary function being to prevent rain penetrating to the underlying fabric. The insulation of the fabric is upgraded by applying a layer of insulating material to the outer face.

Durability of the building fabric is inherent in the original design of any building and assumptions are made regarding the behaviour of materials under the conditions to which the fabric is exposed. The installation of an overcladding system, however, particularly one incorporating an insulating layer, produces significant changes to the local environment around and within the building fabric.

The premature deterioration of reinforced concrete is often caused by corrosion of the reinforcement by carbonation or chloride contamination of the cover concrete, or, less commonly, by alkali-silica reaction. Overcladding carries the risk that the signs of deterioration may be hidden. It is imperative that the progress of deterioration can be confidently predicted as being within safe limits. This requires an awareness of:

*Before and after overcladding*

- the processes of deterioration in reinforced concrete;
- the influence of local environmental conditions such as temperature and humidity on the rates of those processes;
- the changes produced in those environmental conditions by overcladding a structure.

Concerns that overcladding might hasten concrete deterioration by accelerating carbonation provided the basis for the EPSRC/DETR LINK Construction Maintenance & Refurbishment project undertaken by Sheffield Hallam University and its industrial collaborators.

The project developed design guidelines for overcladding systems to maintain durability of the building fabric. The guidelines are intended for use by design teams and technical specialists involved in overcladding systems. They deal with conceptual issues arising from overcladding through to analytical techniques, and primarily aim to ensure durability of overclad reinforced concrete elements. Case studies illustrate the concept of design for durability while demonstrating the methods of analysis required.

The recommendations in the guidelines have been evolved from information available in existing literature and original data obtained from temperature and humidity monitoring in the overcladding cavity of two tower blocks. Monitoring was carried out under different states of overcladding, over a period of 19 months.

*For further information or to order a copy of the Design Guidelines (£30 including UK postage) please contact Professor Pal Mangat, School of Environment and Development, Sheffield Hallam University, Sheffield, S1 1WB (0114 225 3339; fax: 0114 225 4546; E-mail: p.s.mangat@shu.ac.uk).*

# Designing a better urban environment

Too many new developments are still planned as 'climate rejecting' – sealed, air conditioned and deep in plan, with tinted glass to cut out solar gain and daylight. But these measures can worsen the local microclimate: air conditioning results in extra thermal emissions to the surroundings, mirrored glass reflects solar heat and glare, and large, bulky buildings create hostile local wind effects and overshadow neighbouring buildings.

An alternative strategy aims to modulate the external climate and maximise the use of renewable energies. This involves planning the layout of buildings to allow adequate access to solar heat gain and daylighting, and in warmer climates, to promote passive cooling. Good urban layout design also provides an attractive exterior environment – pleasantly sunlit and sheltered in colder latitudes, cool and shaded in hotter climates, and with breezes to disperse pollutants.

A three-year project set out to help designers to use this alternative strategy to produce comfortable, energy-efficient buildings surrounded by pleasant outdoor spaces, within an urban context that minimises energy consumption and the effects of pollution. The project was co-ordinated by BRE and jointly sponsored by the EC's JOULE research programme and national agencies including DETR.

*Tinted glass reflects solar heat and glare*

The principal output was the recently published *Environmental site layout and planning*, a guide to improving solar access, passive cooling and microclimate urban areas.

Under a follow-on EU ALTENER project, Renewables in the City Environment, a web based information resource, has also been launched – http://www.lema.ulg.ac.be/tools/rice/. This focuses on the problems and opportunities of exploiting renewable energies in urban areas.

*For further information please contact Paul Littlefair at BRE (01923 664874; Fax: 01923 664010; E-mail: littlefairp@bre.co.uk).*

BRE



# Knowledge creation and its application for rethinking and sustainability

CRISP

CRISP, the Construction Research and Innovation Strategy Panel, has a principal purpose of identifying and communicating research and innovation priorities to funders and others, while facilitating a culture of innovation across the industry. A CRISP framework document *Construction Research Priorities* has been published recently.

