



IABSE UK NEWS

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

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The lost art of prestressing?



Clackmannanshire Bridge, design by Simon Bourne with Benaim

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IABSE British Group News

Editorial

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

It has been roughly six months since the last newsletter, and in that time there has been a great deal to report.

This time we have reports on two IABSE conferences overseas, in Egypt and South Korea, as well as several reports on the British Group's Young Engineers' Conference, *The Future of Design*, which was extremely successful, attracting a number of prominent and interesting speakers, and an enthusiastic audience. It's very pleasing to report that there are plans to repeat the event next year. There are also reports from this year's Henderson Colloquium, and our annual Milne Medal Lecture (see front cover).

Hopefully all readers will have read in *Structural Engineering International* of IABSE's initiative to transform its activities, to become less formal and address the needs of international engineers more flexibly. A large part of this includes supporting rather than constraining the organisation's national groups, and the British Group are well placed to take advantage of this, with our chair David Nethercot recently announced as the next President of IABSE. A number of possible activities have been discussed by the Executive Committee, including a major refresh and expansion of our internet presence, but if members have their own ideas, please get in touch!

Regards, Brian Duguid, Editor

Events

<u>Date</u>	<u>Time</u>	<u>Event</u>
14-15 February 2013		<u>IABSE Workshop - Helsinki</u> <i>Safety, Failures and Robustness of Large Structures</i> Call for papers by 30 September, 2012
6-8 May 2013		<u>IABSE Conference – Rotterdam</u> <i>Assessment, Upgrading and Refurbishment of Infrastructures</i>
9 May 2013		<u>IABSE Annual Lecture</u> Details to be confirmed, date subject to review
2013		<u>Study tour of Spain</u> Dates and details to be confirmed
July 2013		<u>Henderson Colloquium</u> Details to be confirmed Theme: “ <i>Learning from mistakes and failures</i> ”
12 September 2013		<u>Young Engineers' Conference</u> <i>Future of Design</i> University College of London
24-27 September 2013		<u>IABSE Symposium – Kolkata</u> <i>Long Span Bridge and Roof Structures – Development, Design and Implementation</i>

Unless noted otherwise, all events take place at the Institution of Structural Engineers, 11, Upper Belgrave Street, London. Tea is usually served before evening lectures and meetings from 5.30pm.



IABSE on the Internet

The website of the British Group can be accessed at <http://www.iabse-uk.org/>, where proceedings of Henderson Colloquia and back editions of *IABSE News* are available in downloadable form. We will be looking at refreshing and expanding the information available on the website during 2013.

The international website of IABSE at www.iabse.org contains comprehensive information on IABSE organisation, activities and publications.

The IABSE website includes online versions of a number of the Structural Engineering Documents. The following are available to members who log in (the first four are otherwise out of print):

SED 1 – *Concrete box-girder bridges*

SED 2 – *Dynamic response of reinforced concrete buildings*

SED 3 – *Vibrations in structures*

SED 4 – *Ship collision with bridges*

SED 12 – *Case studies of rehabilitation, repair, retrofitting and strengthening of structures*

A historical archive of documents from IABSE conferences and journals, from 1929 to 1999, is also available, and is free to both members and non-members: http://retro.seals.ch/digbib/en/browse5_2

Disclaimer

The views and opinions expressed in IABSE UK News are those of the respective authors and not those of either the Executive Committee of the IABSE British Group or the Editor. Whereas effort has been made to ensure the accuracy of statements and acknowledgements, we reserve the right to be as wrong as everyone else.

Membership News

Scrambled data? Are you or a colleague having difficulty receiving your Structural Engineering International, or do you know of errors in your name and address used by IABSE? Please pass any queries or corrections on data held by IABSE to the Membership Assistant in Zurich, brigitte.killer@iabse.org.

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. Brian Duguid is the UK Correspondent for *SEI* and can offer assistance to prospective authors (see Directory). Forthcoming issues are expected to include the following themes:

February 2013 – Recent structures and research in India (*submissions closed*)

May 2013 – Seismic engineering (*submissions closed*)

August 2013 – General reports (*abstracts due 10 Dec 2012*)

November 2013 – Assessment, Upgrading, and Refurbishment of Infrastructures (*abstracts due 10 Dec 2012*)

IABSE Conference – May 2012 – Sharm-el-Sheikh, Egypt

Global Thinking in Structural Engineering: Recent Achievements

Report by Natasha Watson, Buro Happold

On the flight to the Spring Conference 2012 in Sharm El Sheikh I was a little nervous. It was my first international conference and my paper on evaluating the market barriers to entry for non-conventional building materials was one of the 93 papers chosen for oral presentation to, quite literally, engineers from all over the world. This thought didn't help the nerves.

On arrival at the conference I was delighted to see the diversity of the delegates who had come from over 30 different countries; designers, contractors, academics, suppliers, and government representatives. This



diversity was evident in the keynote speeches which ranged from designing bridges in Africa, to solar thermal power generation, to an overview of how the Fehmarn Bælt Tunnel which strengthens the connection of Germany and Denmark was constructed. The parallel sessions also covered a wide range of topics, having to be split into three key areas; ‘structural engineering as part of multi-disciplinary systems’; ‘sustainable development and structural engineering’; and ‘smart structures, new materials and construction technique’.

Between the keynote speeches and the parallel sessions, there was ample opportunity to talk to the other delegates and share ideas over coffee, lunch, and at the spectacular conference dinner. Even though I had attended the conference on my own I could always find someone interesting to chat to; one of the keynote speakers had even once worked in the same office as myself 10 years prior!

In the end there was no need to be so nervous about giving my presentation; my audience were friendly and attentive and the Q&A session afterwards was a very interesting and informative insight into how to increase the use of non-conventional building materials such as unfired clay brick and hemp-lime in the U.K. I was able to draw on the collective minds of delegates as well as showcase my research to engineers the world over, something that was only possible by attending such a well recognised and respected conference.

