SEABC NEWSLETTER

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- SEABC's Newsletter is edited and managed by Robert Smith (smithco@axion.net)
- Submissions to the newsletter are encouraged and all members of the SEABC are asked to actively participate in contributing to our newsletter.
- SEABC editing staff reserve the right to include or exclude submitted material and in some cases edit submitted material to suit overall space requirements. If submittals are not to be edited, please advise editor at submission time.

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Message from the President

By Dave Davey; SEABC Interim President

HOW ARE WE DOING?

Well perhaps it is just a bit too soon to ask. But we do really want you, our members, to let us know whether we are representing the structural engineering community and providing services in the manner that you expected.

Communication is our biggest challenge. As engineers, many of us, myself included, were good at putting our heads down and solving the problem of the day, but not good at telling anyone else what we were doing and why. To get our information out to you, we have set up a website, we are sending out quarterly newsletters and we are emailing bulletins (that we call the SEABC Diary) whenever we are advised of some event of interest. We trust that electronic delivery is good for you as it is the only practical way for us to reach over 600 members in a prompt and economic manner.

But communication is a two way street. We need feedback to let us know if we are doing a good job. If you feel that we could do something better – please tell us. If you think that we should be doing something but appear not to be – please tell us.

You can email us at info@seabc.ca and we will forward your message to the Directors or to the appropriate committee. Another way to do this is to use the website FORUM (see the link on the home page). If you have not registered on the FORUM please consider doing so. This will enable you to post a message or question at any time for all the members to see. Even better - come to participate on one of our committees or task forces.

Currently there is a small group in Victoria working to set up a Vancouver Island Branch. If you too would like to be involved in our activities, please let us know. Remember that the organizing and most of the work is being undertaken by member volunteers who have limited time available, so if we can spread the tasks around, we can make the workload less onerous for all.

So what are we doing anyway? Let me give you a brief overview. We have divided our activities into five main functions – Technical, Education, Professional Practice, Corporate and Business Affairs and Communications.

Technical Committee

The job of our Technical Committee is to provide guidance to members in the solving of technical problems and how to put these solutions into practice. One example being considered at the present time is how to put into practice the new Code requirement for including seismic forces in the design of buried foundation walls. Another is the development of a practice guide for the design of guardrails on buildings and their attachment to the primary structure.

Education

The Education function includes the Certificate in Structural Engineering Program and production of regular monthly evening presentations and other seminars, which may be produced in co-operation with other technical groups and societies. Our current objective is to provide web access to as many of our presentations as possible in order to reach our members all across the province and we are well on the way to achieving this.

Professional Practice

The Professional Practice Committee maintains liaison with other learned and professional societies – particularly with APEGBC. Today, being a body separate from APEGBC, we have a better ability to represent the views and needs of structural engineers, whereas APEGBC, by virtue of its mandate, is more tuned to protecting the interest of the public.

One current example of this co-operative work is the development of Guidelines for Providing Structural Engineering Services for Part 9 Buildings, which is about to be published. I believe that a great many of us would like to have a better understanding of where the structural engineer's responsibility ends, when he is retained to work on part of a building governed by Part 9.

Corporate and Business Affairs

Our corporate and business affairs committee is presently under formation to represent the interests of our corporate members and to define their role in SEABC. There is no doubt that our corporate members can contribute significantly to improving the recognition of structural engineers and structural engineering in our community.

Communications

And lastly, our communications group is working hard to keep you all informed. Help us to get the information out by providing feedback or by providing news items affecting structural engineers.

David Davey, P.Eng., SE.
Interim President

On the Web Share your photos

By Stephen Pienaar; SEABC Webmaster

We are looking for new photographs to use on the SEABC website. If you are one of the many talented photographers out there, we would appreciate your sharing some of you pictures. We will welcome all photos related to structural engineering in BC.

We will give credit for all pictures used. You may even be the winner of our "photo of the year" prize (details to be announced). By submitting your pictures, you are granting the SEABC permission to use them on its website and other communications. Photos should therefore be your own, or submitted with the express consent of the photographer. Please send your submission to webmaster@seabc.ca.

Keeping up to date

We have been hard at work keeping the content on the SEABC website current. Amongst other things, we are regularly updating upcoming seminars and courses. Please bookmark www.seabc.ca and check in regularly for updates.

The number of visitors to the SEABC website has been steadily on the rise since its launch in January, suggesting we are doing something right. We would love to hear how you think we can improve the website and electronic mailings. Please send your comments and suggestions to webmaster@seabc.ca.

Communicating with the Membership

By David Harvey; Chair, SEABC Communications Committee

Dave Davey, in his President's Message, points out that member communications is our biggest challenge. Knowing we are challenged gives us an opportunity to show what we can do. Your communications team is determined to rise to the challenge, and provide you with the best information about SEABC in the most accessible format. You will receive four electronic newsletters per year, packed with reports of activities, and articles of interest to BC's structural community. After a mammoth effort to launch our first edition, we are streamlining our publishing effort for future editions and working to fixed publication dates.

The inaugural edition consisted of 30 news-packed pages and received rave reviews. There are some changes in this edition that we hope will make it more user-friendly. Following a request from the CISC editor, our popular Dr Sylvie feature can be accessed by clicking on the link to the web site of Advantage Steel. This link is will provide access to the full content of the current and previous editions of Advantage Steel, including the articles by Dr. Sylvie.

We are continuing to reprint interesting news articles on structural Engineering from New Civil Engineer International, which provides good information from across the world. However, there are also many interesting stories nearer home, and your editorials team very much want to hear from you. Please send your stories, with photos, to info@seabc.ca or to me at harveyd@ae.ca or to newsletter Assistant Editor, Clarissa Brennan, at brennanc@ae.ca.

Our other main area of communications is our website, ably crafted by Webmaster, Stephen Pienaar (see the Webmaster report in this issue). We have some great future plans for our website which are currently under development which we are sure you will be pleased with. You can contact Stephen at webmaster@seabc.ca.

The Communications Committee also looks after SEABC membership. To be "in the loop" you will need to be a member. We need your help to ensure that as many structural engineers as possible are served by SEABC. Our strength is in our membership, and with greater participation and involvement, we can achieve more. In the meantime we are looking at making joining SEABC, and maintaining membership as easy as possible. So please continue supporting us, bring your colleagues and do get involved.

ASCE/SEI Structures Congress

By David Harvey; Director, SEABC
Vice Chair, 2008 Structures Congress

The 2008 Structures Congress proved to be an absolutely stellar event! The fortieth Congress was held in Vancouver, the first time the event has been held outside of the United States. The Congress in Vancouver featured ten tracks, 100 sessions, 300 presentations, and set records for registration (nearly 1300), attendance (over 1500), and exhibits (60 booths). Delegates were drawn from across the world to experience the education, excitement and community-building activities.

Photo Courtesy of Jim Ezell
EZ Event Photography; Long Beach, CA

Also new in 2008 was event sponsorship by four cooperating organizations: the Council of American Structural Engineers, CASE; the Canadian Society for Civil Engineering, CSCE; the International Association for Bridge and Structural Engineering, IABSE; and the Institution of Structural Engineers, IStructE. Each organization arranged technical sessions, advertised the event, and brought in speakers and delegates to create a unique international flavour to this year's Congress.

There were several notable events, including a fascinating talk on science education at the Congress Opening Luncheon, by keynote speaker Dr Carl Wieman of UBC, winner of the 2001 Nobel Prize for Physics. A spellbinding description of the design evolution and construction of the record-breaking Millau Viaduct, the world's tallest vehicular bridge, by its creator, Michel Virlogeux, was given to a packed room of over 200 delegates. Dan Doyle, Vice President, Construction, for the Vancouver Organizing Committee for the 2010 Olympic & Paralympic Winter Games (VANOC) was keynote speaker at the Congress Banquet. Mr. Doyle described how facilities delivery for the Games is on time and budget. His talk was highly informative, yet amusing, and full of interesting anecdotes concerning Canadian athletes and construction staff.

There were two technical tours organized, together with pre-tour presentations. The Canada Line project consisted of a bus tour along the route, with technical descriptions of the $1.9 billion project by Roger Woodhead and Chris MacCarthy. The Olympic Speed Skating Oval tour featured a visit to the new building, the largest new facility for the 2010 Games, by Oval roof designer, Paul Fast.

