SEABC NEWSLETTER

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Published by the Structural Engineers Association of BC

ISSUE No. 001 FEBRUARY 2008

- SEABC's Newsletter is edited and managed by Robert Smith (robert.smith@seabc.ca)
- 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.

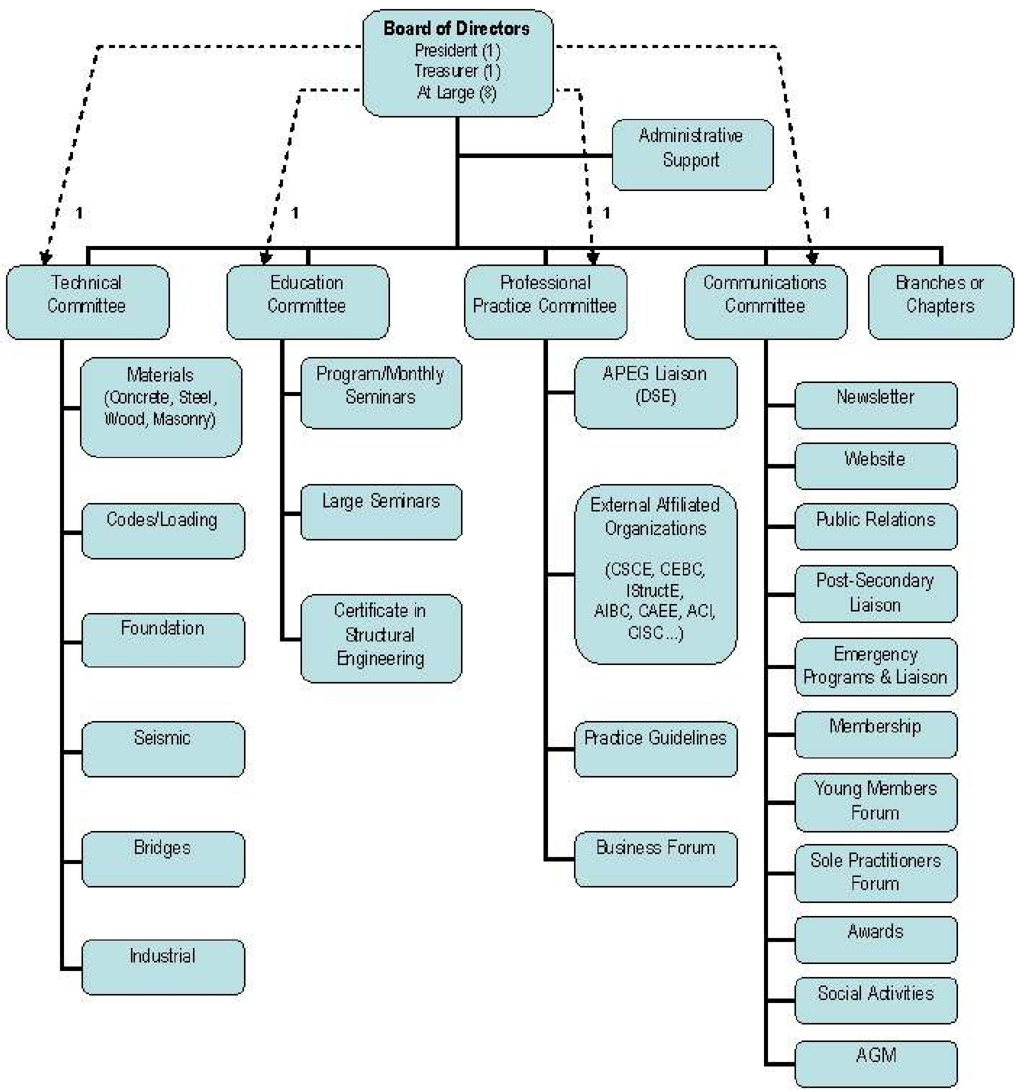
Message from the President

By Dave Davey; SEABC Interim President

It is with great pleasure that I accept the role of President of our newly formed Structural Engineers Association of BC and am able to welcome our new members. Of course, most of you were members of the Division of Structural Engineers or the Vancouver Structural Engineers Group or both and the activities of these two associations are continuing under the SEABC banner.

SEABC was officially incorporated as a non-profit Society under the Provincial Society Act on January 3, 2008. This event marked the culmination of over two years of discussion and a year of planning with input from many structural engineers and with the approval of over 80% of the members of both the DSE and VSEGS.

We have an interim Board of Directors and four committees in place, but there are many vacancies still to fill. The scope of our activities was well set out in the proposed organization chart that was published last year and which is reproduced below. The job of the Directors is to provide overall direction and government of the Society but the main thrust of the Society's activities is expected to come from the committees working in the four main functions shown on the organization chart.



