PRACTICAL APPLICATIONS FOR CONSTRUCTION AND THE BUILT ENVIRONMENT

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Carbon accounting of projects

Estimating carbon emissions, in response to concerns about climate change and resources depletion, has become an imperative for achieving a low-carbon society. The UK's targets are to reduce carbon emissions by at least 34% by 2020, and 80% by 2050, from the 1990 baseline. However, the amount of carbon emitted by construction and maintenance of infrastructure is largely unknown and there is an urgent need for consistent, project-focused carbon accounting.

Aware of this important gap, HR Wallingford has recently developed analytical procedures, including a new HR (Wallingford) Carbon Accounting Tool (HRCAT), that estimates carbon emissions for hydraulic construction schemes such as coastal structures (e.g. breakwaters, terminals, quay walls), river and coastal protection, conventional drainage and SuDS. The HRCAT procedure breaks down the estimation of carbon emissions across the following categories:

Applicability of HR's carbon accounting tool will include marine works development of new breakwaters.

- **materials emissions** – related to the production of the element with a "cradle to factory gate" boundary;
- **transport** – describing the movement of the element from factory gate to the site;
- **construction** – describing those on-site processes which convert the material on site to the final built structure;
- **operation and maintenance**;
- **disposal or decommissioning**.

The methodology is based on existing knowledge and practice, and starts by defining the boundaries and steps for calculating the carbon footprint of a scheme. This scheme's definition includes developing process maps covering individual carbon contributions from the main sub-process areas. For the example of a SuDS scheme, these areas would cover:

- under '**construction materials**', timber, rock, asphalt, concrete, pipework, bricks and geotextiles;
- under '**transport to site**', train freight, and land transport;
- under '**construction activities**', earthmoving, access-road construction, site pollution control, site offices, disposal of construction waste, and construction consumables;
- under '**operation and maintenance**', regular inspection and maintenance, clearing blockages, emptying silt and oil traps, clearing vegetation and dredging ponds; and
- under '**disposal at scheme end**', machinery for dismantling and removal, recycling and disposal.

The tool's comprehensive data-set is important for accuracy of estimates, and is based on a wide range of reliable sources, such as the Inventory of Carbon & Energy, manufacturers' own sources, official Green House Gas (GHG) Conversion Factors, as well as specifically sourced information and worked-out values for construction components, construction processes and maintenance operations.

The outputs show the stages of the scheme that are contributing most to its carbon footprint and more-detailed breakdowns for each of the scheme's main construction elements are also given. The tool also provides uncertainty estimates based on the reliability of available knowledge, the applicability of the data, and the information specific to the scheme.

The tool has been tested on drainage and coastal engineering case studies. These demonstrated that such assessments of carbon emissions need to be carried out with relevant data and in considerable detail. Otherwise the results can be made uncertain or even misleading.

The new HRCAT procedure enables HR Wallingford to provide scheme-based carbon-accounting that can be used for water engineering projects. It supports sustainable option appraisal and feasibility studies, and allows carbon accounts to be reported at detailed design stage, thereby supporting development of specific construction components.

For further information, please contact Manuela Escarameia, Principal Engineer, HR Wallingford (01491 822429; E-mail: m.escarameia @hrwallingford.com).

HR Wallingford

Two-dimensional flood inundation modelling

Heriot Watt University has recently undertaken research designed to support the use of two-dimensional computer models in flood risk management. Such models are now widely used in flood risk management to support decision-making, and can be divided into different model types depending on the mathematical representation of the flooding process, including shallow water equation, simplified flood wave representation and continuity based approaches.

As part of the Defra/Environment Agency Joint Flood and Coastal Erosion Risk Management R & D Programme, Heriot Watt's research has developed eight benchmarking test cases to differentiate between two-dimensional model types in terms of performance and predictive capability. The eight cases demonstrate modelling package capability in terms of predictions of inundation extent, variations in water levels and water velocity, and travel time of the floodplain.

Figure 1 shows a plan view of Test 5, designed to simulate flood wave propagation down a river valley following the failure of a dam, with a peak flow of 3000 m^3/s. Comparison of peak water levels, water velocities, and flood wave travel times were compared at points 1 to 7.

Details of the research can be found at http://publications.environment-agency.gov.uk/PDF/SCHO0510BSNO-E-E.pdf. The conclusions provide guidance of which class of two-dimensional model is best suited to different flood risk management decisions. See figures 2 and 3 for sample outputs.

In addition, as part of the Flood and Coastal Erosion Risk Management R&D Programme, Heriot Watt received support from the EPSRC for Flood Risk Management Research Consortium, Phase 2. Heriot Watt has developed rapid inundation modelling techniques based on a continuity approach. Professor Gareth Pender was sponsored by the Royal Academy of Engineering under the Research Exchanges with China/India Scheme to collaborate on this work with his colleague Prof Qingquan Liu at The Institute of Mechanics, Chinese Academy of Sciences in Beijing.