SEABC now operates as IStructE's Joint Division in BC, and the Structures Congress was SEABC's activity to celebrate the IStructE Centenary in 2008. The IStructE Centenary President, Sarah Buck, attended the Structures Congress, and moderated one of the IStructE technical sessions. IStructE also signed Cooperating Agreements with ASCE and SEI at a signing ceremony during the Structures Congress Banquet.

This event took four years of planning, and was a massive boost to our City, and also to the local community of structural engineers. Over fifty local firms purchased corporate passes, giving over 300 local engineers the opportunity to experience a world-class structural engineering conference. Over 25 local structural engineers served as session moderators, and many local firms manned booths in the exhibit hall. We owe a strong debt of gratitude to 2008 Structures Congress Co-Chairs Don Anderson and Carlos Ventura, and the Local Steering Committee members, that spent a lot of their time in organizing the 2008 Structures Congress.

Coming Soon: Two New Documents on Part 9 Buildings

By Peter Trainor; Member, Professional Practice Committee

The Professional Practice Committee (PPC) of SEABC works on issues of professional practice affecting structural engineers. The committee provides a liaison between SEABC and APEGBC. It provides responses to questions directed to APEGBC and produces professional structural practice guidelines for APEGBC as necessary.

This function was formerly one of the tasks of the DSE executive. Although SEABC is separate now from APEGBC it is important for us to continue work with APEGBC on practice issues. We want APEGBC to consult with us freely on any issues that arise in the future. We will also need to express our concerns to APEGBC on issues that arise from within our membership and work cooperatively to resolve such issues.

For two years now, we (the former DSE executive) have been working on an APEGBC guideline for practitioners providing Structural Engineering Services for Part 9 buildings.

The draft Part 9 guideline provoked some heated debate at a structural forum on Part 9 at the APEGBC annual conference in Victoria in September 2006. Some of the issues raised included:

- Potential Inability of some Modern Part 9 buildings to Adequately resist Sway forces due to severe earthquakes of Windstorms
- Difficulties in understanding the wording of the new Building Code.
- The requirement of all engineers to design to good engineering practice and what does this mean?
- The inconsistency of requirements by different AHJ’s.
- Pitfalls surrounding things such as who should sign Letters of Assurance(LOA) and who should accept a Schedule S from the designer of a structural component.
- Potential weakening of an existing building due to a renovation or addition.

A problem with the initial draft was that it was trying to inform the structural engineering community as well as clients and stakeholders. This was rightly seen as problematic since APEGBC can outline good practice for engineers but cannot tell the stakeholders (e.g. AHJ’s) how they must act. APEGBC’s legal team rejected the initial draft but suggested that a separate document could be produced if the committee felt it was necessary to inform clients, AHJ’s and members of the public. It was suggested that the tone of the language, and even words in the titles, of the two documents should be different.

The DSE felt that there was a need for a public information document on structural issues for Part 9 buildings in addition to the professional practice document. As a result, the following documents have been produced:

(a) Guidelines for Professional Structural Engineering Services for Part 9 Buildings in British Columbia

(b) Structural Design Issues for Housing and Small Buildings in British Columbia – Information for Local Authorities, Homeowners and Developers

The first document is a professional practice document. It outlines good engineering practice for Part 9 Buildings especially in light of the changes to the BC building code in 2006. Engineers may use the document to provide information to clients concerning professional obligations.

The second document briefly discusses Part 9 buildings in terms of wind and seismic resistance, coordination of structural designs, and renovations. The document discusses the potential pitfalls that can be mitigated by the early assignment of a professional engineer to act as the SER. The document notes that engineers are required to design to good engineering practice and refers the reader to the professional practice document.

First drafts of the two documents were produced in December 2006 at the time of the adoption of the new BC building code.

Since that time, we have consulted extensively with practicing engineers involved with Part 9 buildings, authorities having jurisdiction (AHJ's) and academic engineers. We attended meetings at the regional permits and licensing committee (RPLC) and also consulted with the provincial governments' Building Policy Branch. Looking back on things, the changes in the consultation period may not seem all that extensive. However, the wording in such documents is important, especially where professional responsibility is concerned.

At the time of going to press, the documents had been approved by APEGBC Council and reviewed by APEG BC's legal council. There will be one final meeting with the APEGBC's legal council before the final edit and it is expected that the documents will be formally issued sometime in late May or early June.

We urge all Part 9 practitioners to read the documents as soon as they become available. We will be providing links to the documents from the SEABC website.

Thanks are due to all those who acted as readers of the various drafts of the two documents. Thanks also to Peter Mitchell, P. Eng. Director, Professional Standards and Development at APEGBC who is our liaison at APEGBC (Director, Professional Standards and Development).

SEABC and IStructE Agreement Signing

By David Harvey; Director, DSE

As part of the Centenary celebrations of the Institution of Structural Engineers, IStructE President Sarah Buck visited Vancouver recently to meet with the local members. She also attended the ASCE/SEI Structures Congress that IStructE was co-sponsoring. During her visit to our city, Sarah took the opportunity to meet with APEGBC to discuss the use of the Chartered Membership exam for the Designated Structural Engineer program.

IStructE has had a Joint Division in BC since 2002, and with the dissolution of the DSE at the end of last year, this responsibility now transfers to SEABC. Accordingly, on April 23, 2008, a new Agreement between SEABC and IStructE was signed which means that from now on, SEABC will function as IStructE's Division in British Columbia. This benefits IStructE is having an organization to provide services for local members, but it also benefits SEABC members. IStructE will provide a portion of member fees received to fund SEABC activities. In addition, SEABC members will in future be able to access the Members Only portion of the IStructE web site (www.istructe.org) which will provide access to a large amount of technical material published during the last 100 years. To do so, local members should individually contact the webmaster (webmaster@seabc.ca) who will verify their SEABC membership, and provide them with a sign-in password from IStructE.

We look forward to much more cooperation with IStructE in the years ahead, and more future Presidential visits.


IStructE Centenary President, Sarah Buck, and SEABC Inaugural President, David Davey, sign an Agreement in Vancouver

SEABC Monthly Seminar Series: Olympic Speed Skating Oval Roof Structure

By Joel Hampson, SEABC Education Committee

Paul Fast, P.Eng., of *Fast + Epp Structural Engineers*, presented “Olympic Speed Skating Oval - Roof Structure” for the February 27, 2008, SEABC monthly seminar series.

Mr. Fast presented the challenges and processes of creating the innovative design to a “full-house” of SEABC members. The roof of the Long Track Speed Skating venue in Richmond – also known as the Richmond Oval - for the 2010 Winter Olympics is a unique wood-frame structure. Mr. Fast described many of the distinctive structural elements and exceptional design processes of creating this building. Some of these elements are the one-of-a-kind composite wood-steel arches, which span 310 ft, and the novel, prefabricated "wood wave" panels consisting of pine beetle-killed wood. The design process involved trips to European long-track speed-skating stadiums and close collaboration with the carpentry firm during design.

Following his presentation, Mr. Fast answered many questions from the audience about various aspects of this unique and impressive project.

SEABC Monthly Seminar Series: 204th Street Overpass

By Chris Mealing and Marc Gérin

Chris Mealing, P.Eng., and Marc Gérin, P.Eng. of Hatch Mott MacDonald gave a presentation on the 204th Street Overpass, on April 16 as part of the SEABC Monthly Seminar Series.

The 204th Street Overpass Project comprises design and construction of a new overpass connecting 204th Street through to Duncan Way and Logan Avenue in the City of Langley. The overpass begins south of the intersection of 204th Street and 62nd Avenue and provides an elevated structure crossing of the Langley Bypass (Highway 10) and the BC Hydro Right of Way that is used by Canadian Pacific Railway and the Southern Railway of British Columbia. The structure continues south crossing the Southern Railway of British Columbia spur line and descends back to grade along Duncan Way just north of Logan Avenue. The elevated structure is a multi-span bridge, approximately 420 meters in length, which includes four traffic lanes with a median barrier, bicycle lanes and a sidewalk.

