IABSE NEWS

Newsletter of the British Group of the International Association for Bridge and Structural Engineering

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Contents

British Group News

Editorial

Welcome to *IABSE News*, the newsletter of the British Group of IABSE.

The successful distribution by e-mail of the last edition of the newsletter in the summer has prompted publication of a second edition during the year, with the object of improving communications with members and raising the profile of the British Group. To this end, in this edition you will find information about the Annual Lecture by Mike Glover to be held on 9 December, news of the award of the Milne Medal for 2004 and a report on the proceedings of the 2004 Henderson Colloquium on 'Designing for the consequences of hazards'.

I am also pleased to be able to include a feature by Professor Chris Wise on the 'Constructionarium', an exciting educational initiative by which civil and structural engineering students are given the opportunity to put their appreciation of the practicalities of construction to the test.

Within the next month, the web pages of the IABSE British Group will be re-established, hosted on the website of the Institution of Structural Engineers, to which the Executive Committee is grateful for its assistance. The new pages will allow the wider publication of information from the IABSE British Group, most particularly the proceedings of the Henderson Colloquium. It is hoped in due course to expand the information available on the web to include the proceedings of past Henderson Colloquia and thereby bring the work of these events to a wider audience.

The next edition of *IABSE News* is planned for spring 2005 and I would be delighted to hear from any members who might wish to consider writing a short article on a subject of interest for publication, or who know of someone who might be persuaded to do the same.

With best wishes.

Andrew Martin
Editor

Events

Forthcoming IABSE British Group events are:

9 December 2004	5.00pm	Annual General Meeting Institution of Structural Engineers, 11, Upper Belgrave Street, London.
9 December 2004	6.00pm (Tea from 5.30pm)	Annual Lecture **St Pancras – Jewel of the Channel Tunnel Rail Link** Mike Glover (Arup) followed by Annual Dinner. Institution of Structural Engineers, 11, Upper Belgrave Street, London.

IABSE Annual Lecture 2004

St Pancras – Jewel of the Channel Tunnel Rail Link

On **Thursday 9 December** at 6.00pm at Institution of Structural Engineers, 11 Upper Belgrave Street, London, **Mike Glover** (Arup) will give the IABSE British Group Annual Lecture.

The opening in early 2007 of the 109km Channel Tunnel Rail Link (CTRL) and its London terminal, within the Grade 1 Listed St Pancras Station will mark a major milestone in 21st Century transport engineering in the UK. The lecture will place St Pancras within the context of the CTRL project and its overall objectives. The building, its surroundings and the requirements to keep existing train services operational, posed severe challenges to the design of the interchange. A 21st railway environment will be created within a listed 19th century building while maintaining the characteristics of the original. The resulting scheme, design development and construction will be described.

Mike Glover is a Director of Arup with wide experience ranging from the design of very tall building structures to the design and management of industrial facilities both in the UK and overseas for the commercial and industrial sectors. He has been responsible for a wide range of projects, including the signature headquarters building in Hong Kong for the Hong Kong and Shanghai Banking Corporation and for a range of offshore and onshore industrial engineering projects. Most recently, he has been involved in the planning, design and construction of the Channel Tunnel Rail Link. He is Technical Director and Deputy Project Director for all of these works.

Milne Medal 2004

Recipient of 2nd Milne Medal

The second IABSE British Group Milne Medal has been awarded to **Stephen Brown** (Buro Happold) in recognition of his designs for Millennium Point, Birmingham, St Catherine's House, London and the QEII Great Court at the British Museum, London.

The Milne Medal is awarded to an individual engineer for excellence in structural design and is named in recognition of the late Bob Milne, former Honorary Secretary of the IABSE British Group. The winner receives the Silver Medal, a certificate and a financial contribution towards attending an international conference to present a paper on their work.

The judges also gave high commendation to **Naeem Hussain** (Arup), who will receive a certificate to acknowledge his work on Hulme Arch Bridge, CTRL Medway Viaduct and Stonecutters Bridge, Hong Kong.

The Milne Medal will be presented to Stephen Brown on 9 December 2004, immediately before the Annual Lecture.

Stephen Brown

Naeem Hussain

New Members

The following new members have joined the IABSE British Group in recent months:

Stuart Alexander	(WSP Group, London)
Peter Hill	(Bridgemaster - Humber Bridge)
Hassan Jaufeerally	(Barkonsult Ltd)
K G Nenguwo-Khumala	(Mott MacDonald)
Peter Stone	(Research Engineers)
Bill Valentine	(Scottish Executive Development Department)

A warm welcome is extended to all.