The requirement of such models is very fast computation linked to sufficient accuracy and numerical robustness, and they are often referred to as Rapid Flood Inundation Models (RFIMs). Since two-dimensional shallow-water equation models (SWEMs) remain the benchmark for good quality flood inundation modelling, evaluation of RFIMs requires that their performance is comparable with SWEMs using two criteria: (1) a good overall agreement of predicted water depth, and (2) a good overall agreement of predicted flood extent.

Figures 2 and 3 show early comparison between predictions from Heriot Watt's RFIM technique and those of the two-dimensional shallow water equation modelling package TUFLOW.

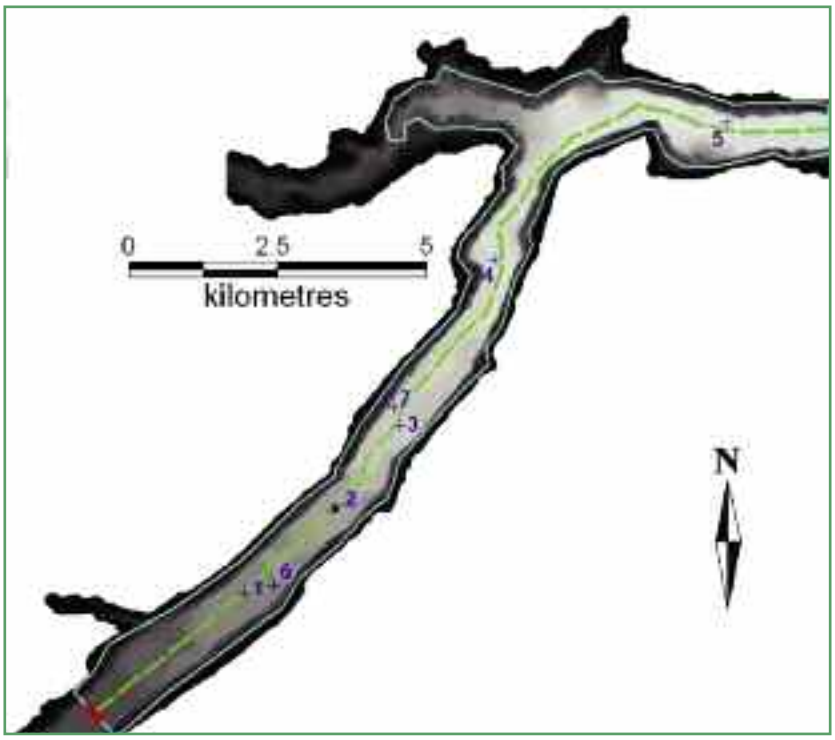


Figure 1: *Plan view of Test 5 – see text.*

For further information please contact Dr Shafiq Ahmed at the Royal Academy of Engineering (0207 766 0642; E-mail: shafiq.ahmed@raeng.org.uk).

Figure 2: *Final water depth using Heriot Watt's Rapid Flood Inundation Model.*

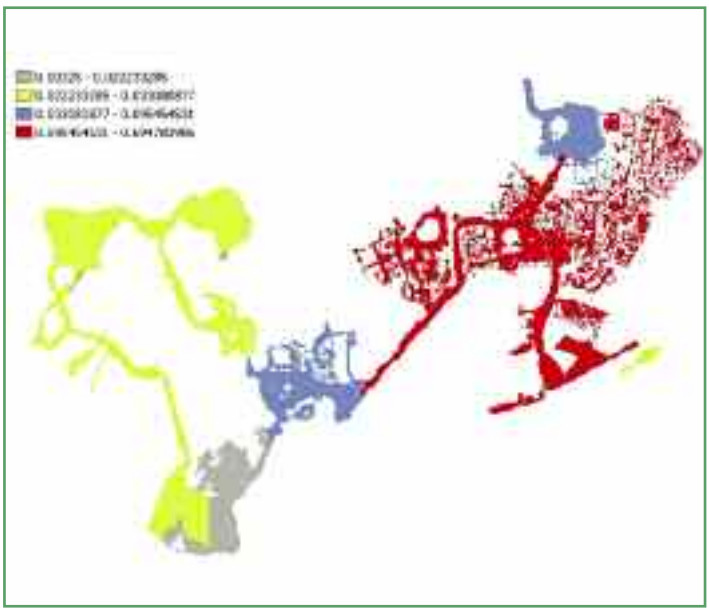


Figure 3: *Average maximum velocity the two-dimensional shallow water equation modelling package TUFLOW.*

Offsite innovation in infrastructure and civil engineering: identifying drivers and constraints

Offsite construction solutions have gained significant prominence over recent years, but most of the progress has been in the building sector. The civil engineering and infrastructure sector has experienced less growth in this new area, although there are some important exemplars, such as motorway bridges, innovative methods for tunnelling and arch bridge design and construction, and some high-profile projects such as the Heathrow Control Tower. One remarkable aspect is that there appears to have been limited application in infrastructure of the new and emerging technologies and approaches that have influenced the building sector.