Project highlights include:

- Twelve-span precast concrete girder structure with precast concrete deck panels
- Structure spans Duncan Ave., 2 separate rail crossings, Logan Creek and Highway 10
- Post-tensioned Concrete Pier Caps
- Deep pile foundations in challenging site conditions
- Lightweight fill (EPS) approach embankments with precast concrete facing panels
- 2 separate Pedestrian Overpass structures adjacent to the bridge
- Widening 204th Street to five lanes approximately 110 meters north and 40 meters south of 62nd Avenue
- Re-construction of 3 intersections
- Construction of stormwater management ponds adjacent to environmentally sensitive Logan Creek
- Drainage improvements
- Designated pedestrian facilities
- Utility relocations
- Property access relocation
- Signage improvements

SEABC Monthly Seminar Series: Seismic Design

By Ken Elwood; Education Committee

SEABC's first monthly seminar on January 23, 2008, drew a standing-room-only crowd to the BC Hydro Building lecture hall. John Hooper, S.E., from Magnusson Klemencic Associates in Seattle provided an insightful look at "Seismic Design Using the 2006 IBC and ASCE 7-05". John's experience as the chair of the International Code Council's Structural Code Development Committee in charge of the development of the 2006 International Building Code and chair for ASCE 7 Seismic Sub-committee meant that the audience received an "under the hood" look at the development of the US codes for seismic design.

John highlighted the close relationship between the IBC and ASCE 7 and identified common pitfalls in applying the two documents. He also provided insight to future developments in the ASCE 7 standard, including the potential adoption of a "uniform risk" approach to determining the design loads, instead of "uniform hazard". It was noted that the current procedure in ASCE 7 for selecting and scaling ground motions for response history analysis is generally very conservative and will likely be changed in future editions of the code. Modifications to the redundancy factor, r, a new concept for many of the engineers in the audience more familiar with the NBCC, were also discussed. The redundancy factor is intended to encourage the use of multiple load paths for the seismic forces in case of failure of critical elements. The new provisions are much simpler to apply than those found in the 2003 IBC; essentially requiring the engineer to design for 30% higher base shear forces if sufficient multiple load paths are not provided. John also highlighted for the audience an important correction to the minimum base shear requirements applied through an emergency change in ASCE 7-05 Supplement 2, limiting the base shear to greater than 4.4% of the design short period spectral acceleration. This was a particularly critical modification for the design of tall buildings in high seismic zones.

It was clear from the numerous questions that followed the talk that the Canadian audience was keenly interested in the new developments south of the border. Clearly John's insights on the development of the seismic provisions were received with interest by the standing-room-only crowd. A great way to kick-off the SEABC Monthly Seminars!

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CLYDE ARC SHUTS AFTER SUPPORT CABLE SNAPS

By Jessica Rowson

Glasgow's Finnieston Bridge, also known as the Clyde Arc, was closed last month after one of its main support cables snapped.

The cable snapped and landed on the carriageway at 11:30 pm on January 14th. No vehicles were on the bridge at the time.

"One of the 14 bridge supports has failed but we don't believe the integrity of the bridge is affected," said Glasgow City Council Land and Environmental Services executive director Robert Booth.

"Clyde Arc is designed to allow for the removal of one of the bridge supports at a time for repair and maintenance without affecting its operation."

> ***"One of the 14 bridge supports has failed but we don't believe the integrity of the bridge is affected"***
>
> *Robert Booth, Glasgow City Council*

The steel bowstring tied arch bridge spans 96 m over the River Clyde. It opened in September 2006. The $40 M bridge, which carries four lanes of traffic, was designed by consultant Halcrow and built by contractor Nuttall.

"There are no thoughts yet on the cause," said a Nuttall spokesman. "We need to look at the component that failed and then check the other components."

Following a meeting today between Glasgow City Council and the Clyde Arc contractors and design team, it has been decided that the bridge will remain closed pending further investigations.

"The bridge is still under guarantee by the main contractor, who will report back to the Council once they have established the cause following their investigations and independent testing of the broken part," added Booth.

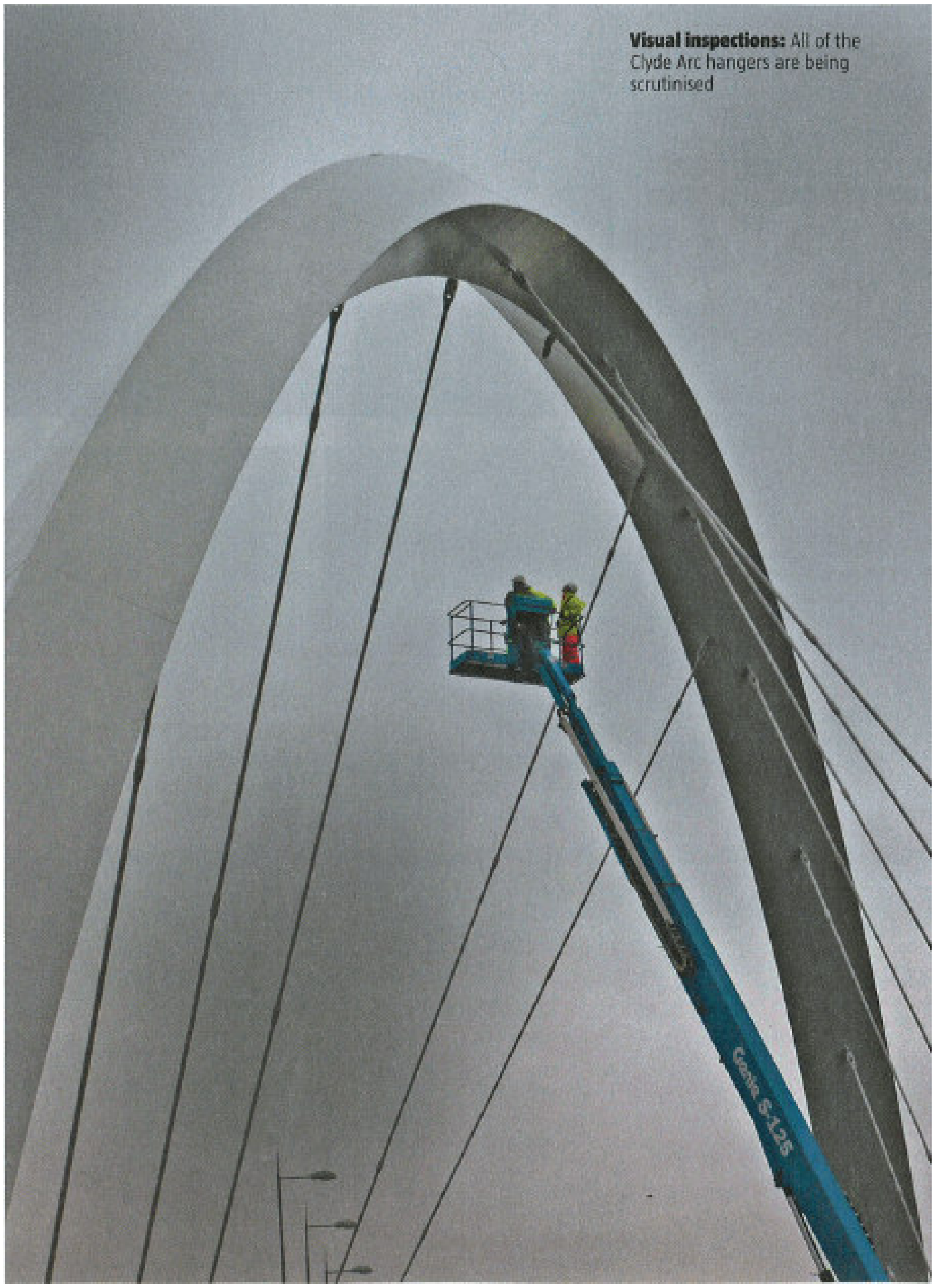
Glasgow City Council said it was unclear when the bridge would reopen but that it was likely to remain closed for several weeks.

The Finnieston bridge won the acclaimed Saltire Award for civil engineering November last year. Judges said it "demonstrated excellence in concept design and construction."

SECOND ARC FAULT FOUND

By Jessica Rowson

Bridge likely to be closed for at least six months as safety fears mount.



Visual inspections: All of the Clyde Arc hangers are being scrutinised

Glasgow's Clyde Arc bridge has suffered two setbacks in a month after one of its tie bar connections failed and a second was found to be showing signs of stress.

The bowstring arch bridge is closed to road traffic and has also been closed to river traffic.

Following the failure of one of the hanger connections on 15 January, the remaining hangers have been inspected in detail.

The first tie rod and connector fell to the deck after a connection detail at the top of the arch failed.