Structural Engineering International

The ongoing opportunity exists for all members to have articles published in *SEI*, the international journal of IABSE. Rules for publication are available through the IABSE website at www.iabse.org. David Doran is the UK Correspondent for *SEI* and can offer assistance to prospective authors. His contact details are given in the Directory at the end of this newsletter.

IABSE Symposium - Shanghai, September 2004

Reflections and Impressions

Personal perspectives by ***Ian Firth***

Shanghai is a pretty vibrant place with an awe-inspiring amount of construction work going on. The Chinese are putting our meagre British efforts at infrastructure development and urban regeneration into the shade by building big bridges, tall buildings and other major structures at an astonishing rate. Much of this work is focussed in and around Shanghai, so this was an entirely suitable venue for this year's IABSE Symposium.

The headline theme was Metropolitan Habitats and Infrastructure which provided ample opportunity for the usual wide ranging subjects for papers and presentations. These included case studies on particular projects as well as several excellent papers on recent developments in areas of design and construction technology. It had been hoped that the theme would attract several contributions on the more philosophical aspects of constructing and maintaining metropolitan habitats and the associated social and cultural challenges, but sadly few of these materialised. Nevertheless there was some excellent material and as ever on these occasions the quality was generally of a very high standard.

The 3 day programme, preceded by the annual meetings of the Association, managed to cram in nearly 150 conventional lecture style oral presentations plus a further 80 or so papers presented one-to-one by the authors in so-called Interactive Sessions. In these latter presentations, authors discuss their work with interested participants in a more direct and intimate manner gathered round a poster displaying information relating to the subject. These kinds of presentation, previously rather uninvitingly called "poster sessions", are particularly well suited to some of the more technical papers and proved very worthwhile for that reason. Sadly space was limited so each poster was only displayed for one of the three days which was a shame.

The programme included keynote lectures from some of the world's leading speakers. In one of these, Man-Chung Tang from T.Y. Lin International tried to persuade a slightly sceptical audience that the self-anchored suspension bridge design for the proposed new Bay Bridge in San Francisco was good value for money, while in another Professor Zheng from Tongji University spoke of the astonishing history and planned future developments of Shanghai to an audience left wondering where all the money was coming from.

The BASAAR sessions provide an excellent opportunity for delegates to enter into debate and dialogue in a seminar style discussion on a subject or subjects of topical importance. These largely depend for their success on the ability of the chairman to prevent any speaker from speaking for too long (this is not intended to be just another oral presentation) and to encourage genuine participation from the floor. Sadly this didn't always happen, but there appeared to be several groups generating plenty of noise which is always a good sign of lively debate.

Outside the technical programme, I was fortunate enough to experience a ride on the new Maglev train which runs from near the city centre to Pudong airport. The train travels the 28 km distance in just 7 minutes, briefly reaching a maximum speed of 430 kph in the middle of the run. I was slightly surprised that the experience of travelling on a cushion of air was not a more silent one, but nevertheless the technology is impressive. Although initial costs are enormous, the running costs are said to be very low, so no doubt we will be seeing more of these for intercity travel in the future, even if it does mean threading a network of short span elevated viaducts throughout the countryside.

As ever, it was not only the technical content but also the important social interactions that made the Symposium worthwhile. We were treated to a first class welcome and organisation by our Chinese hosts who are to be congratulated for a very successful event. These annual occasions remain one of the highlights of the year and I can warmly recommend the next one which will be in Lisbon in September 2005. I hope to see you there!

Henderson Colloquium 2004

Designing for the consequences of hazards - an overview of the proceedings

Magdalene College, Cambridge. 5-7 July, 2004.
*Report by **Angus Low**.*

This overview gives a flavour of two days of presentations and discussions. It does not attempt to summarise the content of the papers and presentations, most of which will be published via the IABSE British Group website (see note at end of this article). Some of the presentations demonstrated how far the state of the art has progressed in computer modelling and physical modelling of impact and in displaying the complexities of structural behaviour. The challenge is to match this capability with a clarity of thought with which to direct our actions.