'Offsite' itself is not a well-defined supply sector, but rather a conglomeration of various, largely material or technology-based supply networks. This sometimes makes it difficult to realise new opportunities.

*Buildoff*site is an organisation that actively promotes offsite techniques. However, it focuses almost exclusively on buildings rather than infrastructure assets. Although there is a lot to learn from *Buildoffsite*, the focus of the research currently being undertaken by Vasileios Vernikos is on identifying factors that may drive or hinder the development of offsite innovation throughout the civil engineering and infrastructure industry.

The aim of the research is to create a sector-wide strategy in order to assist on realising – as well as developing – offsite construction techniques for infrastructure. The research has been divided into three distinct branches:

- to recognize offsite opportunities that would add best value;
- to develop an in-depth understanding through case study analysis of specific offsite solutions; and
- to employ systems thinking to assist in maintaining and employing the offsite knowledge gained in order to ensure best practice.

The research will be delivered through a number of connected work packages, including:

- update of offsite sector analysis;
- review of civil engineering and infrastrutcture sector opportunities for offsite;
- establishing key drivers and constraints for civil engineering and infrastructure offsite implementation such as with major clients;
- working with key suppliers and co-designers to develop new opportunities;
- developing, validating and supporting the implementation of the civil engineering and infrastructure offsite strategy.

Research objectives will be fulfilled through the following main tasks:

- studying past efforts to apply offsite in civil engineering projects;
- focused semi-structured interview-investigation into previous experience;
- case study comparative analysis on the existing schemes which have attempted to employ offsite.

Contributors to the research are Loughborough University and Halcrow Group Ltd, including Alistair Gibb, Chris Goodier, Tim Broyd and Peter Robery. This project is part of an Engineering Doctorate with the Centre of Innovative and Collaborative Construction Engineering at Loughborough University.

If you are interested in this research and would like to learn more about offsite construction, research results or offer your opinion, please contact Vasileios Vernikos at Loughborough University (v.vernikos@lboro.ac.uk).

The award-winning box-jacking at Tipton in the West Midlands to remove the last level crossing on the west coast main line. (Top) *Preparing the box and jacking equipment.* (Above left) *Part way through the jack.* (Above right) *Jack completed and preparation under way for reinstating the track.*

Building performance evaluation

BIS

Do we want low-carbon buildings in theory, or do we want them in practice? The response to this question, particularly from policy makers and legislators is: What's the difference – surely they are one and the same? Otherwise, what's the point of ever tighter Building Regulations, increasingly sophisticated building simulation models, and subsidies for renewable energy technologies? The uncomfortable truth is that the tighter the regulations and the tougher the energy targets, the greater the gap between the design expectation and the operational outcome. No matter how much we turn the legislative screws, new buildings do not seem to be performing any better than the previous generation.

Roderic Bunn is a building performance analyst and BPE assessor for the Technology Strategy Board who comments on a new research programme and the reasons it is needed.

The performance gap shows most clearly in the energy consumption and carbon dioxide emission figures. Even on the best new non-domestic buildings with exemplary environmental credentials, energy consumption is regularly three times the design estimate, and sometimes more.

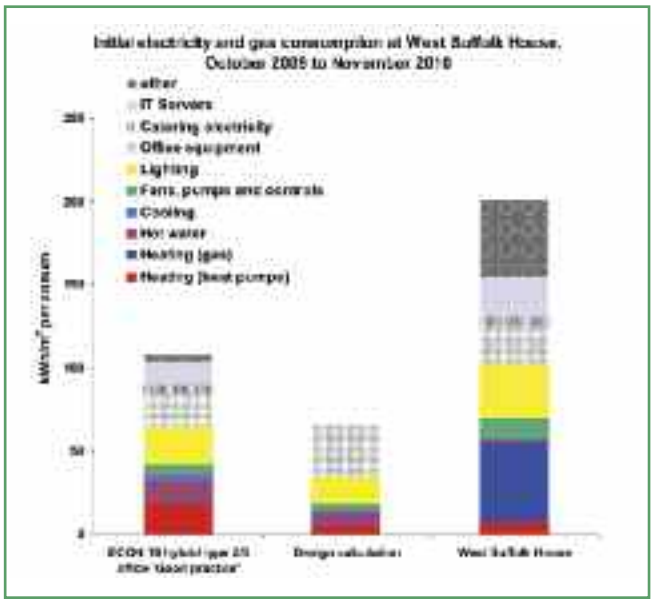
Recent results from two Carbon Trust research programmes *Low Carbon Buildings Performance* and *Low Carbon Buildings Performance Accelerator* has shown this. Even the best buildings struggled to match the ambitions of their designers. To put this into stark context, the new buildings studied by Carbon Trust did not perform any better than those researched by the government-funded PROBE project back in the 1990s.