At one end of the detail was a screw connection to fix to a Macalloy tie bar and at the other were two flattened lugs, which sat either side of a fin welded to the main arch structure.

A pin through the two lugs completed the connection.

Photographs taken after the failure showed that the lugs were fractured across the pin hole.

A crack was found in a second connection during a subsequent inspection.

"We are working on the basis that the crack was not visible prior to that point," said a Glasgow City Council spokesman.

"The cables are being inspected carefully and regularly and it had appeared on that day."

According to the spokesman, the second connection is showing similar signs to the first failure.

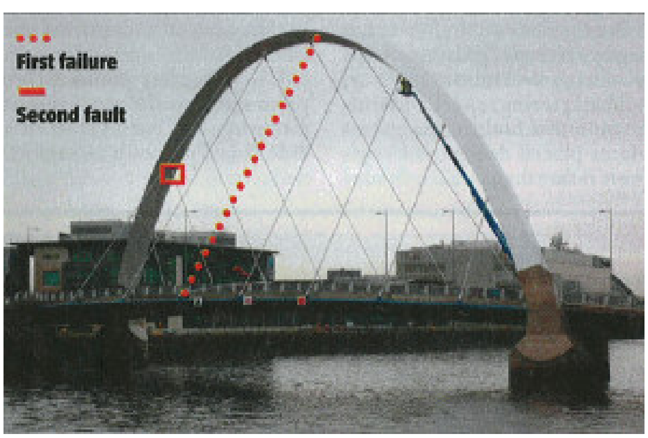
The council spokesman added: "Although the bridge is designed to allow for the removal of one support at a time for repair it is unclear at this stage what impact a second failure would have.

Work to replace the hanger which fell down on 15 January started on Tuesday with cranes operation from the banks to avoid loading the bridge. Remaining connections will be secured with steel wire bands, as an extra safety precaution.

Temporary steel support frames will also be installed on the bridge in the next few weeks.

These will secure the bridge deck during the work on the hangers by connecting the bridge deck outriggers to the arch.

Most of the inspection and repair work is to be carried out from the river with cherry pickers working from a pontoon, a 40 t crane working from a barge and an 80 t crane working from a jackup barge.



Glasgow City Council is in discussions with the design team including consultant Halcrow and contractor Nuttall and suppliers, examining options for replacing all the cable connection components.

The Clyde remains closed to river traffic until further notice. The bridge is likely to remain closed to road traffic for up to six months.

ROUTES TO FAILURE

*How could a relatively new bridge like the Clyde Arc suffer a connection failure? **Jessica Rowson** reports.*

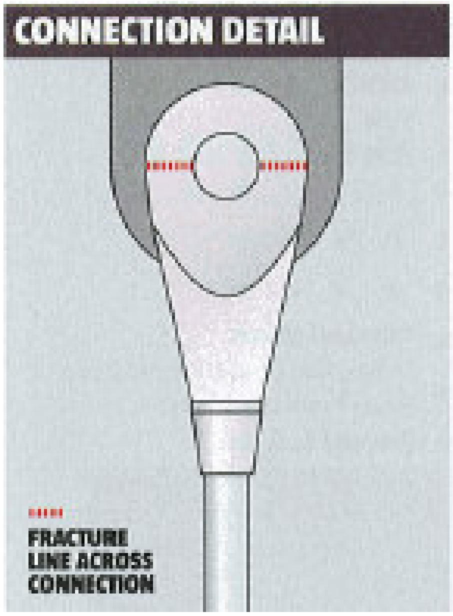
The Clyde Arc in Glasgow is a relatively young bridge, only having opened to traffic 2006. It received awards for excellence in construction and civil engineering. So it came as a big surprise when the connection on one of the 14 tension bars supporting the deck from the bridge's bowstring arch failed on 14 January.

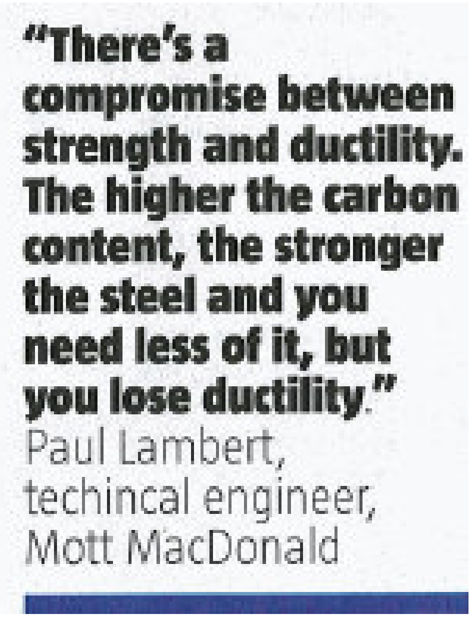
Contractor Nuttall and designer Halcrow promptly began an investigation into this failure and discovered a second fault – a stress fracture in another of its connections.

The Clyde Arc is a tied arch bridge where outward-directed horizontal forces of the arch are borne by the bridge deck, rather than the ground or bridge foundations.

The deck is hung from the arch using 14 inclined tension bars; seven supporting the other, over the 96 m central span across the River Clyde.

The tension bars are connected to the arch using twin lug pin joint connections manufactured by Macalloy.





There was no construction work going on at the time of the first failure, there wasn't even any traffic on the bridge.

The failure is all the more surprising because the bridge is not visibly pushing the boundaries of engineering despite its elegant appearance.

"It's not a radical design as far as the cable system is concerned, but it is interesting in its structural form," says Gifford director Ian Hunt.

"I'd be surprised if design was the issue."

ICE Glasgow and West of Scotland regional chairman Gordon Pomphrey agrees.

"While it is a modern design and was built using up-to-date methods, it is not so cutting edge that the security of the bridge should be in doubt," he says.

So how could connections on such a structure fail?

Modern bridges incorporating tension bar support systems generally use high strength steel, which has a relatively high carbon content. This minimizes the quantity of steel needed and the number of tie bars.

"There's a compromise between strength and ductility," says Mott MacDonald materials and corrosion engineering technical director Paul Lambert. "The higher the carbon content, the stronger the steel and you need less of it, but you lose ductility. The material is more likely to fail in a brittle failure."

"The size of the defect needed to initiate the crack gets smaller and smaller. With a ductile material, if it receives a knock or a bit chips out of it, the stresses will yield and redistribute. In those circumstances [with brittle materials] they just fail."

There are a number of different mechanisms which can cause failure of a brittle material.

"Stress corrosion cracking is specific to certain metals with high carbon in certain environments where water and high stresses are present," explains Lambert. He says that if a susceptible alloy is used, failure will occur if a combination of stress and environmental factors come into play.

Other mechanisms that can cause a brittle failure of high strength steels include corrosion fatigue and hydrogen cracking.

A source from one of Macalloy's competitors believes that the Clyde Arc connectors could have suffered a brittle failure which had its roots in the fabrication process.