Henderson Colloquium – July 2012 – Getting real value in construction

Report by Angus Low, Arup



Front row left to right: Sarah Williamson, Cam Middleton, Paul Sanders, Gerard Canisius, Angus Low, Chris Burgoyne, Giles Waley

Back row left to right: Jeff Young, David Place, Brian Bell, Mungo Stacy, Paul Vardanga

“Getting real value in construction” was the topic addressed by 15 invited participants at St. Catherine’s College, Cambridge, from 9th to 11th July 2012, under the leadership of Professor Campbell Middleton. Each year The Henderson Colloquium provides a wonderful, relaxed environment in which to engage fully over



two days with a topic of current interest. There are so many opportunities for earnest discussions, or just getting to know each other. Each participant presents their ideas and there are chaired discussion sessions. In the past it has been a good forum for airing controversies, and hence much of what is said goes no further. The topic had been chosen in the belief that the various industry-wide initiatives of recent years had resulted in many changes, but not necessarily in cost savings. However the consensus view was that the new procurement methods are working, but there is more to do.

Speakers included engineering designers, engineering academics, one contractor and one client representative, so the discussions crossed the contractual divides that often inhibit open discussion. The range of the discussions is clear from the titles of the presentations:

- *“Getting real value in construction”*, Professor Campbell Middleton, Cambridge University
- *“What represents value to a construction client?”*, Brian Bell, Network Rail
- *“East London Line project”*, David Place, Mott MacDonald
- *“Value – an illusive quality”*, Jeff Young, Mott MacDonald
- *“Humber Bridge cable dehumidification system design”*, Mark Bulmer, Aecom
- *“Understanding value: the role of the designer”*, Paul Sanders, Flint & Neill
- *“Manchester Metrolink: Lessons from 100 bridges”*, Mungo Stacy, Parsons Brinckerhoff
- *“A personal perspective”*, Dr. Sarah Williamson, Laing O’Rourke Centre for Construction Engineering & Technology
- *“Deriving value through the procurement process for major crossings”*, Andrew Yeoward, Halcrow
- *“Is value in the eye of the beholder?”*, Tony Harris, Parsons Brinckerhoff
- *“Who gains from modern contracts?”*, Dr Chris Burgoyne, Cambridge University
- *“Achieving real value”*, Giles Waley, BAM Nuttall
- *“Value through deep design”*, Angus Low, Arup
- *“Acceptance of risk for better value construction – some thoughts”*, Gerard Canisius, URS

Dr Paul Vardanga, Cambridge University, acted as scribe. His report will be posted on the IABSE British Group site, within the IStructE web site.

The general feeling was that the move towards a culture of openness across contractual divides was delivering benefits. Design-and-Build and Early-Contractor-Involvement give constructors opportunities to marry the design to the needs, and to plan the works around safe working, and cost-efficient delivery. But the industry is operating on project by project horizons. Further savings require an undertaking from government to commit to longer term investment plans which will, in turn, allow the industry to invest across projects. There was some dissention. Is it obvious that the new procedures provide contract costs as low as those resulting from the cut-throat bidding practices of old?

Young Engineer’s Conference – September 2012 – The Future of Design

Report by Angus Low, Arup

Young engineers set the agenda for a very full and positive day of Keynote Speakers, Presentations by young engineers and structured discussions, all on aspects of the future of design. The event combined the Young Engineers Conference of the British Group of IABSE and the Kenneth Kemp Seminar of the Institution of Structural Engineers. More than a hundred congregated at University College London on 13 September 2012.

The young engineers, led by Lee Franck and Jumana Al-Zubaidi, had assembled an impressive array of leaders and thinkers from the profession. A clear theme was a plea for designers to engage with the wider context of their work. Sir John Armitt, fresh from delivering the infrastructure for the London Olympics and



Paralympics, expressed it as addressing the Why of a project, as well as the What and the How. Several speakers addressed sustainability issues. Jane Wernick went further and said that happiness should be our goal, and proceeded to show us a series of projects which clearly demonstrated how to achieve it. Tristram Carfrae gave us insights into design as exploration. Feel free to start again. And when we get there, and it is all built, we should be much better at telling people what we have done.

The Young Designer Presentations took us into details of their own work. Two winners won £250 and a year's IABSE membership: Stephen Wilson of Ramboll UK with "*The design of Derby Cathedral Bridge, a unique cable-stayed swing bridge*", and Edward Kwong of Arup with "*The world's longest rope bridge*".

Young engineers aspire to a gracious life and the day extended into the night with fine dining to the accompaniment of a jazz quintet. Old had been asked to sit next to young and in the convivial atmosphere there was a real sense of experiences being passed between the generations.

Organiser's report by Jumana al-Zubaidi, Imperial College / Mott MacDonald

The IABSE British Group Young Engineers Conference 2012 was entitled Future of Design. The conference was a one-day event held on the 13th September at University College London.

The aims of the event were:

- To **bring together** young design professionals from engineering, architecture and academia
- To **inspire** young design professionals through presentations on the design process behind iconic projects by leading figures in the construction industry
- To **increase awareness** amongst young design professionals about issues facing the engineering and architecture industry and to **involve** them in discussion about these
- To stimulate **communication** between experienced figures in the industry and young professionals entering the industry
- To give young design professionals the **opportunity** to present their own work

The Future of Design attracted 107 participants from engineering and architecture backgrounds from around the UK. A third of the delegates were students and the rest were young practicing professionals.

The organising team comprised Jumana Al-Zubaidi from Mott MacDonald and Lee Franck from Arup. Ian Liddell of IABSE British Group and John Eyre of UCL provided advice and guidance.

The programme for the day was extremely busy. The morning was filled with key note lectures followed by lectures from eight young engineers. Discussions on topics including Design Teaching and Bridge Design were held in the afternoon in parallel sessions allowing delegates to choose which sessions to attend.

Following on from the conference itself, a drinks reception and dinner allowed the young delegates to network with their peers and the inspiring key note speakers.

The event was a great success with much positive feedback received from speakers and delegates. *The Future of Design* is now proposed to become an annual event held in September aimed at Young Design Professionals.

Attendee's report by Anthony Chrimes, Mott MacDonald

Why did I choose to attend the Young Engineer's conference? I have never attended an IABSE event before, and this one seemed like a gentle introduction to the conference scene. It would be a relaxing break from the office, a chance to top up those CPD hours, do a bit of networking, and meet up with some old colleagues and friends.