But it's not just wasted energy that's the problem. Excessive energy consumption is often the smoking gun for a whole host of other shortcomings in new, ostensibly energy-efficient, buildings, such as poor build quality, compressed and/or inadequate commissioning, and rushed handover. These things cause double trouble where a building's architectural and engineering systems are very complex, which raises the significant likelihood that they will not be manageable and maintainable in operation.

The computerised controls systems that overlay the building's systems are also often too complex in themselves. Even fundamental technologies, like basin taps and room controllers, often seem designed to confuse and bedazzle. They end up feature-laden rather than provide the simple functionality that people need.

The lack of usability of control interfaces is the final nail in the low carbon coffin. Systems will not operate optimally, and occupants can end up disgruntled, alienated, and quite possibly less productive.

If we are to get buildings to perform better, and closer to design expectations, we need to know where design theory and construction practice is breaking down. We need to get under the skin of buildings to understand the underlying causes of our undelivered expectations. This is what the Technology Strategy Board's four-year, £8 million Building Performance Evaluation (BPE) programme for domestic and non-domestic buildings is hoping to do.



(Top) *Brighton Library: A typical set of complex controls that can easily baffle building occupants. The users have been forced to label the top controls with a marker pen.*

(Middle) *A motion-sensing tap that students at a new School of Arts try to turn on by twisting the top. Despite being a separate casting and thereby giving the appearance of being a moving part, the top doesn't turn, with the result that many of these expensive electronic taps are now coming loose in the basins and rapidly becoming a maintenance headache.*

(Above) *The energy performance of West Suffolk House compared with design modelling and the relevant (hybrid) benchmark from Energy Consumption Guide 19 (ECON 19). The carbon factors used to calculate emissions were 0.198 for fossil fuel (gas) and 0.529 for electricity.*

The research programme

The Technology Strategy Board is funding two phases of study for domestic buildings: Phase 1, Post-completion and early occupation, and Phase 2, Post-occupancy of buildings already in use.

Phase 1 studies will typically be carried out within a 3–6 month window, spanning practical completion and early occupation. Phase 2 studies generally follow on from Phase 1 projects, and last around two years to enable energy monitoring over two heating systems.

While a domestic research study can be of a single dwelling or dwelling type, it can be a comparative study between substantially identical dwellings where the performance of specific attributes are of interest, such as ground- or air-source heat pumps. The Technology Strategy Board is also interested in domestic projects where the lessons learned from studying a dwelling type can benefit the design or delivery of future housing schemes.

Suitable non-domestic case study buildings will either be nearing completion or those in operation, and no more than three years old. The Technology Strategy Board is seeking to study a range of building types, such as retail, office, industrial, healthcare and educational buildings from small to very large.

None of this research would be needed of course, if the construction industry – domestic and non-domestic – conducted feedback as a routine part of its service delivery. It does not, largely because it is not paid to do it, and because there is no compulsion to take custody of building performance once legal responsibility for operation and maintenance of the new building passes to the owner at handover. The lack of feedback from operation back to design is a significant reason why operational outcomes are poorly understood by architects, engineers and constructors.

Legislative pressure is forcing designers to put greater effort into the dynamic simulation models to generate calculations that can prove compliance with the Part L of the Building Regulations. The fact that these early calculations are rarely revisited, once the design has been signed off, creates the 'perfect storm' for divergence between design and operation.

These calculations are often misreported as energy predictions, a misconception amplified by challenging targets captured in the Energy Performance Certificate (EPC). The figures in the EPC will bear little relation to the way the building is subsequently used, and therefore will be at variance with the in-use figures reported in the subsequent Display Energy Certificate. The picture is further muddied by plug-in power loads, and any problems with build quality and rushed commissioning described earlier.

It is therefore vital that the BPE study programme attempts to build capacity in skills and experience of using building performance evaluation tools, at the same time changing the perception of BPE, so that it becomes a natural part of the professional's toolkit, rather than something to be feared and avoided.

It is important to be systematic, structured and consistent in order to generate comparable results between and among building projects. All the studies are sticking to a range of standard research procedures, protocols and techniques. Chief among these are the CIBSE TM 22 *Energy Assessment and Reporting Methodology for Energy Surveys*, and the *Building Use Studies Occupant Satisfaction Survey*.