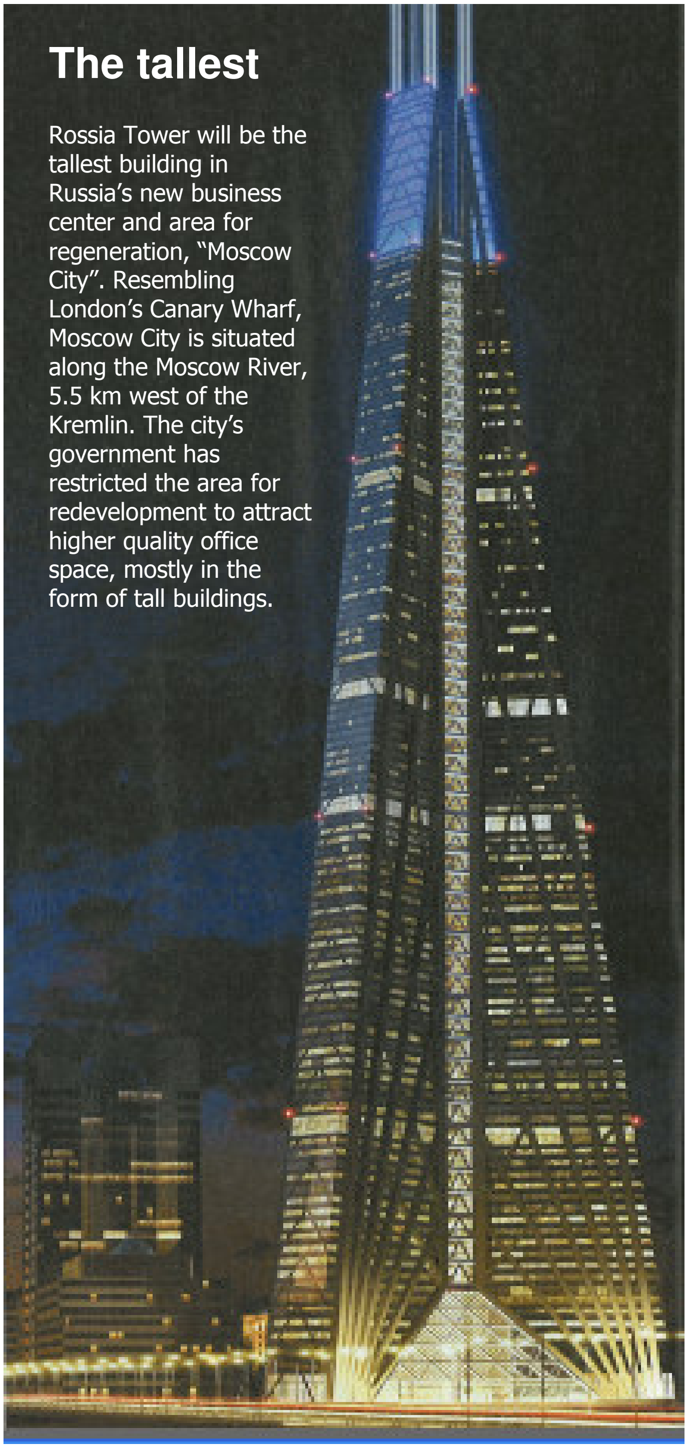
"It looked to be a brittle failure which could have been caused by inadequate heat treatment during manufacture."

But if there was a fabrication issue, should this have been picked up in the production process? Engineers often have to deal with insitu construction defects but factory made components usually come with some guarantees.

"All manufacturers purchase from a foundry and they specify the product," says the source.

"They should then be testing to make sure [they get what they specify]."

When a steel bridge collapses, fatigue is often an issue. When the I-35 bridge in Minnesota collapsed in August last year, it was fatigue that caused underdesigned gusset plates to yield. This is unlikely to have been the problem on such a young bridge.



"When engineers see metal crack, they often think of fatigue," says Lambert. "It comes from cyclic loading, where a defect is caused to generate and then propagate. However it seems unlikely on a new structure, because it won't have been through the necessary number of cycles."

"It's very early in its history for fatigue issues. It looks to be a tensile failure even though shear has been talked about," agrees Hunt.

Thermal issues are another possibility. On the Clyde Arc, the slender 100 mm diameter 35 m tension bars could be affected by temperature change.

"The bar is not particularly flexible and if the sockets [connections] are not aligned properly and temperature changes change the shape, the two wings of the socket may not be picking up equal load," says independent consultant Jolyon Gill.

"You would normally overdesign the sockets so they wouldn't fail like that."

Thankfully no one was on the bridge at the time that the tension bar came down, but it does raise the issue of what caused the connection to go at that particular time.

"Nothing strikes me as being out of the ordinary," says Ramboll Whitbybird director, Mark Whitby. "It is curious it failed unloaded."

Materials consultant Sandberg is currently examining the pieces of the fallen tension bar to try and find out exactly why the failure occurred.

Given the rarity of such incidents, perhaps the second occurrence on the same bridge points to a specific problem with a particular batch of castings or the way in the connection elements are used on the Arc, which should provide some degree of reassurance for other structures that use tension systems.

ROSSIA WITH LOVE

By Jessica Rowson

Europe's tallest skyscraper is being built in Moscow.

If you're thinking of designing a tall building, make it at least 600 m or nobody will bat an eyelid. Moscow's latest addition to the 600 m plus club is the

612 m high, Rossia Tower, a cool 2 m higher than the Chicago Spire (NCE 25 October).

Rossia's site is currently being cleared to make way for what will be Europe's tallest building. The skyscraper will incorporate retail and office space, a hotel and apartments on its 120 floors, three of them below ground level.

To the untrained eye, Rossia is an elongated pyramid, or rocket shaped structure, but on the inside, the structure tells a different story. At its base are three, colossal, high strength concrete abutments clamping the whole structure down. Each abutment forms the base of the three wings of the building, from which columns radiate. The wings converge at a central spine, or concrete core, which runs the full height of the tower. Consultants Waterman International and Halvorson have designed the steel frame and composite floor structure.

The plan and profile of the building take on the efficient geometry of a triangle to achieve maximum stability using the minimum amount of material.

Initially architect, Foster & Partners, designed the tower as three discrete blocks, arranged in a Y shape in plan. But this meant that each block was too slender, having a height to width ratio of 10:1.

"Structural solutions were possible for this option of independent towers, but at these aspect ratios, the solutions would be inefficient," explains Waterman International project director Hugh Docherty.

The decision was made to merge the blocks, so they leaned into the central core. The sloping parallel columns could then brace the core laterally as well as carrying vertical loads. The result was a more efficient height to width ratio of 5:1." So in terms of height to base, the building is squat," says Docherty.

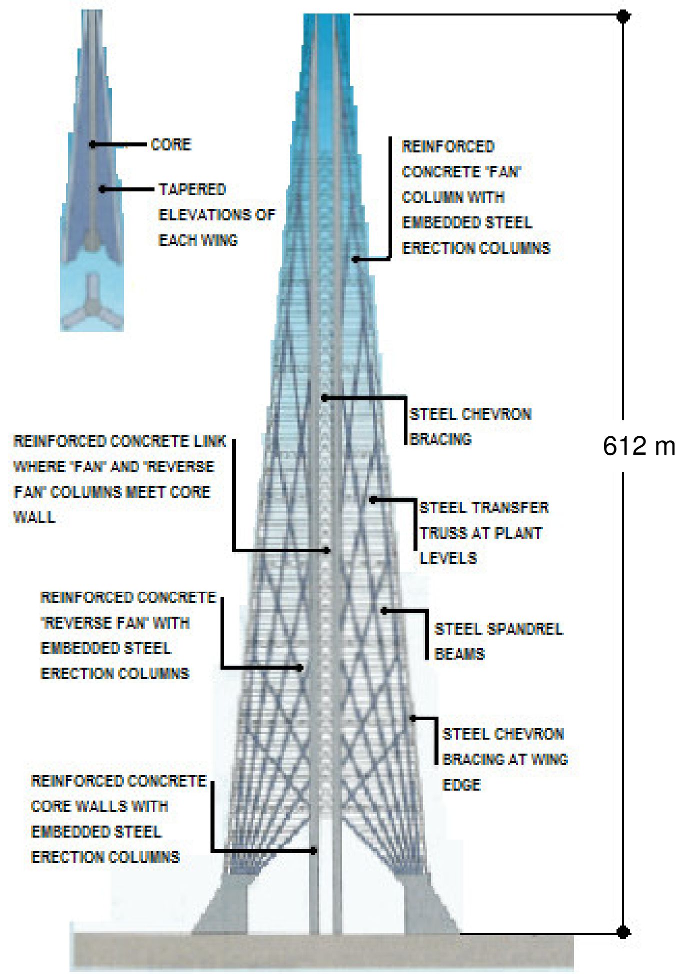
The design was starting to look like the familiar form of a cable stayed mast. However instead of tension cables, Rossia uses the sloping columns to act in compression – propping the central core and essentially acting like three dimensional arches.

The fan columns carry gravity load and wind overturning forces as direct axial loads. And as the weight of the building and its inhabitants exceeds the design wind load in the majority of the columns and core, there is little tension in the system.

Piling contractor Soletanche is currently building a diaphragm wall on the site, but it will be at least six years before the 100 m tall mast crowns the building.

"We used tension ties in the raft to stop the feet from spreading. We could have propped against diaphragm walls or relied on friction, but tension ties were the most controllable options"

Hugh Docherty, Waterman International



Rossia Tower: How it Works

The tower's three wings comprise steel and concrete columns which fan out from the three massive abutments at the base.