But when I got the chance to read through the timetable it seemed that I couldn't have been more wrong! We faced a very busy schedule of lectures, presentations and discussions. Few people I spoke to thought such an ambitious programme was feasible ...



A busy morning of keynote lectures kicked off on a happy note with Jane Wernick's talk on "*Engineering Happy Walks*", which discussed how our built environment can affect our state of mind, with Kew's treetop walkway as an example. Katerina Dionysopoulou spoke to us about some of the designs that have come from Heatherwick Studios, and I think the entire audience was enthralled by her description of how the Olympic torch was conceived and crafted. This lecture on the fine detail of the design of the Olympic centrepiece was in marked contrast to John Armitt's later talk on the vast challenge of delivering the Olympic project as a whole.

The afternoon started with young engineers' presentations. There was a mix of presentations from architects, engineers, and other designers, with themes ranging from retrofit and remediation to record-breaking footbridge concepts. These were followed by discussion panels. I attended discussions on bridge design and design teaching. The discussion about design teaching seemed to touch some raw nerves and a rift opened between the older and younger engineers in the room! We pondered the question of whether or not design is something that can be taught, and the origin of differing philosophies of design between engineers and architects. The consensus of engineers young and old seemed to me to be that teaching of engineering design is in a bad state, which is a cause for concern for all of us who care about the subject.

Another round of keynote lectures separated us from the drinks reception. Famous projects were namechecked such as the Centre Pompidou, London's Lloyds Building and Heathrow Terminal 5. We needn't have worried about the programme, as the well-organised event finished on time, and soon we were on our way to the Bloomsbury Hotel for a wonderful evening dinner and entertainment at the Bloomsbury Hotel.

Highlights

Although this was the "young engineers" conference it was enriching to hear from a number of speakers who share my interest in design but come from very different professional backgrounds. It was also beneficial to hear from some very high calibre speakers such as John Armitt, speaking about the delivery of the Olympics and reminding us all of the hard work behind London's "Golden" summer of 2012.

For me, the highlights of the whole day were the young designer presentations. Tom Osborne's talk on footbridges over railways and Edward Kwong's "*Worlds Longest Rope Bridge*" stood out for me personally. But everyone will have their own favourites.

Lastly, at the Young Engineers' conference it was satisfying to meet so many of the older generation of engineers and other professionals who still have a passion for design, even though we know from their heartfelt lectures that engineering projects are a constant source of stress! The theme of the conference was the Future of Design and it aimed to promote design and inspire future generations. It certainly left me energised with renewed enthusiasm for my chosen career.

I was asked to write a short report on "the delegate's view" of the conference. My report is a reflection on my own experience on the day and will be subjective. I hope that everyone else got as much from the day as I did. From speaking to many other delegates through the day I got the impression that most shared my satisfaction, and gratitude for the organisers' hard work.

I look forward to the chance to attend an IABSE event again, and will certainly be recommending the next Young Engineers' Conference to other young designers.

Report by Antony Oliver in New Civil Engineer, 20 September 2012

The event received excellent coverage in *New Civil Engineer* magazine, and their report is reproduced with permission at the end of this newsletter.

Milne Medal Lecture – November 2012 – Simon Bourne: Prestressing, Recovery of the Lost Art

Report by Peter Curran, Ramboll

In front of a packed Institution of Structural Engineers the 2012 Milne Medal was awarded to Simon Bourne, an internationally renowned expert in the field of prestressed concrete, and a former owner of consultant Benaim. The Milne Medal is a unique award, made in memory of the late Bob Milne, in that it seeks to recognise an individual's exceptional contribution to design in the field of structural engineering, and in this respect Simon was a worthy recipient.

Following the award, made by David Nethercot, Chairman of the British Group of IABSE, Simon gave a pacy and punchy presentation entitled "Prestressing – Recovery of the Lost Art" which focussed on the demise of prestressing, and then explored if and how the relevant skills could be recovered.

It was suggested that the demise of post-tensioning in the UK could be traced back to the mid eighties with the collapse of the Ynys-y-Gwas bridge and the subsequent moratorium on grouted post-tensioning which was imposed by the Highways Agency. In response the Concrete Bridge Fevelopment Group, of which Simon is now the Chairman, explored and developed improved specification for grouting of tendons, assisting the Concrete Society to publish its work in the state of the art guide TR47. However, the damage was done and since that time very few internally post-tensioned bridges have been built in the UK, and those which have been built,

have been externally post-tensioned rather than internally, something that Simon suggested was regrettable. This in turn has permitted a significant growth in the use of steel composite construction and a significant loss of skill not only in the design of prestressed bridges but also in contractors' abilities to both price and construct such structures. But can this position be recovered and if so, how?