CRISP was formed in the mid-1990s as a forum for the research interests of the industry's umbrella bodies, to work with Government to promote more-effective research and innovation. Since 1998, CRISP has worked towards industry improvement, while looking to future needs and creating an effective research base for the benefit of the whole industry.

Chairman Turlogh O'Brien CBE emphasizes that 'achieving the objectives in 'Rethinking Construction' depends not only on the effective application of existing knowledge, but on the development of new approaches that support both step changes and continuous improvement. This calls for a closer relationship being forged between industry and the research community, which then enables the research done to be perceived as being relevant, and for the outcomes to be applied. The recently published CRISP framework document provides this structure.'

In the past year, four principal CRISP task groups have reported to the Panel: Design, Motivation and Communication, the Research Base, and Sustainable Construction. Work has also been undertaken on Housing, the Regulatory Framework, and Construction Futures. This last activity was undertaken via the Construction Associate Programme of the Foresight Building Environment and Transport Panel. Foresight will play a crucial role in shaping the way society uses and benefits from the products of the construction industry.

Consultancy studies commissioned by CRISP include scoping exercises to review work done and identify gaps; examination of barriers or perceived barriers to progressing valued initiatives; and developing methods by which findings of previous research can be effectively communicated to research funders and the industry at large. Commissions are often used as the basis of workshops and similar events, drawing in wider industry participation and enabling greater learning by the task group themselves. Task groups provide final reports on their work with clear recommendations for further action.

For the current year, CRISP has identified three broad drivers for Industry Improvement: Customer Needs, Respect for People, and Sustainable Construction. Within Industry Improvement, task groups are currently active in three areas: Performance, Process, and Technologies & Components.

The CRISP website contains information on CRISP priorities, membership, activities and outputs and includes all CRISP reports and proceedings. CRISP is keen to ensure that its output is communicated effectively to a range of audiences and produces material specifically orientated to particular research funding organisations.

CRISP is working to develop its agenda for action and to support the development of the new Construction Industry Board (CIB). The review of the CIB indicates a prominent role for CRISP, and for innovation and research, and reflects a clear relationship between M4I, which is demonstrating and testing new practice, the Construction Best Practice Programme, which is disseminating proven best practice, and CRISP, which is identifying future practice.

*For further information about CRISP and to request copies of Construction Research Priorities 2000, please contact Jim Meikle or Martin Lockwood at CRISP, Davis Langdon Consultancy, Princes House, 39 Kingsway, London, WC2B 6TP (020 7379 3322; fax: 020 7379 3030; E-mail: crisp@davislangdon-uk.com or see the CRISP website at: www.crisp-uk.org. uk).*

DETR
Environment Transport Regions

# Increasing the use of fibre-reinforced polymer composites in the construction industry

Glass, aramid and carbon fibre-reinforced polymer (FRP) composite materials have been used successfully in construction in the UK. This has been for cladding and some structural elements of buildings over the last 30 years and, more recently, as structural elements in civil engineering, including many bridges, wind turbines and water tanks. However, in comparison with North America and Japan, it seems clear that FRP composites have not been exploited to anywhere near their full potential.

These materials have a number of well-documented advantages that can provide technical and economic benefits to the construction industry, including:

- a high strength-to-weight ratio;
- good long-term durability with minimum maintenance;
- good resistance to adverse external conditions;
- their ability to be manufactured to complex shapes with a wide variety of integral finishes and textures;
- a neutral response to electromagnetic radiation.

Using a wide variety of constituent materials results in a range of composites to suit different applications. In addition, advances in design methodology, such as the use of CAD finite element analysis and developments in automated manufacturing techniques, have extended the practical and economic possibilities. These are achieved by optimising design to the performance requirements, minimising use of materials and reducing production costs, thus enabling innovative solutions.