Visually, this gives the form of a tripod supporting the rest of the building – a structural form known for its efficiency. "Three legged stools are great. With four legs you start to bring in redundancy," says Waterman International project director Hugh Docherty. Having established the path for vertical and lateral loads, the remaining challenge was torsion. The façade of the wings is stiffened by a series of "reverse fan columns" which triangulate the façade. "The wings are designed as boxes with crossed bracing. These resist twisting," he explains. The rigid façade is further stiffened by steel chevron bracing up to the fourth floor on the outer edge of each wing. This provides sufficient torsional stiffness. But a structure with sloping columns causes other problems in the form of horizontal loads amassing at the base. We used tension ties in the raft to stop the feet from spreading. We could have propped against diaphragm walls or relied on friction, but tension ties were the most controllable option," says Docherty. The construction sequence requires the fanning columns to be designed for erection loads. Later they will be encased in reinforced concrete to achieve the final strength for permanent loads.

I-35 W COLLAPSE LEADS TO CALL TO BEEF UP US INSPECTIONS

By John McKenna

Current inspection regime focuses only on cracks and deterioration, not structural integrity, warns US safety board

United States bridge engineers should undertake a greater degree of structural analysis when carrying out routine inspections, America's leading civils body said last month.

The call followed publication of the United States National Transportation Safety Board's (NTSB) interim report on last summer's I-35 W bridge collapse in Minneapolis, Minnesota.

The 139.6 m span steel truss bridge suffered a catastrophic collapse last August killing 13 people.

At the time, an inadequate inspection regime was identified as one of the chief reasons why a possibly critical fault or deterioration of the structure went unchecked.

Last month the NTSB said that gusset plates holding together eight of the 112 joints on bridge's main truss were under designed, with some of them having a load to capacity ratio of more than two.

"We should analyse the bridge as it stands today, not as it was designed"

David Mongan, ASCE

The NTSB's interim report on the collapse claims that bridge inspections would have been unable to identify the design fault because they focused on detecting cracks or corrosion rather than errors in the original design.

But American Society of Civil Engineers (ASCE) president David Mongan said, "Maybe a lesson to learn from this is that we should examine all the critical elements of bridges during inspection and before [capacity] alteration, and analyse the bridge as it stands today, not as it was designed."

This extra analysis, added Mongan, would add little to the cost of bridge inspections and alterations.

Standing Committee on Structural Safety secretary John Carpenter said the finding showed that in the UK, where much of our bridge infrastructure is ageing, inspection contracts should not be awarded on a cost basis.

"It is important that the money is spent so that bridge inspections are carried out by engineers with experience, and that they are given sufficient time so that they are not doing just minimal checks," said Carpenter.

The I-35 W bridge opened in 1967 and was designed by consultant Sverdrup & Parcel, now part of Jacobs Engineering, Jacobs was unavailable for comment.

The bridge was subject to annual non-intrusive visual inspections, and only the beam was checked before two major renovations.

Two renovations in 1977 and 1998 increased the average thickness of the road deck from 6.5 inches (165 mm) to 8.5 inches (203 mm) and central reservation and outer impact barriers were also increased in size.

As a result of the NTSB's interim findings, US secretary of transportation Mary Peters issued safety guidance that all states should calculate how possible changes in bridge weight or capacity will affect gusset plates on non-load path redundant steel truss bridges.

Of the US's 13,000 steel truss bridges, only 700 are thought to be non-redundant structures similar to the I-35 W, so wholesale gusset plate inspection was unlikely, said Mongan.

But the State of Minnesota has begun a review of gusset plates on all of its 59 steel truss bridges.

The interim report's identification of a fault in the gusset plates placed design and engineers rather than publicly funded maintenance in the spotlight.

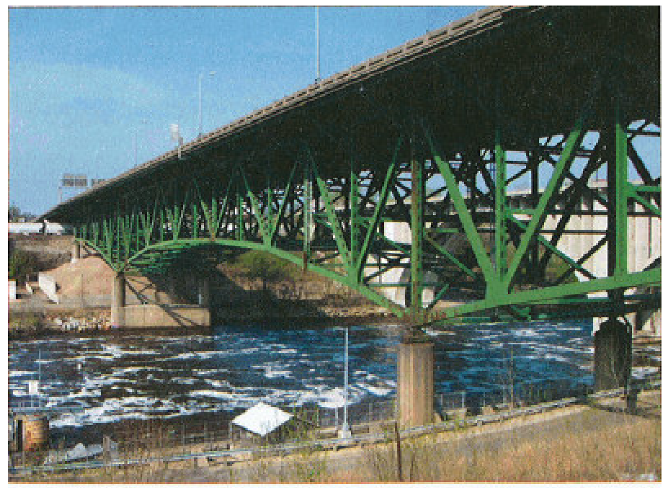
As a result it drew criticism from University of Pittsburgh assistant professor of civil engineering Kent Harries.

"They haven't identified the mode of failure," said Harries.

"The structure stood for 40 years without deformation or distortion, why did it fall when it did? This report tells us very little."

UNDER-DESIGNED GUSSET PLATES HOLD KEY TO MINNESOTA FAILURE

Plates on eight of the 112 I-35 W bridge joints were under designed say investigators.



Before the collapse: The I-35W bridge collapsed 1 August 2007

Investigators probing the I-35 W bridge collapse found fractured gusset plates, which had held together steelwork connections.

Back calculations revealed a serious error in the sizing of some of the gusset plates in the main truss, with some having a load to capacity ratio of more than 2.

Undersized pairs of gusset plates were found at eight of the 112 joints on the main trusses of the bridge.

Load to capacity ratios for these plates for shear, tension and compression ranged between 1.1. and 2.1, with an average of 1.7. A load to capacity ratio over 1 indicates that the design load is exceeded.

Original fabrication drawings show that the gusset plates that were undersized on the bridge were also undersized on the drawings.

Investigators were unable to find original calculations for the plates, so it is unknown whether the mistake was a drafting error, calculation error or some other mistake in the design process.

The joint design was not reviewed when the bridge underwent major renovations in 1977 and 1998.

As the connections are designed to be stronger than beams to avoid a sudden failure, only the beams were checked, on the assumption that the other components were stronger.

The bridge was a non-load path redundant structure, so failure of a single member would lead to the collapse of the bridge.

Modern bridges today aim to design redundancy into structures to prevent sudden catastrophic collapse should a single part be overlooked.

BEIJING DREAM

Just six months to go until the Beijing 2008 Olympics and it looks as if China's capital has come up trumps. ***Ruby Kitching*** *spoke to the engineers who helped construct the showpiece structures.*

The run up to the 2008 Olympics is a very different affair to Athens in 2004. When NCEI reported from Greece four months before the opening ceremony, the main stadium roof was still to be jacked into position and just a week before the start of the Games, test events were being cancelled because mechanic al and electrical equipment was not ready.

Now, with six months to go until Beijing takes center stage the Olympic stadium is structurally complete and fitting out has begun. And at the aquatics center, a programme of test events just started.

These two structures are the most spectacular of the 2008 Games; the national stadium is dubbed the "Bird's Nest" because of its intricately arranged steel roof structure and the national swimming centre's plastic bubble cladding has earned itself the nickname of the "Water Cube".

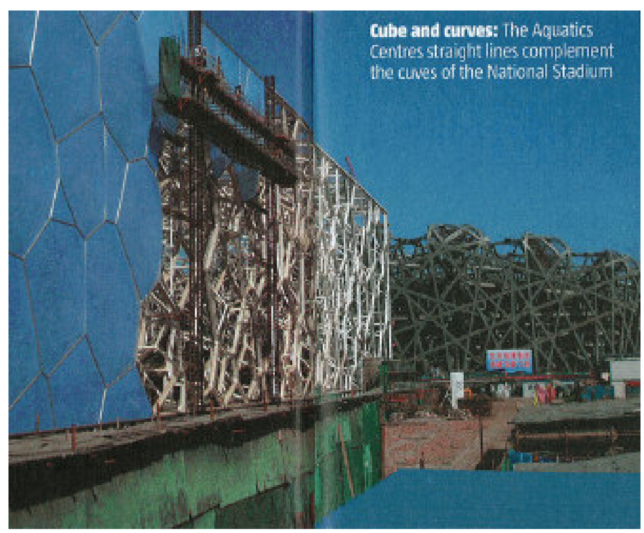
"It's more than just about the business, it's about national pride," says National stadium project director Michael Kwok speculating on what has driven the Chinese nation to excel in competing its Olympic sporting venues in good time for the start of the Games in August.