We start with the main conclusion: all buildings are potentially subject to accidental loadings and the only significant protection is via inbuilt 'robustness' however that may be defined. We agreed that engineers have the duty to provide robust structures but it is far from clear how this is to be achieved and to what degree. The issue is pressing since the new revision to Part A (Structure) of the Building Regulations will require 'a systematic risk assessment' of foreseeable hazards for a new - Class 3 - category of structures. This includes hospitals over 3 storeys, most other buildings over 15 storeys, public buildings over 5000 m^2 and stadiums accommodating more than 5000 spectators.

Is this a sensible list of structures to be assessed with risk analysis? What hazards should be considered? What risk is acceptable? Society's expectations are changing, and in the context of BSE a report had called for 'Zero tolerable risk'. How do we define and measure robustness? Should the process be prescriptive or should it be more free thinking? These were some of the thorny issues debated. There are of course well known failures from lack of robustness, starting with Ronan Point and the progressive collapse saga. It was noted that the tie force rules we use were conceived for this particular panel system structure, but are not so relevant for most current structures. More recently, the failure of Piper's Row car park is a forcible reminder

that robustness exists at a point in time and natural degradation processes superimposed on weak structures have the power to initiate sudden collapse.
In some industries, systematic approaches are made to assure capacity via the definition of basic fault or hazard loadings. The structure is then 'tested' against these. The nuclear industry is one such, achieving high reliability via this method. But the nuclear and other industries, such as the leisure industry in designing fairground rides, additionally require a systematic examination of the all the engineering disciplines involved in the project looking for what might go wrong, learning from past failures, seeking to minimise the chances of fault and eliminating the adverse consequences when the faults cannot be avoided - summarised as Prevent, Protect, Mitigate.

Never forget the Prevent option. It is standard in modern nuclear plant never to lift heavy loads for fear of dropping them and having to design against impact. In more normal industries there may still be choice. For example it was pointed out that we are building high value structures close to waterfronts where they are inherently at risk from ship impact. Siting them just a little way back achieves significant protection. Similarly, increasing the stand-off from blast loading is enormously beneficial

In bridge design, the approach to hazard and accidental loading is traditionally more prescriptive. Some of the presentations covered this area, and one made a plea that equivalent static loads should be specified with a defined duration so that designers would have the option to benefit from the resilience of their structures. One of the participants was responsible for a key standard in this area and was receptive to the idea. Hopefully there will be at least one clearly identifiable outcome from the Colloquium.

Impact loading on parapets and the risk of shipping collision for bridges over water are obvious dangers. Do they get too much attention? Taking ship impact as an example it is clear that probability and mitigation measures, as well as the costs of protection and the consequences of failure (both direct and consequential), are all matters to be weighed up and judged when deciding what the appropriate design basis should be. Bridge design also exemplifies the significant fact that economic losses to the community consequent on failure may be totally out of proportion to the costs of avoiding the loss in the first place. But what needs to be done? This is the classic dilemma of a low probability/high consequence event. In weighing up the pros and cons, the cost of business loss, the costs of life loss and the costs of asset loss all need to be weighed in the balance.

There were some participants nervous about risk based approaches because they could be time-consuming and they offered an apparent rigour which can often be deceptive. The choice of question that can be addressed is skewed by the availability of quantitative data. They are sometimes used simplistically in pass/fail systems which are administratively attractive and potentially less confrontational. There was a desire for the rigour of risk based approaches, without the constraints. Someone called for "risk assessment with imagination." The solution might lie in the presentation given on Bayesian statistical techniques because they can incorporate subjective judgements. It may be just what is needed to give value to the flood of risk assessments responding to the new Building Regulations.

While discussing numeric approaches to risk an anomaly was identified: The accepted risk of ship impact on a bridge is quoted in AASHTO and the ISO code as 10^{-4} p.a., whereas the risk usually accepted for variable loading is 10^{-6} p.a. Is this an inconsistency in structural practice, or is it a case that like is not being compared with like? Either way, it is clear that most engineers are unfamiliar with the magnitudes, and also the concepts, which underlie a numerically based risk approach.

The general mood of the Colloquium was that in high value structures especially there was real need for the exercise of professional informed judgement tempered by peer review when considering the likelihood of accidental loadings and how they should be treated. It was strongly felt that 'Regulation' should only be there in the background. In conducting any of these processes, the design team and owners must realise it is their prime duty to provide adequately safe structures and their first responsibility is to satisfy themselves rigorously that what they have done is enough. The Regulator may set the hurdles, but the team should cross them. The process should not be focussed on doing something just to satisfy the Regulator. His role should be limited to that of audit.