River Dee Viaduct, Benaim

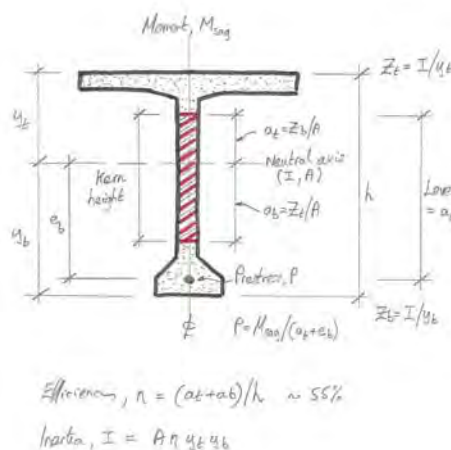


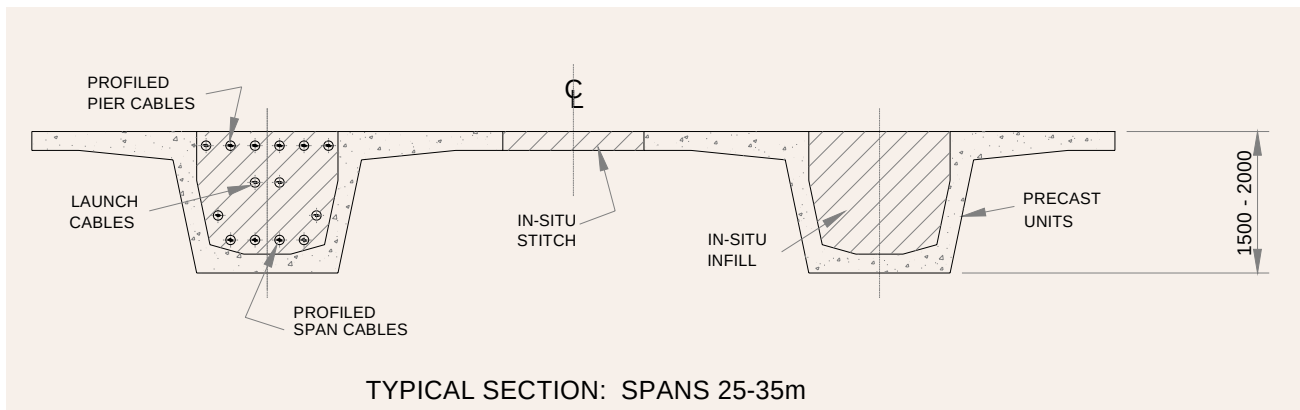
Diagram explaining kern height

zones and the difference between external and internal loads was given, followed swiftly by an exploration of the different bridge types and construction methodologies which could be adopted, with an impressive array of real examples given.

Simon then made a detailed comparison of sections, reinforced, partially prestressed, fully prestressed and steel composite, and summarised the different structural aspects, advantages and disadvantages of each, concluding with an all-important summary of relative costs. Simon concluded, perhaps not surprisingly, that

Simon's starting point for recovery was to promote simplicity in design. He recalled the Benaim mantra of making the complex simple, and advocated a shift away from complex finite element analysis and a move back to a more fundamental appreciation of good design and an understanding of the fundamentals of engineering. No amount of FE analysis will correct an inappropriate solution he suggested, and such sophistication was often unnecessary with high levels of perceived accuracy simply not justified. Keep it simple he said and focus rather on making things easier to build.

Fundamental to recovery was an understanding of prestress as an active system. A clear summary of the basics of prestressing such as kern height, parasitic moments, the behaviour of anchorage



Concept for modular post-tensioned bridge incorporating precast shells

prestressed concrete was the most cost effective. It was acknowledged that there are natural variations in such an assessment but the point was well made that prestressed concrete is an appropriate efficient structural material and one that should be considered if UK designers and contractors are to compete internationally.

A lively question time then followed the presentation with the first questioner suggesting that actually the issue wasn't with designers but rather with contractors and that UK contractors had simply lost the skills and understanding of the material and that this should be a major area of focus, again if we are to compete internationally.

A straw poll was taken of the younger members in the audience, of which there were an encouraging number, of their experience of prestressed concrete teaching at university. This seemed generally good with the response that in Switzerland it was very good, Spain very common but also covered in the UK which again, it was suggested by one questioner that the issue might be in construction rather than just design.

Simon was pressed for his view on the form over function debate with particular reference to recent views expressed on the proposed Wear Bridge, but resisted the somewhat overt attempt to generate further controversy, rather offering a wry smile in response.

A very informative and enjoyable evening concluded with a humorous and grateful vote of thanks given by Angus Low of Arup.

IABSE Congress – September 2012 – Seoul, Korea

Report by Ian Firth, Flint and Neill

Landing at Seoul's Incheon airport on the tail of a typhoon was a somewhat lively and disturbing experience! And as if that wasn't enough, emerging exhausted after a nearly 2 hour journey on the metro to drag a heavy suitcase through torrential rain to my hotel didn't exactly put me in a buoyant mood. However, although I arrived soaked and suffering from lack of sleep it was not enough to dampen my expectations, and after that somewhat inauspicious start, the rest of my visit to the 18th Congress of IABSE and the Annual Meetings that immediately preceded it was thoroughly enjoyable and worthwhile.

As always on these occasions, it was great to meet up again with friends and colleagues from all round the world, and to hear what everyone is doing. It seemed as if the intervening year had passed in just a flash and it was only yesterday that we were all in London exchanging news and views. These events are undoubtedly the most important gatherings for finding out what is happening around the world, what projects are underway, what is in the pipeline and what is new in the world of bridge and structural engineering. Not only that, but among the presentations there are always some that teach you something that you didn't know or that you didn't know you needed to know. It also has to be said that there are also sometimes one or two that you didn't know that you didn't need to know!

This year, meeting in Seoul, it was no surprise that the programme included coverage of several extraordinary and awe inspiring projects that have characterised the output of many Asian engineers and designers in recent years. Coming from the UK where the scale of our construction industry seems tiny by comparison, it was certainly an eye opener to learn what has been going on in Korea and the surrounding region.



Yi Sun-sin Bridge

Certainly there was a fair representation of mega-projects on the menu, such as the Yi Sun-sin Bridge and the Busan-Geoje Fixed link for example. But in addition, and rather more significantly given the theme of the event, there were many presentations on smaller scale projects. Not surprisingly, several focused on sustainability and the effects of our endeavours upon the planet and its human population. On the first morning we were challenged by Tobia Zordan in his keynote address to think about why we do what we do as much as how we do it. Reminding us that since 1972 we have been in overdraft - consuming the planet's natural resources faster than they can be regenerated - he urged delegates to act more responsibly and aim for genuine sustainability, and not necessarily to do something just because it can be done. So, although I was impressed by the big projects which are always good to hear about, I was also excited to learn about short span bridges in the USA made from recycled plastics, research in Germany using bamboo shells as concrete reinforcement, and other novelties.

I was unable to join any of the technical excursions or social visits, but as usual there was a variety of options to suit most tastes. Seoul is not without its attractions, and I understand that delegates enjoyed what was on offer. I did, however, attend the Congress Dinner at which we were entertained by an extraordinary performance of knife-wielding chefs using kitchen utensils as percussion instruments! How they ended the evening with all their fingers and thumbs still attached is beyond me. Terrifying! Oh, and the meal was good too!