The Technology Strategy Board's team of expert building performance evaluators will be providing training and mentoring in the use of these tools during the period of research. It is also vital that the lead organisation in the research, particularly when it is a client body, is willing and able to take the findings and use them to benefit future procurement.

What the Technology Strategy Board's programme cannot do is change a culture of construction fixated on time and cost, with quality a distant third. Neither can it force collaborative and integrated working onto forms of procurement predicated on rigid contractual hierarchies. Arguably, terms of appointment and forms of procurement that militate against the regular and predictable delivery of low carbon buildings simply have no place in a low carbon construction economy.

That nut is going to take some time to crack. If only time was on our side, but it is not. Even if building performance in-use requirements are included in the 2013 edition of Part L, it will take four or five years before we know whether the legislation has been effective. We cannot wait that long – construction culture has to change now. The BPE programme might just provide the evidence and the motivation.

For more information on the Building Performance Evaluation research project and application forms go to www.innovateuk.org.

For further information please contact Kerry Mashford at the Technology Strategy Board who runs the BPE Programme (E-mail: Kerry.Mashford@tsb.gov.uk) or Roderic Bunn, Evaluator on the Programme (E-mail: Roderic.Bunn@bsria.co.uk).

Structural engineering: window onto current research

The Institution of Structural Engineers

The Institution of Structural Engineers 2011 Young Researchers Conference showcased a broad range of topics currently being researched by PhD students across the UK and Republic of Ireland. The following summary is drawn from the 60 projects represented at the conference. Synopses of all the projects can be found on the Institution's website at: www.istructe.org/knowledge/ topic_areas/research/yrc/Pages/default.aspx

Dynamics: Studies continue into human-induced vibration on bridges and slender structures. Active vibration control systems have been used in these situations and are also being deployed to improve the performance of floors. Several techniques are being developed to improve the structural health monitoring of bridges, one focusing on the measurement of vibrations to assess condition and another using time-frequency representation techniques. The influence of long-term soil-structure interaction on offshore wind turbines is also being investigated.

PhD students discussing a project at the Young Researchers Conference.

Connections: Blind bolted connections for concrete filled steel tubular columns and connections for steel I-beams and circular hollow sections are both being investigated under cyclic loading. Various steel frame connections, including fin plate connections, are being studied for use at elevated temperatures. Elsewhere, investigation of the performance of gusset plate connections to brace members under earthquake loading is aimed at improving designs. Other materials being researched include bolted connections for fibre reinforced polymer structures. The strength of connections for timber plated structures and folded timber structures are to be improved and elsewhere design guidance has been produced for dowelled timber connections.

Sustainability: Several projects aim to facilitate adoption of sustainability, one on de-risking the introduction of innovative materials and another providing a knowledge and comparison tool to encourage the use of natural materials in construction. New materials are also being investigated such as stabilised soil blocks using local waste as a cement replacement and hemp-lime composite timber frame construction. The loading and geometry of vertically oscillating wave energy converters are being studied so as to enable the frequency of the converter to match the peak frequency of the wave spectrum at a given location. Other projects are seeking to reduce the energy consumption of steel portal frames and to reduce the embodied energy of reinforced concrete structures.

Structural behaviour: The effect of blast loading is being studied on reinforced concrete columns, cable supported structures and ceramically protected reinforced concrete slabs. Other research aims to improve the stability of soil and rock slopes and improve the efficiency of foundations for offshore oil and gas foundations. Elsewhere, researchers are working on optimising cold-formed steel portal frames and studying the interaction between cold-formed sigma steel purlins and roof sheets. Other behaviours being studied are the shear transfer in void form flat slab systems, the global buckling of pultruded, fibre-reinforced polymers and spandrel wall failures on masonry arch bridges.

Materials: Studies in this area include the use of compressed wood blocks to reinforce glulam beams is being optimized; the effect of grout fluidity on the properties of preplaced aggregate concrete; and exploring the use of fabric formwork to generate structurally optimised variable section reinforced concrete beams. Continuing on the concrete theme, an expert system is being developed for the fibre reinforced polymer strengthening of concrete structures and studies have begun on the use of ultra-high-performance, fibre-reinforced concrete for bridge deck applications.

The 2011 conference was sponsored by Atkins, Flint & Neill Partnership, ICE and URS/Scott Wilson and sponsorship is currently being sought for the 2012 conference.

For further information please contact Berenice Chan at the Institution of Structural Engineers (020 7201 9125; E-mail: Berenice.chan@istructe.org).