CIRIA has recently begun a project on applications of FRP composites in construction. Due to be completed in mid-2001, the work is being undertaken by Buro Happold in collaboration with Bath University. The project is being funded by the UK Government through DETR, CIRIA's Core Members and raw material suppliers and composite manufacturers.

The aims of the project are:

- through case studies of existing applications, to increase the confidence of designers and clients in the ability of the materials to meet their requirements and design life;
- to demonstrate the types of application that are practical now or could be in the future;
- to help designers choose the 'right' materials for the design to optimise the advantages, by providing general guidance and references to sources of detailed information.

A workshop on potential applications concluded that the use of FRP composites will have maximum benefit where the inherent advantages of the materials are optimised, which may be in a particular niche market, where standardisation and preassembly can be used, and for lightweight temporary or movable structures.

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

*Aberfeldy Footbridge, Scotland (1992): the first all-composite bridge in the world.*



# New design guidance coming on contaminated land remediation

Tough new environmental guidelines came into force in April that will force people and companies to clean up contaminated land, regardless of whether they caused the pollution.

Under Part IIa of the Environmental Protection Act 1990, local authorities will have a duty to inspect their areas to identify contaminated land, force those responsible to clean it up and be able to join forces with the Environment Agency to compel polluters to pay for cleaning up the sites.

Set against the background of a government target to provide 60% of all new homes on brownfield sites, BCA anticipates increasing use of cement-based stabilisation and solidification to treat a significant number of sites. As in the USA, the 'dig and dump to landfill' approach to dealing with contamination will give way to alternative treatment technologies.

There is little or no guidance for stabilisation and solidification in the UK. So BCA is sponsoring a programme to develop detailed design guidance for engineers on the remediation of contaminated land and treatment of hazardous wastes. Taking place at the Centre for Contaminated Land Remediation at the University of Greenwich, the project will cover theory, past and present practices, projected future UK activity, testing techniques and an assessment of the longevity of treated waste forms and future R&D of the technology.

Dr Colin Hills from the Centre said: 'The design guide will be an invaluable tool for engineers designing stabilisation and solidification remediation schemes. As the landfill approach to dealing with contaminated land becomes increasingly impractical, costly and unsustainable, we expect these innovative technologies to be more widely used. It is therefore important that engineers have the right information and guidance ready to hand'.

*The new guidance will help engineers to design cement-based remediation schemes.*

*For further information please contact either Dr Colin Hills at the University of Greenwich (020 8331 9820: E-mail: c.d.hills@greenwich.ac.uk) or Martin Hopkins at the British Cement Association (01344 725729: E-mail: mhopkins@bca.org.uk).*

# Increasing the use of PFA in structural concrete

Most national standards covering pulverised-fuel ash (PFA) as a cement component in concrete require dry storage before use. This is similar to Portland Cement (PC) and is intended to prevent deterioration and handling difficulties. While some PFA is stored dry, most of the PFA collected at power stations is water moistened (called 'conditioned') and stockpiled, or slurried and stored in lagoons. In the UK, only 40% of the almost eight million tonnes produced annually is used in industrial applications, with much of the wet PFA requiring disposal.

The retraction characteristics of PFA are different to PC, so the material could conceivably be used wet as a cement component, without affecting the properties of concrete. This has been investigated in a five-year study by the University of Dundee, part funded by the DETR and a group of industrial partners. It examined the influences of water addition to the properties of PFA, considered how the material can be used in concrete, including production issues, and established how it influences engineering and durability properties.

Moisture addition to PFA tends to cause agglomeration of particles. This occurs almost immediately after mixing and is progressive with storage period, particularly during the first 6 months. For PFA of relatively low lime content, the initial material properties have little influence. However, with total lime contents > 3.0% (free lime > 0.1%), significantly faster rates of initial and ultimate agglomeration occur.

Tests have demonstrated that the material can be stored and used in concrete production from a sand hopper, although forced action may be required for removal, and storage periods should be short. Successful large-scale production trials have been carried out and verified the suitability of pfa stored in this way.