As usual, the Annual Meetings of the Association took place immediately before the Congress itself, at which we debated some changes to the organisation of the Association designed to encourage the National Groups to be more active and thereby attract more members. You will be hearing more about that in these pages in future issues. But for us in the British Group, the most significant piece of news coming out of these meetings was the election of our very own David Nethercot as the next President of the Association. This is a very high honour indeed, and David follows a long and illustrious line of well known and highly regarded engineers from around the world who have distinguished this office over the years. He will take over from Predrag Popovic at the conference in Kolkata next September. I hope many of you will be there to mark the occasion and support him as he embarks on his 3 year term of office. Congratulations to David from all of us.

Altogether, Seoul was yet another first class event, which was very well organised. Having been responsible for organising the conference in London last September I know what it takes, so I can appreciate the excellent job the organisers in Seoul did this year. I would like to warmly recommend these gatherings to all British Group members and their guests. Look out for the next one in Rotterdam in May and then Kolkata in September. I hope to see you there.

Young Engineer's Conference – Joint Winner, Young Speaker

The Design of Derby Cathedral Bridge, a Unique Cable-Stayed Swing Bridge

By Stephen Wilson, Ramboll

Summary

Derby Cathedral Bridge opened to the public in April 2009. The bridge is part of a wider masterplan regeneration providing access between a new residential development to the east of the city and the historic Cathedral Quarter in the City Centre. The bridge also forms a focal point in the re-landscaped Cathedral Green, and is sympathetic to the adjacent historic architecture of the Cathedral and the Silk Mill.

Inspired by Derby's textile industry, the bridge's unique design won a national design competition in 2007. The structural form is a cable-stayed swing bridge, rotating in a horizontal plane clear of the river channel in the event of flood. The deck and mast are both slender, mild steel box girders with three locked coil cable-stays providing the connection. To satisfy the tight site constraints at each abutment, the deck structure is kinked in plan providing a 30 degree elbow at the pivot point. This also allowed the incorporation of a structural backspan which links across the reinstated historic Mill Race and increased the material efficiency of the bridge.

The mechanical drive is provided by a hydraulic motor at the rear of the bridge, pushing the tail-end bearing around a geared track fixed to the soffit of a reinforced concrete ring beam. The bridge rotates about a pivot bearing located beneath the mast.

Architectural Intent



The bridge takes the form of a cable-stayed swing bridge. The bridge deck is approximately 58m long and is supported by three locked coil cable-stays off a 20m high tapered mast structure.

The design concept is drawn from the world renowned local textile industry, an industry which in turn owes its prominence to the fast flowing waters of the River Derwent, once utilised to power the mills in the area.



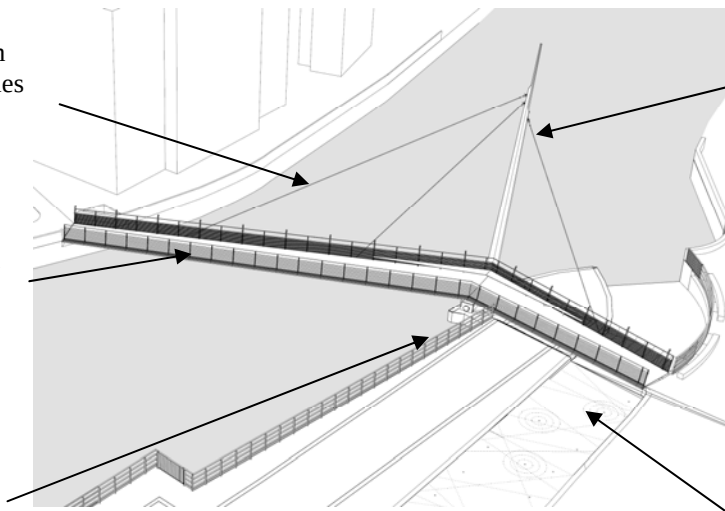
The basic form is derived from a tailor's shears, in particular the action of the hinged blades as they open and close. The bridge deck is equivalent to one of the blades, with the pivot along its length and the force to open and close the shears applied at the opposite end.

Structural Elements

Cable-stays – 3no. 50mm diameter locked coil cables connect deck and mast structures

Deck mainspan – plated box girder spanning 38m between pivot abutment and nose-end abutment

Arm beam – concealed beneath elbow in the deck, connects bridge to central wheel and pivot bearings



Mast – 22m high plated box girder inclined at 15 degree angle away from elbow in bridge deck

Deck backspan – plated box girder spanning 19m between pivot abutment and concealed RC ring beam along tail-end of bridge

Deck and Mast Precambers

A significant challenge in the design, fabrication and erection of Cathedral Bridge was the control of the structure's cantilevered self-weight deflection.

To provide a flat deck surface and a straight mast in the permanent condition, theoretical dead load deflections were mirrored by a precambered profile. Whilst supported on temporary trestles, the precamber saw the deck and mast fabricated and set-out such that the nose-end of the deck was raised over 1200mm and the tip of the mast was lent back approximately 500mm respectively from their permanent positions.

Thermal Movement

The bridge is highly sensitivity to vertical thermal fluctuations. Using the FE analysis model, the range in theoretical temperature gradients was shown to result in a variation of deck tip level of approximately 200mm between its lowest and highest positions. This challenge was overcome with a staggered ramp solution.

Conclusions

Cathedral Bridge was successfully completed and opened to the public in April 2009. It has been extremely well-received by the public and has encouraged more people to use the green space in the city centre and visit the Silk Mill museum.

The bridge has satisfied the client brief, providing a link to the city centre and complementing the existing architecture in and around the new Cathedral Green. It was used as a focal point in the 2009 summer festivals and now forms part of Derby City Council's marketing campaign to encourage tourism in the city.

Its innovative design and successful implementation has been recognised in three industry awards – winning the British Construction Industry Small Civil Engineering Award and shortlisted in the Institution of Structural Engineers Pedestrian Bridge Award and Corus Structural Steelwork Awards.