How to access €140m of European funding

The EU has recently announced €140m of funding through the Energy-efficient Buildings Public Private Partnership (EeB PPP). This is a joint initiative of the European Commission and the private sector to promote research on new methods and technologies, the objective being to reduce the energy footprint and CO_2 emissions related to new and renovated buildings across Europe.

The construction industry is a large contributor to CO_2 emissions, with buildings responsible for 40% of total European energy consumption. The Energy Efficient Building European Initiative was set up by the European Construction Technology Platform (ECTP) to help the construction industry address climate change, reach the European Commission-set 2020 targets and achieve energy-neutral buildings and districts by 2050.

In order to help ensure UK companies can utilise this opportunity, the Modern Built Environment Knowledge Transfer Network (MBE KTN) has set up the Access EeB group. The aim of this group is to help the UK increase its capabilities related to energy-efficient buildings, raise awareness of the Initiative, help increase capability, develop working relationships between relevant international, national and regional groups and signpost other existing support services.

Since the inception of the EeB PPP in 2009 it has funded projects totalling €150m. The main focus of past and current work programmes is the integration of research and innovation for energy efficient buildings and districts. Future calls will concentrate on achieving energy neutral and energy positive buildings and neighbourhoods. The latest calls, announced in July 2011, saw particular emphasis being placed on SMEs. The call topics include:

- **Interaction and integration** between buildings, grids, heating and cooling networks, and energy storage and energy generation systems;
- **Systemic approach** for retrofitting existing buildings, including envelope upgrading, high performance lighting systems, energy-efficient HVAC systems and renewable energy generation systems;
- **Development and validation of new 'processes and business models'** for the next generation of performance based energy-efficient buildings integrating new services;
- **Nanotechnology based approaches** to increase the performance of HVAC systems;
- **Novel materials for smart windows** conceived as affordable multifunctional systems offering enhanced energy control;
- **Methodologies for knowledge transfer** within the value chain and particularly to SMEs;
- **Concepts and solutions for improving energy efficiency of historic buildings**, in particular at urban district scale;
- **Demonstration of nearly Zero Energy Building Renovation** for cities and districts;
- **ICT for energy-positive neighbourhoods**.

The deadline for the calls is 1 December 2011. For more information on the calls please visit http://ec.europa.eu/research/participants/portal/page/ then click on the Cooperation tab, then on energy, and then select Energy-Efficeient Buildings.

To keep up to date with E2B news and developments, and for further information on the TSB-supported community, register as a member and access the forum at https://ktn.innovateuk.org/web/access-e2b/overview.

FLOOD RISK MANAGEMENT

International handbook on flood embankments

Over the last decade, storms such as Hurricane Katrina in New Orleans and Tempête Xynthia in France, have made landfall with accompanying surges in water level that have severely tested local flood defence systems. In some cases, critical defences have failed leading to loss of life and devastation of large tracts of land. Poor performance of coastal and river flood defence embankments was a critical factor in the scale of the tragedies in New Orleans and France, just as it had been in the North Sea floods of 1953, which badly affected the Netherlands and the UK.

Flood embankments are used throughout the world to provide a vital line of defence against flooding. The tragic events in New Orleans in 2005 demonstrated the critical nature of such structures and the catastrophic consequence of failure. The need for a comprehensive approach to management of flood defences is critical to their reliable long-term performance.

There is considerable experience worldwide, and it makes good sense to draw together the different knowledge and skills on the assessment, design, construction and maintenance of levees across various countries. Collating and sharing good practice would provide significant benefit to those who face the increasing challenges in flood risk management. To make this vision a reality, a single, comprehensive handbook collating international practices and knowledge is being prepared by experts from Germany, France, Ireland, Netherlands, UK and USA working together.

The International Levee Handbook will make the dissemination and wide use of consistent standards and approaches more effective, thereby providing greater value for money invested in flood defence. It will also enable good practice, suitable to local conditions, to be applied across a wide range of countries. As a first step, a comprehensive scoping report has been produced by the international partners, which highlights the main drivers behind the project, and outlines how practical guidance will be structured. Work on the handbook began last year in July 2010 and is expected to be completed by 2013.

Large coastal embankment in Holland.

The handbook will give an overview of recent advances and approaches in use in existing national and international codes, standards and guidance. It will provide a "decision support" framework for the life-cycle of flood defence embankments, rather than a prescriptive "decision making" code of practice just looking at specific predetermined challenges.

The UK-Ireland input is being managed by CIRIA with the support of the Environment Agency, Office of Public Works Ireland, Scottish Government, the Association of Drainage Authorities, the Building Research Establishment, HR Wallingford, Royal Haskoning, Halcrow, Mott Macdonald, Atkins and Jacobs. HR Wallingford is leading and coordinating the technical input from the UK and Ireland. Details of the partners and funding organisations from other countries can be found on the project website: http://www.leveehandbook.net/.