Introduction of conditioned PFA to concrete can be made by allowing for the water present in a similar way to that for aggregates. Storage for periods of up to 6 months leads to minor reductions in strength, which increase slightly as this is extended and with concrete maturity. A method has been devised to take account of these, through fineness measurement of PFA and water/cement ratio adjustment. The workability and bleeding of conditioned PFA concrete may reduce slightly, and minor increases in admixture requirements may be necessary.

Although losing a little more in terms of performance, work with lagoon PFA suggested that this material can also be used as a cement component in concrete.

The implication of this work is that the wider use of PFA is possible and, where restrictions on storage and handling have presented difficulties in the past, they no longer apply. Concrete of equivalent performance to that made with dry PFA can be met with conditioned PFA, and the known benefits associated with PFA in concrete are achievable.

*There is much scope for increasing use of PFA in concrete*

*For further information please contact Dr M J McCarthy, Concrete Technology Unit, University of Dundee (01382-344924; fax: 01382 344924; E-Mail: m.j.mcarthy@Dundee.ac.uk).*

DETR Environment Transport Regions

WATER ENGINEERING

# Self-cleansing inverted siphons

Inverted siphons are used when it is necessary to take flow in a gravity sewer, pumping main or open channel beneath an obstacle such as a river, estuary, highway or railway line. The hydraulic design of inverted siphons must be such that sediment in the flow is transported through the system without deposition and blockage.

Past research has focused on sewers that are nearly horizontal, and inverted siphons have received little attention. Through a DETR-funded project, HR Wallingford has been able to develop design equations to ensure that self-cleansing conditions are achieved in inverted siphons.

Minimum velocity depends on the size of the pipe, the relative depth of flow, the concentration of the sediment and the size and density of the sediment particles. HR established equations that showed the relationship between these factors for self-cleansing conditions. From surveys and test results, the project team then to developed a unique design equation for predicting the limit of deposition in sloping pipes.

The equation can be used to calculate minimum self-cleansing velocities in inverted siphons for a range of pipe sizes and sediment conditions. This will be extremely beneficial to hydraulic engineers during the design and planning stages of future projects.

*For further information please contact Richard May, HR Wallingford (01491 835381; fax: 01491 832233; E-mail: rwpm@hrwallingford.co.uk).*

BUILDINGS & SAFETY

# Target hardening

There were over 1.6 million burglaries in the UK in 1997, according to the British Crime Survey. Carrying out a burglary is often a very simple task. But, equally, simple security measures – so-called target hardening – are effective in deterring residential burglary. This was among the findings of a two-year study reported to a conference in June 2000 on *Residential Burglary: the Evidence and specification for cost-effective physical security*.

The study was carried out by BRE, under DETR's Partners in Innovation Scheme, in partnership with police forces, housing associations and local authorities. It set out to determine the effectiveness of applying basic security devices – door and window locks – in reducing crime and the fear of crime.

To do this, the project examined Safer Cities HomeSafe schemes. These involve the appointment of a co-ordinator with a small budget to fight crime in a particular city or area. Four different locations were studied – Merthyr Tydfil, Plymouth, Greenwich and North London – where target hardening had been implemented. In all cases there was strong evidence that target hardening has reduced burglary and the fear of crime experienced by residents.

The project also investigated whether it would be more effective if the correct security hardware, doors and windows had been fitted at the time of original construction. The Secured by Design scheme is a police initiative in which officers inspect building designs and recommend actions to prevent crime. The scheme was examined and found to be both an effective package of measures for reducing crime, and an appropriate way of delivering target hardening at the most beneficial time – during initial build.

*For further information please contact Tim Pascoe at BRE (01923 664418; fax: 01923 664910; E-mail: pascoet@bre.co.uk).*

BRE

# Fire performance of high-grade concrete

Incorporating polypropylene fibres into a high-grade concrete mix can prevent spalling of the concrete in a fire. This was one of the findings of a recent study carried out on reinforced and unreinforced concrete columns to investigate the use of polypropylene fibres for improving performance in fire of high-grade concrete.