Young Engineer's Conference – Joint Winner, Young Speaker

The World's Longest Rope Bridge

By Edward Kwong, Arup

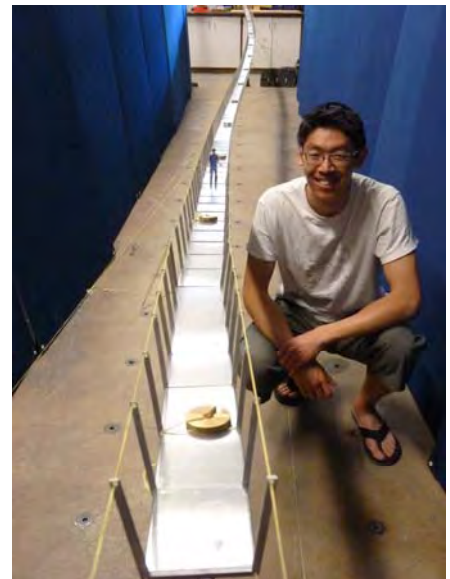
Introduction

An ambitious and unique S-shape design was proposed for the world's longest pedestrian rope bridge. It would form a tourist attraction on a site spanning 180m on disused railway abutments across the River Tees, in the town of Barnard Castle, County Durham, UK.

The design elegantly implements a diagonal stay cable to prestress it into this shape, while simultaneously giving the system its stiffness.

Much of the design and analysis was carried out using a full scale model of the bridge made from Kevlar wire and aluminium (pictured right), in conjunction with a finite element model in ABAQUS.

The title of 'world's longest rope bridge' has since been superseded. Nonetheless this design journey was pleasantly unpredictable, slightly accidental, and certainly enjoyable!



Project Background



The site once accommodated the Tees Viaduct, designed by Sir Thomas Bouch. It was demolished in 1971, leaving only the abutments (pictured left). The proposed rope bridge was to serve as a tourist attraction and boost the local economy. It would be integrated into a picturesque circular walk encompassing the surrounding landscape, Barnard Castle (the town) and Barnard Castle (the castle).

Teesdale Marketing first put forward the concept in 2003, but never made it past consultation due to local objections. The design presented in this report was a fourth year university project undertaken in 2009-10. Recently, the project has regained traction, with a pre-planning consultation in October 2012.

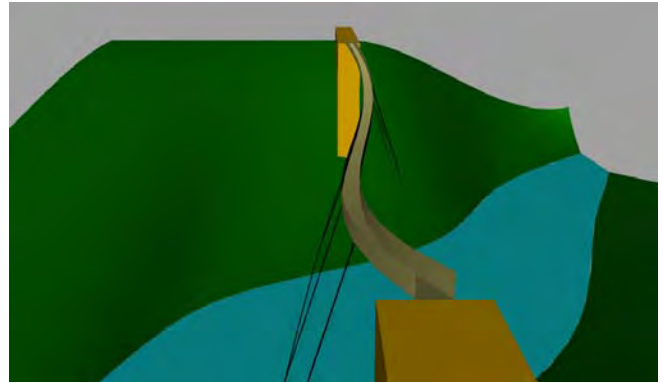
Design Journey

Current designs were first researched, though most inspiration was taken from the stunning Trift Bridge, spanning the Trift Glacier in Switzerland (below).



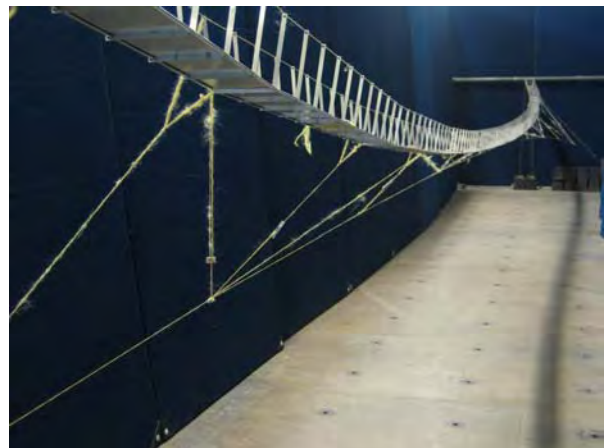


Using Rhino, this geometry was copied across to the River Tees site, including the prominent stay cables to form a starting point. With a desire to change the somewhat fixed design, various options were explored to use the stay cables to modify the bridge shape. From this the S-shape was born, using a single stay cable underneath and diagonally across the bridge (pictured right). Aesthetically, it complemented the site with its skew abutments and river alignment. No calculations were carried out at this stage, although feasibility was crudely checked using guitar lead suspended across a room.

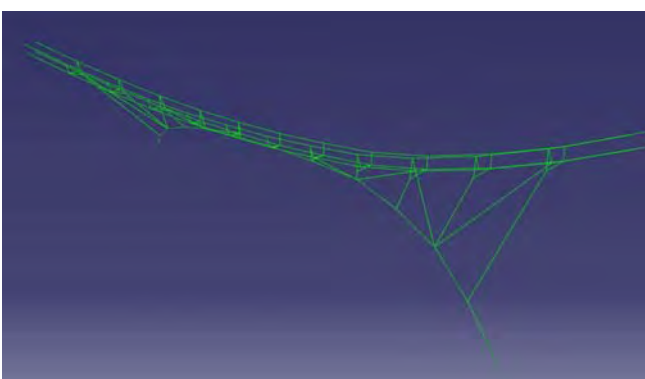


Full Scale Model

With a university supervisor's semi-serious suggestion, a full scale model of the S-shape design was built. The first 12m version was made of Kevlar wire, cardboard and paper clips, and the initial visualisation of the shape was encouraging.



To further the possibilities with a scale model, a new 9m version of Kevlar wire and aluminium was built (pictured above). A pulley system was integrated to adjust the main cables and stay cable tensions, and variable length ties were implemented to gain a large degree of control over the shape.



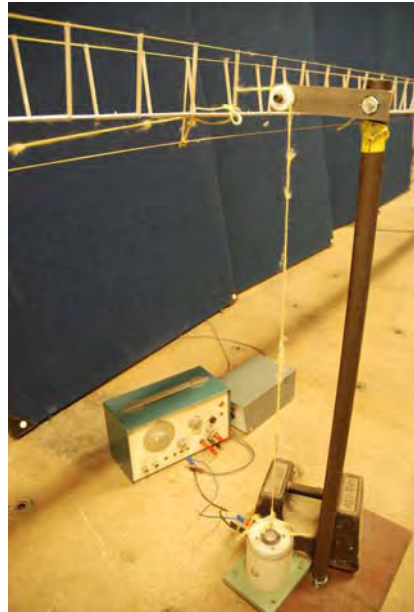
Finite Element Model

Calculations were initially carried out to understand the non-linear behaviour and size steel spiral strand cables, under a nominal extreme pedestrian load.