Kwok is director of consultant Arup's Hong Kong and China office. Arup, together with China Architecture Design and Research Group (CADR Beijing) and Swiss architect Herzog & DeMeuron, makes up the stadium design team.

"People fought really hard to work on Olympic projects. Because most contractors are Chinese, they are doing it for their country and put more effort into it. They work day and night because they want to build things on time," he adds.

Kwok says that when he first set eyes on the Birds Nest scheme, he knew it would be a winner because it was so different but recalls that his initial reaction of, "Wow" was swiftly followed by, "well how do we design this?"

He explains that the stadium was designed "inside out" and that his first priority was to make sure that spectators were as close as possible to the action, with clear sight lines. "This produced a very compact design. It was very important from a structural point of view that spans were as short as possible – this impacts on cost, so it was a clear objective to minimize the spread of the stadium".


Cube and curves: The Aquatics Centres straight lines complement the cuves of the National Stadium

The other challenge was to establish whether the twisted and skewed steel components could be fabricated and erected in China to the accuracy required. "it's such a random, chaotic looking structure, but for it to work, we needed to find some logic to it."

Kwok explains that the roof consists of a primary steelwork structure of 24 trussed columns spaced regularly around the stadium perimeter and connected at the top by horizontal trusses which cross the elliptical opening. They effectively form 12 portal frames which span the stadium. The opening itself is framed by a 10 m deep steel truss ring. This structure resists wind and seismic loads and is "quite regular" he assures, while the secondary structure which sits on top of it, is what gives the stadium its "chaotic" feel. The secondary steelwork supports reduce the distance the cladding must span. "It also gives extra stiffness to the structure to dissipate energy during earthquakes: these elements are designed to reach their yield point, protecting the main members in the primary structure."

The steelwork was designed using the 3D software CATIA to define to milimetre accuracy the spatial arrangement of each steel element. These coordinates were then passed to the fabricator, the contractor and eventually the steel erectors to ensure the accuracy with which the structure was designed could be transferred onto site .

"I think the stadium is simpler than it looks. People think that there's no order to it, - that it's a random collection of elements – but when you look at each layer, there is a clear geometry. Each quarter of the roof is actually identical," says Kwok.

The steel elements which make up the roof are all box sections fabricated from flat plate and, on the outermost layer of steelwork, all measure 1.2 m by 1.2 m. "Where stresses are low, the plate thickness of the box sections is just 25 mm. But this increases to 100 mm where the stresses are highest. From the outside they all look the same," Kwok adds.

Like many spectacular stadiums this project has had its ups and downs. In Beijing, it was the scrapping of the retractable roof after the whole structure had been designed. During a design review with the client in 2004 the issue of cost savings came up due to the increase in the price of steel. Says Kwok: "in terms of savings, removing the retractable roof reduce the weight of steel by 20%, but it affected the whole concept of the Bird's Nest." He explains that removing the burden of the retractable roof's weight, steel member sizes could be reduced and the central opening above the athletic field enlarged.

"Because most of the contractors are Chinese, they are doing it for their country and put more effort into it."
Michael Kwok, Arup

"We knew we had to make these cost savings, but we were nervous about how long it would take for the new design to be

Three layers of China's 'Bird's Nest' National Stadium

approved. We had to work very hard not to compromise the Bird's Nest image and still satisfy the client." The main changes were in redesigning the connections, rather than altering the overall shape. However, the process ate up nearly four months of the tight programme.

The stadium's success, he says was achieved chiefly because design changes were approved and agreed quickly.

"There was a really focused effort to move forward and create the least disruption while still improving the design. Much of this was driven by the government and the Olympic Authority who were prompt in giving their consents. They understood the pressure we were under and the last thing they wanted was to hold things up."

Deputy chief engineer for the stadium with CADR Zhong Fan adds that the success of the project is largely due to the "scientific attitude of the design team". He told NCEI, "We did a lot of testing and scientific research, and a huge amount of calculations, reading a tremendous amount of manufacturer's literature and meeting with many specialists to design and build this complex building."

With such a unique structure, the onus was on the design team to make the structure as simple, safe and economic to construct. "What the National Stadium has done for China and the world, is to introduce a new type of structure," says Fan. "The London Olympics can learn from this and produce an even better Games, as each city does every four years."

Erecting the roof involved building it first on temporary towers until the whole structure was complete. It was then ceremoniously de-propped over three days, with the final day's activity being televised live.

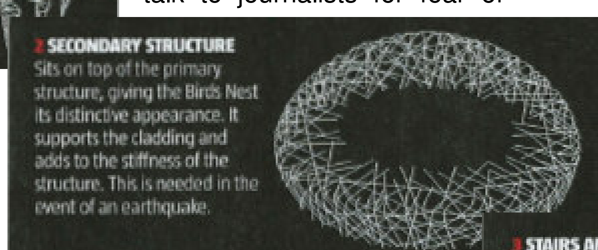
The live broadcast was symbolic of the increased confidence the Chinese government and Olympic Committee has developed over the course of the construction period, says Kwok.

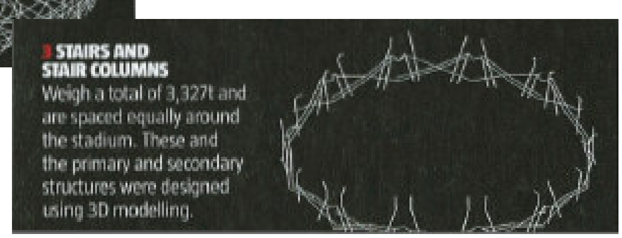
"To start with there was very little media coverage of the stadium and for a long time, our client didn't want to talk to journalists for fear of getting an adverse reaction. But the atmosphere changed when we finished the stadium and people started saying how much they liked it."

Kwok hopes that the lasting legacy of the stadium will be more than just as a sporting venue. "It shows the role an engineer can play in defining what is possible in architecture. It also shows that China, and Beijing, want to innovated and have no fear in challenging existing systems and going beyond them. For China, it shows its ability to construct some of the most difficult buildings in the world, and shows off our determination to succeed."

One of the main criticisms of the stadium is that it is vastly overdesigned with nearly 42,000 t of steel structure to enclose 91,000 seats. But Fan says that steel was the only material which could achieve the high strength required in each component, with a relatively low mass. "For us, it was the most economical choice because there was no other choice."

Kwok is more pragmatic about these criticisms, "if the stadium was just for sport, then it wouldn't be cost effective. But the Bird's Nest is more than just that. It is a temple for the people, a place to visit and photograph, a reason to stay in Beijing for an extra day.





World's biggest building

The biggest building in the world, Terminal 3 at Beijing Capital International Airport, opened this week. Designed and completed in only four years, the structure is 17% bigger than the combined floorspace of Heathrow's terminals 1, 2, 3, 4 and 5. Together with the airport's ground transportation center, the new terminal will enclose a floor area of approximately 1.3 Mm^2, mostly under one roof. UK consultant Arup provided engineering consultancy services on the design.

Ask Dr. Sylvie

To access Dr Sylvie's information, and to read the current or earlier issues of Advantage Steel, click on the following link:
http://www.cisc-icca.ca/content/publications/publications.aspx

Mark Your Calendars

SEABC Education Committee

Wednesday, May 21, 2008

Seminar

Topic:	Kicking Horse River (Park) Bridge
Presenter:	Robert Gale, P.Eng., KWH Constructors/Somerset Engineering
Venue:	BC Hydro Building, 333 Dunsmuir
Time:	6:00 p.m. – Refreshments 6:30 p.m. – Presentation

Robert Gale, P.Eng. is a Structural Engineer with KWH Constructors and Somerset Engineering of Burnaby, BC, Canada and has over 19 years experience in the construction of structures, specializing in bridges. Mr. Gale holds a Bachelor Degree in Civil Engineering from the University of British Columbia and has professional status in both the United States and Canada.

The new 405-metre-long Kicking Horse River (Park) Bridge, east of Golden, B.C., is billed by Premier Gordon Campbell as a vital artery linking British Columbia to Canada and beyond. Ottawa and B.C. are sharing costs of about $130 million for the bridge and 5.8 kilometers of upgraded approaches. This work is part of a $960-million project involving two major bridges and reconstruction of 26 kilometers of highway.