Use of high-grade concrete in buildings is an important innovation that can reduce the size of structural elements compared with those made from normal grade concrete. This can enable more efficient construction, but concerns have been expressed over the fire performance of high grade concrete including the possibility of an increased susceptibility to spalling.

*C85 reinforced concrete columns after fire testing. The column on the left has no polypropelene fibres; the other column has 3kg of fibres per kg of concrete.*

Spalling may expose the steel reinforcement, increasing the risk of its being affected by the heat from the fire – this may bring problems with structural strength and possibly stability. In addition, spalling can be a safety hazard, for example it presents an additional (if relatively small) risk to fire fighters.

It has been suggested that including polypropylene fibres in the mix can reduce the susceptibility to spalling in fire, so BRE carried out an appropriate study with support from DETR. Although the study confirmed the beneficial effect with respect to spalling, it also found that the ability of concrete columns to survive the fire test was not affected whether polypropylene fibres were included or not. The residual strengths of the columns after the fire tests were increased by incorporating polypropylene fibres, but not dramatically.

Strength tests on specimens found that the cube compressive strength of concrete containing polypropylene fibres to be significantly reduced because of the resulting lower concrete density. This needs to be allowed for in design.

*For further information please contact Nigel Clayton at BRE (01923 664568; fax: 01923 664786; E-mail: claytonn@bre.co.uk).*

BRE



# Waste minimisation & recycling in transport renewal works

The minimisation of waste and use of recycled materials contribute to sustainability objectives of effective protection of the environment and prudent use of natural resources. Much work has been done on this in recent years but in some areas, such as renewal of transport infrastructure works, these techniques are not being implemented to the extent that might be expected.

A number of barriers, mostly non-technical, limit the amount of recycling and re-use of materials, and lead to the continued use of unsustainable 'dig and dump' practices. TRL have been appointed by DETR under the Partners in Innovation scheme to carry out a study into the factors affecting recycling in transport infrastructure renewal works and to produce guidance on how to overcome the barriers.

The renewal of pavements, drainage and earthworks for roads, railways, canals and airports is different in several ways from new construction activities. The works are extensive rather than confined within one site. They may also cause significant interference with the operation of the infrastructure – see photograph. There is therefore economic and public pressure to complete them as quickly as possible. Regulatory aspects, such as whether the material should be classed as a waste, and the length of time required to obtain the necessary licences and authorisations, can be significant factors in whether recycling is used or not.

Due for completion in autumn 2001, the project is supported by a steering group with representation from all sectors of industry – infrastructure owners, regulators, contractors, aggregate suppliers and professional institutions. Lafarge Redland Aggregates Limited are also supporting the project financially, as well as supplying a member for the steering group. A website and discussion group is being set up on the TRL web site at www.trl.co.uk and the project team would be glad to hear from anyone with practical experience on the topic, to ensure that the guidance is well-informed and acceptable to all sectors of construction.

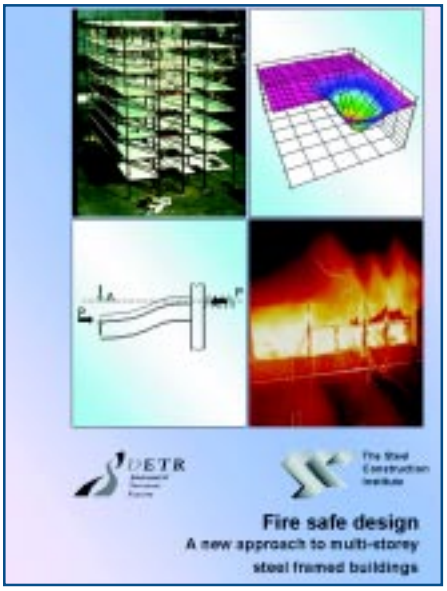
*For further information please contact Murray Reid (01344 770283; fax: 01344 770748; E-mail:* jreid@trl.co.uk*).*

TRL

*Delays to road traffic during renewal works.*

# Fire-safe design

The first design guidance based on the results of the Cardington fire tests has been published. *Fire-safe design, a new approach to multi-storey steel framed buildings* contains design recommendations and background material.