The footbridge was then modelled in ABAQUS finite element software (pictured left), which could apply sequential loading to replicate how the bridge could be built. It was initially modelled as straight, then a cooling load was applied to the stay cable and ties to simulate the prestress.

Dynamic Analysis

Basic analysis was carried out on both the physical and finite element models. A shaker was attached to the physical model at various locations and configurations to excite its vertical, lateral and torsional modes (pictured on next page). Whilst not entirely scientific, it was certainly interesting shaking a 9m physical model to observe its resonant frequencies. Between tests, a main cable failed, causing partial collapse and heartbreak, though it was successfully rebuilt.



Pedestrian dynamic amplification and wind dynamic effects (flutter, static divergence and vortex shedding) were only briefly analysed using the FE model, though not in sufficient detail to be conclusive. It was believed that there was adequate vertical stiffness within the system so users would not be thrown off, and enough torsional stiffness so that it could not physically flip over in high winds.

All engineering aside, crossing the bridge would definitely be an interesting and potentially terrifying experience!

Conclusions

This unique design has a visually exciting shape that complements the site (see visualisation, below). Its aesthetic defines the way it functions: whilst the shape is in no way necessary, prestressing it into this profile elegantly gives the whole system its stiffness. It also only requires a single main stay cable and half the number of anchorages, compared to the more conventional two stay cable system.

The concept was thought up out of boredom but organically, and it is believed that no other footbridge has been designed with this exact form.

The design process was interesting, unexpected and fun. A full scale model made it more convincing and ultimately more entertaining than a Rhino dream and FE analysis alone, albeit slightly unscientific. It proves that the design is statically possible, though there is still work to be done to make it sufficiently safe.

Scheme Progress and Future Work

Teesdale Marketing proposed this design to Durham County Council, but a traditional design was favoured. The council now own the project, with a 265m span proposed across a different nearby site. The October 2012 pre-planning consultation is still ongoing.

This S-shape design remains without a site and partially incomplete. Whilst the concept works, it could potentially benefit from geometry optimisation. More importantly, it requires a thorough dynamic analysis. As a tourist attraction with children in mind, it is neither possible nor necessary to design it within strictly defined deflection, acceleration or comfort limits. Perhaps the biggest remaining challenge is to design the bridge such that crossing it is a deliberately terrifying, uncomfortable but exhilarating experience!





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SPECIAL REPORT: STRUCTURAL DESIGN

'Why' not 'what' is

Young design professionals from engineering, architecture and academia met in London last week to discuss the Future of Design. **Antony Oliver** reports.

Despite decades of technological advances, procurement reforms and focus on collaboration, construction remains a deeply unsophisticated industry, Olympic Delivery Authority chairman John Armitt told an audience of young design professionals last week.

"I have been to countless conferences throughout my career demonstrating just how little we have learnt about how to achieve better efficiency in delivery of construction," he said.

"The debate [by designers] is always about integrating the why, what and how, yet we still spend far too little time as an industry really understanding the 'why'."

Speaking at the Future of Design conference organised by University College London and the International Association for Bridge and Structural Engineers, Armitt insisted that in future, designers must spend more time tackling the "why" question if they are ever going to deliver better solutions for clients and so truly boost the sophistication of the profession.

Armitt gave the example of the London 2012 decision to only build permanent venues for the Olympics if there was

a genuine role for the asset – a legacy use – after the Games were over. The question "why are we building this?" he said, always came first.

Rather than simply launching into solving the "what" and "how" of a particular solution, designers of the future, he said, must be encouraged to move their thinking and skills upstream to question the underlying rationale of "why" that solution has been chosen.

A similar approach could, he said, be applied to the highway network where designers should lead the debate about the use of technology to slow and control flows rather than simply opting for widening schemes.

Armitt referred back to Isambard Kingdom Brunel's innovative Maidenhead Bridge which had been highlighted earlier in the conference by bridge architect Martin Knight.

Knight had explained that Brunel's rationale for creating the world's flattest brick arch in 1839 was not simply an academic exercise to create an engineering record, it was driven by the real economics of running a railway.

"Brunel's design thinking at Maidenhead was beyond the 'will it fall down?'" said Knight. "Brunel understood that a flatter arch gives a lower alignment and so a flatter overall line. As a shareholder in the railway he also knew that this meant lower overall running costs and so a more competitive route."

Armitt agreed. Holding his copy of the *Financial Times*, he underlined to young designers the importance today – as in Brunel's day – of appreciating the financing of infrastructure. He pointed to the recent appointment of London Organising Committee for the

Leadenhall: Pioneering the use of offsite work via mass prefabrication



TEACHING DESIGN REMAINS A CHALLENGE

Design in the construction industry has long been characterised by tensions and conflicts between engineers and architects with their different approaches to problem solving.

"The difficulty stems from the two disciplines' very different philosophies," Dr Sebastian Macmillan, course director for the interdisciplinary design for the built environment masters course at the University of Cambridge, told delegates.

"Engineering is essentially a branch of applied mathematics whereas architecture is really a branch of fine art," he said. "The two disciplines are then expected to work together seamlessly. It can work, but..."

Macmillan presented three pairs of statements to highlight his thinking (see right). He maintained that they graphically illustrated the difference in thinking that pervades the professions, often causing tensions across the design process.

Chris Wise, founder of Expedition Engineering and the creative force behind the London 2012 Velodrome agreed that there was a difference in the teaching approach between the disciplines but reminded delegates that engineering was "an art not a science".

Commenting on the fact that young structural engineers often found themselves detailing reinforced concrete beams or checking structures against design codes, he pointed out that codes are simply a test against which to

Olympic Games chief executive officer Paul Deighton, a former Goldman Sachs banker, as Treasury minister with a brief to drive the infrastructure agenda as a significant step.