A comment was made on a difference between US and UK practices - characterised as US authorities emphasising the importance of the qualifications of the decision maker, and UK authorities putting more emphasis on recording the basis of the decision. Among the case histories presented to the Colloquium were two where design changes made without an understanding of the original design strategy had led to a failure and a near miss. The latter approach was favoured.

The Colloquium was reminded that experience shows we are unlikely to foresee all the demands made on the structures we design. Not least because of the increasing threat of terrorism - and even this is changing. We used to have bombs with warnings of their placement and location defined. Now we have bombers prepared to die and attacks with no warnings.

So we generally conclude that structures important to our national security and economic well being will be subject to accidental loading of some kind; some of these will be reasonably foreseeable, many ill defined but there is a fair expectation that over a long life our structures will be called upon to withstand loading as yet unimagined - genetically modified exploding squirrels were mentioned! The obligation is to provide a general measure of robustness. Codes can go someway to assisting in this but robustness is a more imaginative quality to be built in by experienced engineers: it is to do with structural form and a multitude of other attributes. There was a hope across the Colloquium to be able to measure or quantify robustness in some way. Formal concepts of "unzipping" and "clustering" were presented, but these are at an early stage. In the meantime the group felt there were various tests that could be made all pointing towards this elusive quality.

The presentations were diverse, but many common themes emerged. In dealing with many buildings, bridges and high profile facilities the loads and conditions to be sustained are necessarily vague. In nuclear structures, it is common to schedule out various hazards and extremes events which are described in the Design Basis, but beyond this there is a need to reflect on the actual structure, and how it will respond to the undefined hazards that might affect its safety. The nuclear industry also wrestles with the complex legacy of older structures beyond their design life, and yet still required to function. Engineers face the challenge of assessing the risks they pose and deciding what to do about them and their contents. It is accepted that many hazards may not be definable.

How to achieve robustness

The subject of robustness arose in all our discussions. The following is an attempt to indicate the view of the Colloquium.

Robustness is a mixture of:

- Understanding as much as we can about the hazards
- Providing an appropriate structural form
- Detailing rules
- Construction quality.

The degree of attention we give to hazards needs to be proportional to the building use. EN 1991 and the new revision to the Building Regulations provide a framework for this. the latter requiring, for Class 3 structures, a 'systematic risk assessment' of foreseeable hazards. The nuclear industry has a list of 44 hazards, but for most buildings it was suggested that the hazards were not knowable, and the undefined hazards could be 'enveloped' by three standard events:

- An internal gas explosion
- An external blast
- An impact.

These would provide a specific, quantitative test for robustness.

More generally, robustness of the structural form can be tested by posing certain qualitative questions:

- Is the structure redundant?
- Are there alternative load paths?
- Are the load paths diverse?
- Is the structure insensitive to minor deviations in material strength?

- - or in member position?
- Do we understand the mode of failure?
- - is it slow or sudden?
- Is the mode of failure ductile and energy absorbing?
- Is the failure stress or displacement controlled (the latter is far more conducive to robustness)

Some of these can be tested mathematically. The technique of 'push over analysis' used in seismic design will give insights into the collapse system and the ductility demand made on joints, and should identify the 'weak link'. Other techniques are being developed. Many experiences in blast resistance plus observations after earthquakes reaffirm the crucial role of joints in providing a frame with robustness. All joints need to be capable of carrying normal loads and be capable of sustaining imposed distortion without fracture. One of the presentations showed a simple design method for steel frames which put the strength in the connections, with considerable savings in the beams when compared to limit state design.

Another analysis technique to identify the mode of collapse, and the weak link, is to carry out a cliff edge assessment as adopted for nuclear structures. The performance of the structure under overload is examined to assess the closeness of the 'cliff edge'. Primarily there should not be one, certainly not one close. Rather the objective is to avoid sudden failure and to seek a progressive mode of ever increasing displacement.

We learn much by experience, and younger engineers need instruction in the mistakes of the past. We also learn from those structures that have been subjected to significant accidental loading yet have not collapsed. As a generality, the Colloquium felt that any 'innovative' structure would score minus points on the robustness scale simply because its behaviour may contain actions which are overlooked. There are plenty of examples of novel structures failing, as was demonstrated in one of the case histories presented.