It is aimed at conventional composite steel-frame buildings, which normally require 30- or 60-minute fire resistance, and will now enable many beams to be left without applied protection.

Research into the behaviour observed in the Cardington fire tests has concentrated on the behaviour of the composite slab, which turns out to be crucial. The new guide's design recommendations are based on a mathematical model of the composite floor in which membrane action and yield line theory are combined. The model has been calibrated against the Cardington tests and is conservative.

Floors are divided up into a number of 'floor design zones'. Design tables are given showing reinforcement requirements for a range of applied loads for different sizes of floor design zone. Intermediate beams may be unprotected. The practical maximum size for any zone is about 9 m x 12 m. The beams bounding each zone would normally be fire protected although, if only 30-minute's protection is needed, they could be 'over designed' and check ed as unprotected beams using BS 5950 Part 8.

This new guidance can be seen as conservative 'Level 1' guidance. Research continues on the behaviour of composite steel framed buildings and on real fire behaviour. In a few years, it should be possible to publish 'Level 2' guidance, based on real structural and real fire behaviour.

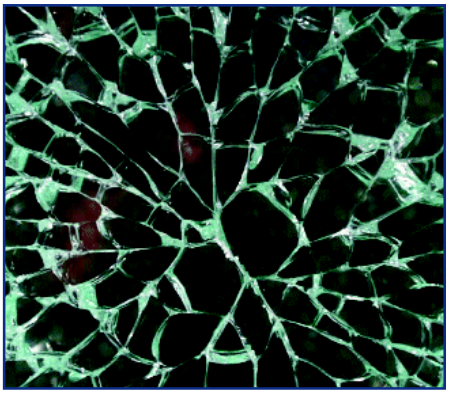
*For further information please contact Gerald Newman, The Steel Construction Institute (01344 623345; fax: 01344 622944; E-mail: g.newman@steel-sci.com).*



# Nickel sulfide failure in glass

Recent glass failures have led to numerous articles in the press about nickel sulfide-induced failure of glass. One of several causes of glass failure, it is an important cause, and predominantly affects toughened glass.

Nickel impurities in the glass melt can lead to the formation of nickel sulfide inclusions. During thermal processing of the glass, these may take up their α-state. They will subsequently revert, and expand, to their β-state over a period normally measured in years. This leads to over-stress in the surface zone of the glass and failure of the glass pane.



*Butterfly-shaped failure in glass indicating nickel sulfide as the cause.*

The risk of failure can be reduced by heat-soaking the glass. Heat-soaking is frequently referred to as a 'test'. However, it is simply a stage in the manufacture of heat-soaked toughened glass. By subjecting the glass to a sustained temperature of 290 $^{0}$C and using the correct time-temperature regime, it is possible to accelerate the failure of glass panes containing nickel sulfide inclusions. By this means it is possible to remove 99% of all nickel sulfide inclusions and reduce the risk of a pane failing by a factor of 100.

The consequences of failure can be mitigated by the use of appropriate glass combinations. The location in which the glass is to be used is also an important factor to be taken into account when specifying. Overhead glazing obviously presents a greater hazard if it fails.

Although this mechanism has been understood for over 20 years, little has been written outside scientific papers. The new CWCT publication *Nickel sulfide in toughened glass* describes the causes of glass failure, the heat soaking process and specification, remedial action to be taken in the case of glass failure and the rudiments of risk assessment.

*Further information is available from CWCT on http://www.cwct.co.uk or from Brenda Apted (01225 826541; fax: 01225 826556; E-mail: absbaa@bath.ac.uk).*

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