"Infrastructure has got every-

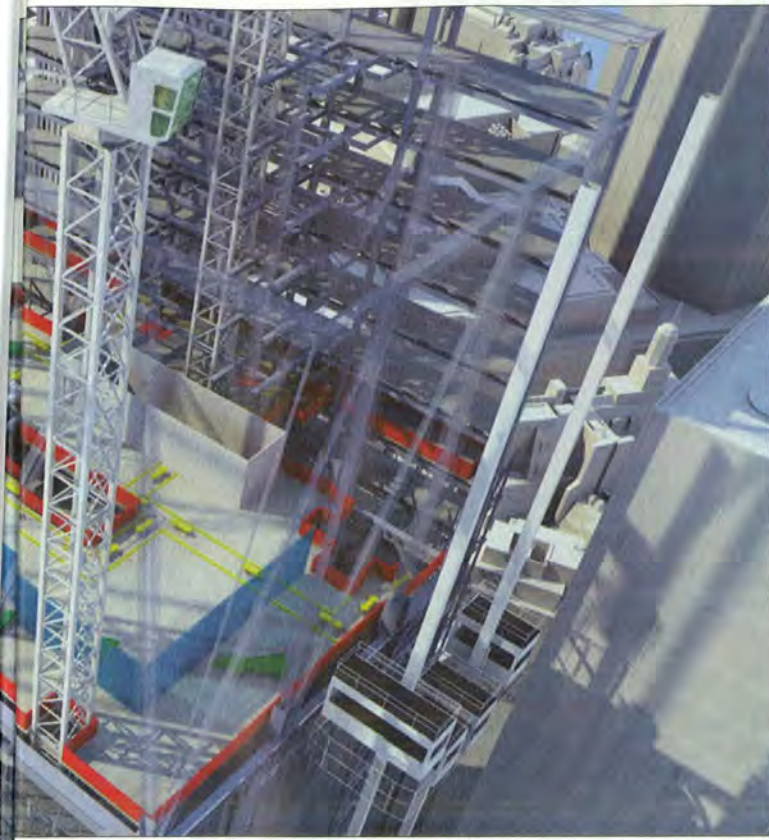
thing to do with banking," he said. "It simply will not happen without it."

Yet while it is clear that designers have a key role in securing the financing for future infrastructure projects – and

"We spend far too little time as an industry really understanding the 'why'"

John Armitt, Olympic Delivery Authority

Key issue for designers



LEADENHALL EXAMPLE

London's new Leadenhall Tower was highlighted by Laing O'Rourke project director Andy Butler as one of the industry's seminal projects in terms of changing the way the industry designs and delivers projects in the future.

The £250M job will be the first of its kind to see no concrete poured on site and will take off-site fabrication and modular construction to new levels as the contractor meets its own targets to construct 70% of products off site, use 60% less labour and deliver the job 30% more quickly than before.

"In fact we will actually see 85% of our work delivered off site on the job," explained Butler. "We will never have more than 200 people on site, which will have a significant impact on our safety record."

But Butler said that the real game changer being pioneered by Leadenhall was its use of Building Information Modelling (BIM) with a single model controlling all aspects of the job from design through procurement, construction and delivery.

"But BIM is about creating a cultural change in the industry rather than simply using software," he explained.

Highlighting her recent series of pedestrian walkways – the Kew Treetop Walkway, built in 2004; the Kuwait children's hospital walkway built in 2011; and most the recently the 2012 Rainham to the River walkway – Wernick reminded designers that their role must go beyond getting the calculations right.

"As structural engineers we have a responsibility to delight clients and the public, not just to ensure that structures do not fall down," said Wernick. "It is imperative that we focus on how our designs impact on the overall well-being of people and society in general."

This emphasis on the designer's ability – perhaps even responsibility – to delight their client was graphically illustrated by Heatherwick Studios project architect Katerina Dionysopoulou who gave delegates a behind the scenes tour of the unique creative process behind projects such as the London 2012 Olympic cauldron, the UK Pavilion for the 2010 Shanghai Expo and the new Bus for London project.

In particular the project to create a new bus for London incorporating an open "hop-on hop-off" back, she said, meant working with a huge number of established bus designers and convincing dozens of authorities that the design would work.

However the creation of the now iconic 2102 Olympic cauldron with a single "petal" on a moving stalk for every

participating nation had, she explained, taken a mammoth multi-disciplinary effort to bring to reality in front of such a vast global audience.

"For the 2012 Olympic cauldron the client was very specific," she said. "They simply said make sure it had no moving parts. Of course our solution had to have 204 moving parts! And that meant a huge amount of work to demonstrate it would work."

Working with a creative force such as Thomas Heatherwick, she added, resulted in the design team often having to work hard to convince the client that the design could work practically as well as aesthetically. That meant prototyping and testing in the studio to prove ideas and come up with the best ways to deliver solutions.

However, for all the testing and design simulation tools now available to designers, Dionysopoulou reminded delegates of a simple truth born out by the 2012 flame: "There is no substitute for a good idea."

"As structural engineers we have a responsibility to delight clients and the public"

Jane Wernick
structural engineer

measure a particular solution.

"Engineering design is a physical activity that needs to be grounded

in reality," he said. "Fundamentally it is about creating useful things that improve the lot of humanity."

CONTRASTING APPROACHES

ARCHITECTS	ENGINEERS
Design is an individual pursuit best undertaken on an airline napkin	Design is a strongly iterative and collaborative process
ARCHITECTS	ENGINEERS
Every design problem is unique with a single 'right' solution	There are many possible design solutions that meet design criteria to a greater or lesser extent
ARCHITECTS	ENGINEERS
Design starts with a creative leap based on faith and intuition	Design starts with rigorous analysis and is followed only then by the search for solution

getting the economic case right – the conference also heard how increasingly important the so-called "economics of happiness" were becoming to modern clients. "People are happier if they are engaged with their

environment," insisted structural engineer Jane Wernick, pointing out that throughout her career she had increasingly developed "a preoccupation" with what she described as "buildings that make you smile".