Finally and collectively we conclude there is much to ponder, much to learn and much to do.

Participants and guests enjoying a short break from the formal business of the Colloquium in the gardens of Magdalene College, by the River Cam.

[Thanks are due to Angus Low, Dr. John Tubman and Prof. Haig Gulvanessian for organising the Colloquium on behalf of the IABSE British Group, and to the authorities of Magdalene College, Cambridge for the their hospitality. Ed.]

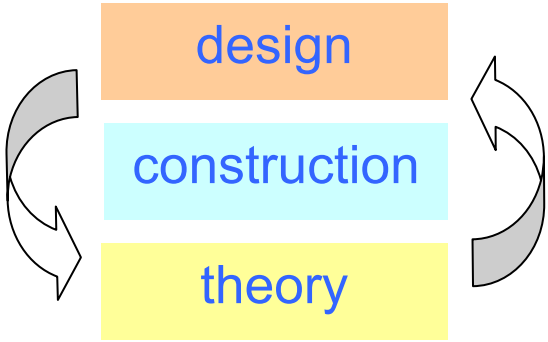
Feature

The Constructionarium

Professor Chris Wise
Chair of Civil Engineering Design at Imperial College London and Founder of Expedition Engineering.

> Constructionarium (L.); like an aquarium but full of construction

This summer the civil engineering students of London's Imperial College floated 25 tonnes of hand-crafted reinforced concrete oil rig into the middle of an artificial lake in Norfolk. There they sank it to the applause of their mates. They had personally experienced construction, and they were delighted.



If engineering is "the art and practice of changing the physical world for the use and benefit of mankind", it relies on the virtuous link between design, theory and construction. Nevertheless, construction and design in engineering education have always been rather slim portfolios. Recently they have dwindled in the face of large classes, small labs and problematic staff: student ratios. And the research imperative means that construction and design expertise is increasingly rare among academics. Something had to be done, and this year the 25 tonne oil rig was it, as part of a new educational venture called the Constructionarium.

The seed for this was probably Sir Jack Zunz of the Arup Foundation when in 1998 he instigated the Chair in Civil Engineering Design at Imperial College, held by the author. (Even Jack may not have imagined that "design" teaching would end up with 80 students up to their metaphorical necks in concrete and water in Norfolk in 2004). Fast forward from 1998 to the first major feedback session from that course in February 2002, attended by designers, lecturers, consultants and contractors interested in improving design at university. That evening, Stef Stefanou of John Doyle Construction said his company was really struggling to get value from the significant investment it made in engineering education. Challenged to give some of that investment to Imperial, Stef agreed on the spot to give £25,000, provided the university matched the figure. Shortly after, Stef and the author held a courtship lunch with 2 other passionate key players, Doyle's Peter Goring and Imperial's Ed McCann. Together, we decided to give the students real construction on a real site, as big, dirty, heavy and challenging as possible. This would engage students who were blissfully innocent of the charms of construction and had been starved of its satisfaction, let alone its link to their theoretical education. This link was later strengthened when Imperial's Alison Ahearn, who runs a course which gives Engineering a legal, communications and team context, joined the initiative.

We called it the Constructionarium, after the fish. The model of contractor: university: consultant was the basis of the concept. Doyles would provide site supervision and all equipment, training and materials; Imperial the students, academic supervision and space in the curriculum; Expedition Engineering design consultancy. Then to find a site for the pilot…….provided by the developer Stanhope at their award-winning Chiswick Park in west London. Here Doyles built a 60m artificial river up to 12m wide and 0.75m deep. Student teams were given drawings, materials, clothing and plant and asked to get on with it. In 5 eventful days in 2003 they successfully built:

- Rion Antirion Bridge: constructed in a dry dock and from boats
- Ponte sul Piave, constructed in precast segmental concrete over a gorge.
- Neves arch dam and its spillway system

They also tried to make concrete walls 2.5m high using standard formwork (donated and supervised by Doka), which proved trickier.

Along the way they learned the benefits of a communal concrete plant and having someone competent in charge.

The pilot was so enjoyable and satisfying for all involved that it has evolved. The Constructionarium now has a permanent site at the National Construction College in Norfolk, open all year round to any university. Its 2 hectares has a scaled-down river which flows through a gorge into a 4m deep lake, mountains, and deliberately dodgy sites with porous strata and high ground water. There are 16 sites, each 900m^2 , where all sorts of projects can be built. Here the Constructionarium can easily be tailored by universities to suit their specific curriculum.