The two functions of education and professional practice are basically the functions that were well performed by the VSEGS, the CSE Committee and the DSE in the past and those bodies are carrying on with this work under the cloak of SEABC. However, the functions of our Technical committees and Communications groups are widening the range of services that we want to offer to our members.

It is gratifying to see the re-activation of technical committees that were originally set up by SECBC in the 1990s. The Technical manual that was drawn up by SECBC, though not quite a DIY guidebook for general practitioners of Structural Engineering was a valuable reference to help engineers keep up to date on the state of the art. Design codes are constantly changing and so are construction procedures and so the topics of interest are changing also.

Two such topics have already been selected for review. One is the design of guards and handrails, of which a good proportion of recent construction can be seen to be deficient. Currently, guardrail design is often left to the manufacturer and does not begin until construction is already under way. This can mean that the inter-face between guard and structure is not coordinated and the question arises as to who is responsible (and who is being paid to look after it). The design of guards is the topic of an APEG seminar in Kelowna on January 30th.

The second is the question of how the 2005 Code seismic requirements impact on the design of foundation walls. The change in design from 10% in 50 year return period to 2% in 50 years has resulted in a large increase in seismic retaining wall design pressures coming from the geotechnical consultants. This needs to be addressed in a manner similar to how the 2005 NBCC liquefaction issue was dealt with by the geotechnical task force. The whole area of soil / structure interaction is complex. How do we bring this whole problem down to the practical level so that practicing engineers can produce realistic designs? We'd like your input on this or any other technical matter that you feel needs to be brought to attention.

The Communications group already has our website up and running at www.seabc.ca. I hope that you have already had a chance to view it. It will improve and grow in time and very shortly it will incorporate an interactive forum for members to communicate directly with the SEABC body. It will be a site to post information of interest, to pose questions and to receive answers.

This Newsletter is a continuation of the DSE Newsletter. We hope to have the Newsletter issued quarterly in order to bring you more articles of local interest and to keep you updated on what we are doing.

I see Communications as the most important function of SEABC. I believe that we all want to know what is going on in our province, we want answers to our problems, we want a way to exchange information with others, we want all engineers to be working to a common standard that we can all reach. We want communication and feedback. This is the task of our Communications Group.

We are a non-profit society. We have no office and we have no full time staff. We are a body of volunteers. Our success will depend on the number and contribution of our members. If you are not yet a member of SEABC, I encourage you to register. If you have not received a Registration Form by email, please download the form on the website. If you would like to be a volunteer to work on one of our committees, please let us know. We will try to fit you into your preferred area of interest because the more volunteers that we have, the less becomes everyone's workload.

The committee members are as follows:

Interim Directors

David Davey - President
Surinder Parmar - Secretary / Treasurer

- David Harvey
- Cameron Kemp
- Andrew Seeton
- Jim Mutrie
- Rob Simpson
- Carlos Ventura
- Leslie Mihalik
- Thor Tandy

Technical Committee

Ken Elwood - Chair

- Rob Simpson
- Robert Jirava
- Thor Tandy
- Kevin Lemieux

Education Committee

Andrew Seeton - Chair
Leslie Mihalik - Vice chair
Fran Abbuhl - Secretary

- Surinder Parmar
- Martin Bollo
- Joel Hampson
- Tony Martin
- Joe Tam
- Ken Elwood
- Mahmoud Rezai
- Donald Burkholder
- Gord Shannon

CSE Organizing Committee

John Pao - Chair
Fran Abbuhl - Secretary

- Carlos Ventura
- Joel Hampson
- Martin Bollo
- Bob Schubak
- Steven Kuan
- Svetlana Brzev

Professional Practice

Thor Tandy - Chair

- Jim Mutrie
- David Harvey
- Mazeed Abdulla
- Leonard Pianalto
- Peter Trainor
- Andrew Watson
- Marian Podlovsky
- Rob Smith

Communications

David Harvey - Chair

- Rob Smith
- Stephen Pienaar
- Robert Jirava
- Jeff Corbett
- Greg Beaveridge
- Doug Williams
- John Peddle
- Grant Newfield
- Elizabeth Lawrynowicz

SEABC Technical Committees

Proposed working of the committee:

TECHNICAL EXECUTIVE COMMITTEE

- The technical executive committee is responsible for coordinating the work of the technical sub-committees and task groups. It should be as small as possible (approximately 5 to 6 people).
- The technical executive committee will have regular meetings at an interval to be decided. It is expected that 2 or 3 meetings per year will be sufficient; with some of these conducted by email or conference call. Will SEABC cover the expenses of using a conference call service?
- The technical executive committee is the conduit for communication between the membership and the sub-committees.
- The response of SEABC to technical issues of concern to the membership is the responsibility of the technical executive committee. They decide whether the issue can be addressed directly by expertise within the technical executive committee or is best handled by one of the standing sub-committees or whether a task group is required.
- The chairs of the sub-committees and task groups are appointed by the technical executive committee.