For further information, please contact Mike Wallis, HR Wallingford (01491 822373; E-mail: m.wallis@hrwallingford.com).

Assessing and managing climate risks

Climate change has two main issues – *Mitigation* of carbon emissions and *Adaptation* to be comfortable in the future climate. Many accept the drive for mitigation to radically reduce our CO2 emissions; adaptation is new on the block.

Design for Future Climate: Adapting Buildings is the largest programme on climate change adaptation of buildings in the UK. It is the brainchild of the Technology Strategy Board, which supports innovation in UK industry.

This work aims to engage the UK buildings industry in the opportunity of adapting to the changing climate by funding design teams to create adaptation strategies for 50 real building projects. The challenge is making buildings resistant or resilient to flooding, overheating and extreme weather events such as storms, through to the 2080s and beyond.

The programme has developed a guiding methodology for those preparing adaptation strategies, which has been found to give good results:

- **Qualitative assessment of client and users tolerance to climate risk**, such as hospital occupants needing close control of internal temperatures, housing developments focusing on flood risk and drainage;
- **Quantitative assessment of climate risks for the specific site** such as water management, thermal management and structural material stability using modelling and existing climate data sets from the Environment Agency, the UK Climate Impacts Programme and other sources;

The future climate is forecast to exhibit higher wind speeds and changes in rainfall that will affect soils and structures.

- **Options appraisal** and presentation to client on the subset of climate risks of most concern to their building project;
- **Detailed design and costing** of adaptation measures to manage these risks;
- **Creation with the client of an adaptation strategy** over the lifetime of the building.

This methodology gives clients appropriate information in a timely and costed fashion, enabling them to adopt recommendations for adaptation measures, for example, lining of basements now to prevent ground water ingress, but planning additional shading to manage overheating as part of the next façade upgrade. Every building project supported in the first half of the Design for Future Climate programme has adopted some cost-effective adaptation measures.

By following the methodology developed here, clients can avoid being overwhelmed with data and issues allowing them to focus on mitigating risks and keeping costs down over the lifetime of the asset.

For further information please contact Dr Fionnuala Costello, Technology Strategy Board (07824 599788; E-mail: Fionnuala.costello@tsb.gov.uk; website: www.innovateuk.org/adaptation).

Light steel wall tests to improve BS EN 1993-1-3

The use of light steel framing and modular construction has developed rapidly over the last 10 years and the design of light steel structures has become very efficient both from the structural design and the detailing points of view. BS EN 1993-1-3: *Eurocode 3: Design of Steel Structures Part 1.3 – General Rules – Supplementary Rules for Cold Formed Members and Sheeting, and its National Annexes*, was implemented in April 2010. Its use in practice has identified design problems and conservatisms in comparison to the former national standard, BS 5950-5.

One area in which the practical use of BS EN 1993-1-3 can be improved is in taking account of the stiffening effect of boards attached to one or both sides of walls and floors. Plasterboards or sheathing boards have an important effect on reducing the effective slenderness of the members and improvement in their buckling capacity, which is not taken into account in codified design methods.

The Steel Construction Institute has undertaken a collaborative research and testing project with Oxford Brookes University, Tata Steel Strip Products, Lafarge Plasterboard, and 4 of the main light steel manufacturers, to investigate the stabilising effects of the attachment of plasterboards of various types on the compression resistance of light steel walls.

The C sections that were included in the programme of tests were generic 100mm x 50mm x 1.6mm, 150 x 50mm x 1.2 and 1.6mm C sections in S350 steel that are produced by a range of manufacturers. The walls were all 2.4m long and 1.2m wide and were loaded in pure compression with boards on one or both sides. Resilient bars used to provide acoustic attenuation were also included in some tests. A total of 24 load tests were carried out, including 5 replicate tests on one configuration to evaluate the characteristic value for design.

(Top) *Typical light steel load-bearing wall and floor in a medium-rise residential building, also showing loading by bathroom 'pods'.*
(Above) *Mode of failure of light steel wall in compression with plasterboard attached on one side* (Oxford Brookes University).
Photo courtesy of Oxford Brookes University

It was found that when plasterboards are attached on one side, load-bearing frames can support up to twice the calculated load to BS EN 1993-1-3, as given by their minor axis buckling resistance. The typical load capacity of a wall was over 150 kN/m when using 100 x 50 x 1.6mm C sections placed at 400mm centres, which is more than sufficient for the loads acting on the ground floor walls in a 7-storey residential building. The mode of failure shown in the second illustration involves distortional buckling of the thin C sections, which mobilises the flexural stiffness of the boards and the pull-out strength of the fixings. When plasterboards are attached on both sides, minor axis buckling is prevented and the boards also provide some stiffening effect on major axis buckling.