In its new home in 2004, the students tackled projects familiar to the consultants (part of their fun):

- The guyed Torre de Collserola, Barcelona
- Canary Wharf Underground Station, in water-bearing sandy sludge
- Expedition's double bow footbridge at Stockton-on-Tees
- A concrete gravity oil platform built in a dry dock and floated into position

For each project students form a construction company about 20 strong. Each runs as a real construction site for the week. Everyone receives a full safety induction (this proved useful when small practice bombs were found on the old airfield site). Students do everything themselves, as labourers, foremen, schedulers, managers and estimators. They practice with formwork, concrete and steel, steel-fixing, are trained in power tools, and visit the National Construction College to see other construction plant and people in action.

The contractor checks method statements for each activity, and risk assessments. The constructionarium has developed its own plant and labour rates to suit the telescoped time and scale of the projects but still give a credible out-turn cost. Where teams fall behind, they can ask for expert help or equipment, although this is added to their out-turn costs. Here there are some painful lessons: even though an excavator costs £25,000/hour, one team this year had a machine on standby for 36 hours "just in case". (They didn't hit their tender price and their claim for "unforeseen ground conditions" was rejected by the client).

So far about 150 Imperial undergraduates have built real construction projects under Doyles' guidance. In 2005 at least another 150 students from Leeds and Imperial will share the experience, with Shepherd's working with Leeds.

The regular, practical construction projects have changed the Imperial MEng curriculum, now forming the first part of the students' five week group design project in the 3rd year and informing the rest of it.

An activity like the Constructionarium isn't free, of course, and this begs the question of value. Altogether the investment by the construction and design industry exceeded £70,000 in 2004, and happily the fruits of this investment are now available to those who follow at CITB. Imperial believes the scheme has enormous value, both as an introduction to the mysterious world of building things, and also in improving the students'

understanding of everything else they learn. In the Imperial model, the university only pays for travel and accommodation (about £250 to £300 per student). Other costs are borne through the scheme's many other enthusiastic industrial contributors who include CITB, The Arup Foundation, The Concrete Centre, John Doyle Group, and Shepherd Construction.

From its simple beginnings, the Constructionarium is evolving into a sustainable model with a life of its own. It partly fills a very important hole in engineering education. It is a great opportunity for those involved to show their commitment to the future of their industry. And it provides one of the most rigorous down-to-earth interviews that an engineering company can hold with some of the brightest engineering undergraduates. As some students admit they have never even put up a shelf, the learning curve is very steep when faced with a 30 tonne excavator. For some students, it is a life-changing experience. For others, it just makes them want to get designing and building for real. And for everyone, just as in real engineering, it's a terrific adventure. Those involved believe it should be an integral part of 21st Century engineering education and hope that their example will inspire others to follow suit.

Quotes from the Constructionarium 2004 by 3rd year students, together with some images of the projects undertaken.

"what a foreman might say contradicts what we have been taught"

"if you don't understand the basics then you can't possibly master anything more complicated"

"Some might find it strange that a student would want to dig holes"

IABSE British Group

Chairman
Professor D.A. Nethercot FREng FCGI
Imperial College, London

Vice-Chairman
Dr J.B. Menzies FREng
Consultant

Hon. Secretary
Dr G.P. Tilly
Gifford & Partners, Carlton House, Ringwood Road, Woodlands, Southampton. SO40 7HT.
Tel/Fax: 01252 621430 (H) E-mail: Graham.Tilly@tesco.net

Hon. Treasurer
Mr A.C. Oakhill
Gifford & Partners, Carlton House, Ringwood Road, Woodlands, Southampton. SO40 7HT.
Tel: 023 8081 7599 Fax: 023 8081 7600 E-mail: tony.oakhill@gifford.uk.com

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Mr A.W. Hill	

'Structural Engineering International' UK Correspondent
Mr D.K. Doran
Tel/Fax: 020 8989 9082 E-mail: David.Doran@btinternet.com

Editor of 'IABSE News'
Andrew Martin, Arup, Admiral House, 78 East Street, Leeds. LS8 9EE.
Tel: 0113 242 8498 Fax: 0113 242 8573 E-mail: andrew.martin@arup.com