KWH Constructors Corp. was retained to erect the steel superstructure in the new bridge. The New Park Bridge is a horizontally curved steel plate girders superstructure that was designed, fabricated and successfully erected using the incremental launching method. The bridge was launched as two separate parallel girder-pair units with each weighing about 1430 tons.

June 5, 2008

Course: Design of Aluminum Structures

www.csce.ca

Description:
The objective of this course is to provide consulting engineers, professionals, technicians, instructors and students with training on the design of aluminum structures as well as extensive information on the main characteristics of structural aluminum. The course guides the participants through the most significant portions of the practical and theoretical developments of the reference book Design of Aluminum Structures written by Dr. Denis Beaulieu.

The first book dealing with structural aluminum to be published in Canada, it adopts a pragmatic approach and offers practicing engineers and technicians a practical tool for designing aluminum structures. It is supported with a number of numerical examples covering all the material. The book draws from the Canadian standard CSA S157-05, Strength Design in Aluminum and from other Canadian, American and European standards in order to broaden its contents.

It is recommended that participants obtain a copy from www.pral.ca. They will obtain a 25% discount on the purchase price.

The Author and Speaker:
Denis Beaulieu, Ph.D., ing. Professor of civil engineering at the University of Laval and Special Consultant at the Quebec Industrial Research Centre, Denis Beaulieu has carried out extensive research and work on steel and aluminum structures. He is a member of CSA, CSCE, IABSE, CQRDA and a CSCE past president.

Location:
Plaza 500 Hotel
500 West 12th Avenue
Vancouver, BC V5Z 1M2
604-873-1811

To download a registration form go to:
https://www.csce.ca/admin/docs/DAS_CSCE_2008.pdf

September 2008 Term Course Offerings

Certificate in Structural Engineering Program

All courses listed below will be offered in classroom at the Vancouver Public Library, 350 W. Georgia Street, Vancouver, and by internet webcast.

Please see www.seabc.ca for detailed course and registration information.

C4 Earthquake Engineering and Seismicity

Purpose:
This course covers fundamental concepts of earthquake engineering and will provide the student with a background necessary for understanding and performing seismic analyses and design of building structures covered in other courses of this program.

Selected Topics:
Introduction – how earthquake forces are developed and resisted; seismic response of single-degree-of-freedom systems and the concept of response spectrum; seismicity, earthquake hazard, and the background of uniform hazard design spectra; seismic design philosophy (ductility, seismic vs. wind effects); fundamentals of dynamics for multi-degree-of-freedom systems; NBCC seismic provisions – base shear formula; seismic force distribution; torsional effects; types of diaphragms and the effects on seismic response; irregular structures; ductility and capacity design; foundation design considerations; parts of buildings (nonstructural elements); seismic design of non-building structures (bridges, tanks, pipelines); concept of base isolation and seismic damper devices; development of seismic design objectives and seismic risk considerations.

Instructors:
Carlos Ventura, Ph.D., P.Eng., Professor, Department of Civil Engineering, UBC; ***Don Anderson***, Ph.D., P.Eng., Professor Emeritus, Department of Civil Engineering, UBC; ***Ken Elwood***, Ph.D., P.Eng., Assistant Professor, Department of Civil Engineering, UBC; and ***Svetlana Brzev***, Ph.D., P.Eng., Instructor, Department of Civil Engineering, BCIT.

Contact:
Carlos Ventura, email: ventura@civil.ubc.ca
Communications: Notices to students and questions outside of class will be handled strictly through e-mail.

Schedule:
4:00 to 6:00 P.M. on 12 Tuesdays, September 16 to December 9. EXCEPTION: No class on November 11 – instead this class will be held on Wednesday, November 12.
(Mid-term break: Oct. 28).

Location:
Alma Van Dusen Room, Vancouver Public Library
C9 Computer Structural Analysis
E1 Masonry Design of Buildings

C9 Computer Structural Analysis

Purpose:
This course covers the major concepts of computer structural analysis which provide a basis for most commercial analysis packages. The main focus of the course is on illustrating the fundamentals of the direct stiffness analysis method using the general engineering worksheet program Mathcad. Access to, and very basic working knowledge of, Mathcad (Version 11 or higher) is strongly recommended. The course will provide a solid basis for further studies of static and dynamic responses of structures.

Selected Topics:
Degrees of freedom and discretization; local coordinates and member stiffness matrix (axial members, bending members, springs); global coordinates and stiffness matrix; geometric transformation; nodal loads; solving for deflections; solving for member forces; member loads; thermal loads and prestrains.

Instructor:
Andreas Felber, Ph.D., P.Eng.
Buckland and Taylor Ltd.

Contact:
Andreas Felber
e-mail: afelber@b-t.com

Communications:
Notices to students and questions outside of class will be handled strictly through e-mail.

Schedule:
7:00 to 9:00 P.M. on 12 Tuesdays, September 16 to December 9. EXCEPTION: No class on November 11 – instead this class will be held on Wednesday, November 12.
(Mid-term break: Oct. 28

Location:
Alma Van Dusen Room, Vancouver Public Library

E1 Masonry Design of Buildings

Purpose:
This course is intended to provide the practicing engineers with the skills and knowledge required for effective design of masonry buildings according to the Canadian Masonry Standard CSA-S304.1-04. The main focus is on design concepts and practical field applications of Canadian masonry construction. Special emphasis is made on seismic design, including an overview of the NBCC 2005 and S304.1 seismic provisions for masonry structures. The upcoming publication Guide to the Seismic Design of Low and Medium-Rise Masonry Buildings in Canada will be used as the main resource for seismic design portion of the course. Students will be exposed to practical aspects of masonry construction through project examples and a hands-on session. The course is delivered through lectures, design assignments, case studies, and the final exam. The course textbook Masonry Design for Engineers and Architects (including CSA Standard S304.1 on CD), the Masonry Institute of BC Technical Manual, and the new Guide to the Seismic Design, are complimentary.

Selected Topics:
Masonry materials and components; basic design considerations for masonry structures per CSA-S304.1; design of masonry beams; design of masonry walls for axial load and bending, including slenderness effects; design for shear; seismic design of masonry shear walls; design of veneer walls; construction and building science issues; detailing of masonry structures; masonry specifications and design notes; MDS 2007 computer software applications for design of masonry structures.

Instructors:
Svetlana Brzev, Ph.D., P.Eng., Department of Civil Engineering, British Columbia Institute of Technology;
Bill McEwen, P.Eng., LEED AP, Executive Director, Masonry Institute of B.C.; and supplemented by guest speakers.

Contact:
Svetlana Brzev
e-mail: sbrzev@bcit.ca

Communications:
Notices to students and questions outside of class will be handled strictly through e-mail.

Schedule:
4:00 to 6:00 P.M. on 12 Thursdays, September 18 to December 11.
(Mid-term break: Oct. 30

Location:
Alma Van Dusen Room, Vancouver Public Library

E12 Seismic Design of Steel Structures

Purpose:
The 8th edition of CSA standard S 16-01 "Limit States Design of Steel Structures" has incorporated a considerable number of technical changes reflecting the latest research developments and changes in practice. The changes effected are probably the most extensive since the introduction of limit states design in the 1974 edition. This course seeks to summarize the relevant new information on the seismic design of steel structures into different lectures on materials, plastic sections, capacity design, and component and system response, while providing useful guidance on detailing. Emphasis will be on earthquake-resistant design of steel structures. This is because the provision of ductile structures is crucial to seismic survival. Clause 27 of the code, and all different classes of frames with various energy dissipation capacities or ductility rations, will be discussed.

Selected Topics:
Topics to be covered will include: Common properties of steel materials; plastic behaviour, Hysteresis models; analysis and design of moment resisting frames; concentric braced frames and eccentric braced frames; Capacity design for components including pedestals, anchor bolts, footings, and connections (gussets, bolts and welds).

Instructor:
Mahmoud Rezai, Ph.D., P.Eng.
EQTec Engineering Limited

Contact:
Mahmoud Rezai
e-mail: mrezai@eq-tech.com

Communications:
Notices to students and questions outside of class will be handled strictly through e-mail.

Schedule:
6:30 to 8:30 P.M. on 12 Thursdays, September 18 to December 11.
(Mid-term break: Oct. 30)

Location:
Alma Van Dusen Room, Vancouver Public Library