With this test information, effective length reduction factors will be proposed that can be implemented as Non-Contradictory Complimentary Information (NCCI) when using the National Annex to BS EN 1993-1-3.

For further information please contact Andrew Way or Mark Lawson at the Steel Construction Institute (01344 636577; E-mail: a.way@steel.sci.com or m.lawson@steel.sci.com).

IRF distribution to change from next issue, with improvements to follow

We wish to remind readers that the Sponsors of *Innovation and Research Focus* have agreed to a significant change to the way IRF is distributed to Members and Fellows of the Institution of Civil Engineers, and to many contacts of other sponsors. We trust that it will enhance the usefulness of the Newsletter to those who prefer their technical information to arrive electronically, while maintaining the service to those who need or wish to receive it physically, whilst at the same time enabling us to send IRF electronically to all graduate and student members of the ICE.

From the next issue of *IRF*, to be circulated in the late Autumn, all Members and Fellows who presently receive a *physical* copy of *IRF* with *New Civil Engineer* and who have registered their email address with the Institution of Civil Engineers will receive their copy of IRF electronically. In addition, if you receive a physical copy from one of the other sponsors, they too are likely to be transferring to electronic distribution. This will augment the electronic mailing started with Issue 85 of sending *IRF* (by email) to Graduate and Student members of ICE for the first time.

All recipients with an email address logged with ICE, and those who have added their name to the e-circulation list on the website will receive an 'email alert' (see illustration) telling you that a new issue is available. It will include a link to the website so you can view the latest issue there, and a link to enable you to download a pdf copy of IRF, which you can of course print if your need or wish to.

But, if you are an ICE Member or Fellow or other sponsors' contact who does not have an email address or a quick internet connection, or would just prefer to receive your IRF as a physical copy, you will still be able to have one. We will seek to identify from sponsors which readers have not registered an email address and gather the addresses together. But the sure-fire way of ensuring, if you wish to, that you *continue* to receive a physical copy is to email the Editor's PA, Melanie Manton (irf@venablesconsultancy.co.uk), with your name, address, ICE Membership grade and number, or the name of the sponsor who sends you a physical copy, asking to be added to the IRF (physical) mailing list.

Innovation & Research Focus

IRF E-NEWS 1 AUGUST 2011

Dear Reader

The sponsors of IRF have decided to adopt a new policy for distribution of the newsletter, with most being electronic from November. So you are receiving this email because you have either signed up to the IRF mailing list or you are a member of ICE, a key sponsor of Innovation and Research Focus.

Innovation and Research Focus 85 is now available online. Browse some of the highlights of the new issue below or visit the website to read all the new articles. Alternatively you can download IRF 85 as a single pdf. Please do not feel you have 'missed' something because this issue is dated May yet your are getting it only in August. We had a delay and interruption to production outside out control, and are now getting back on track.

All of us involved in preparing and delivering IRF to you hope that you find this distribution method helpful but if you would still find a physical copy useful, please email my PA, Melanie Manton, with your name and full address.

Roger Venables, Editor, Innovation and Research Focus

We plan to use the resources saved by these changes to improve the IRF website, and to promote innovation in other ways. Candidate activities include:

- securing new sponsors under the new arrangements, and thus extending the scope and coverage of IRF;
- publishing summaries of and details of how to access results of studies sponsored by the ICE R&D Enabling Fund;
- providing additional links to built environment innovation resources;
- increasing the size of issues of IRF, now that printing physical copies will be a much smaller proportion of total costs.

For further information please contact the Editor, Roger Venables, or Melanie Manton at the address below.

SPONSORING ORGANISATIONS

GOVERNMENT

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Construction Sector Unit
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ABOUT *INNOVATION & RESEARCH FOCUS*

also on the web at www.innovationandresearchfocus.org.uk

Aims – The aim of *Innovation & Research Focus* is to promote the application of innovation and research in building, civil engineering and the built environment by disseminating new information as widely as possible. Its sponsors wish to promote the benefits of research and innovation, improve contacts between industry and researchers, encourage investment by industry in research and innovation and the use of results in practice, and facilitate collaboration between all the parties involved. Articles may be reproduced, provided the source is acknowledged.

Enquiries – If you wish to know more about a specific project, contact the person or organisation named at the end of the relevant article.

Mailing List – If you receive *Innovation & Research Focus* by direct mail (i.e. not with NCE) and your address is incorrect, please e-mail the Editor.

Editor – Professor Roger Venables at Venables Consultancy, 6 Electric Parade, Surbiton, Surrey, KT6 5NT, UK (020 3137 2375; fax: 020 8399 1650; E-mail: irf@venablesconsultancy.co.uk).

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