STANDING TECHNICAL SUB-COMMITTEES

- The Material Codes, Loading Codes, and Special Structural Systems standing sub-committees do not have regular meetings. They meet at the call of the sub-committee chair for specific tasks requiring meetings (for example, code development).
- The makeup of the sub-committee is the responsibility of the sub-committee chair. The chair decides the desirable size (max and min) of the sub-committee and recruits a core committee membership.
- Additions to the sub-committee membership are decided by the sub-committee chair, in consultation with the sub-committee members. New members will be selected from a list of those members who have expressed an interest to the technical executive committee in joining the sub-committee.

TASK GROUPS

- Task groups will be formed by the technical executive committee or at the request of the sub-committee chairs.
- The task groups have regular meetings until they have completed their assigned task.

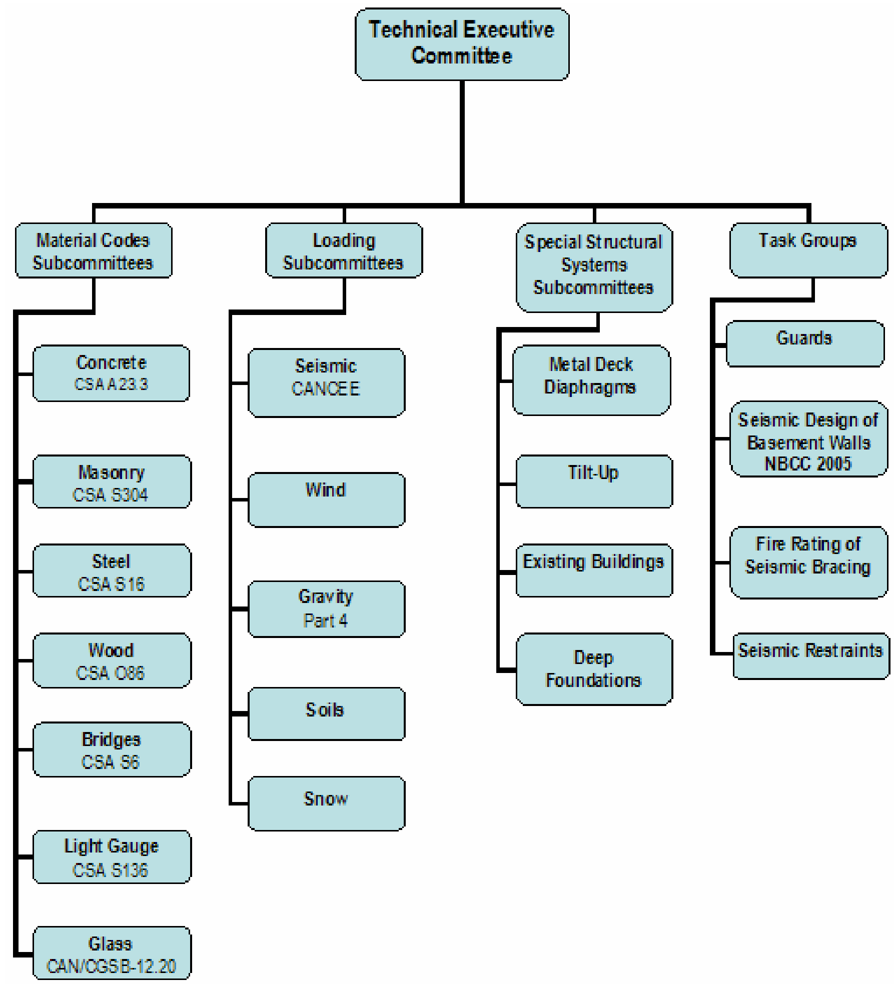
REPORTS AND BULLETINS

- All task group or sub-committee reports or bulletins are subject to a “peer review process”, as determined by the technical executive committee, prior to becoming an official SEABC document.
- Draft reports and bulletins may be posted on the SEABC website prior to final review to receive public comments. Such posting will be announced to the membership through the SEABC newsletter.

MEMBERSHIP

- Any member of SEABC would be eligible and encouraged to sit on a sub-committee or a task group. Expressions of interest would be channelled through the technical executive committee.

The Technical Committee Organization Chart follows:



Seismic Restraint Task Force

Chair: Rob Simpson, P.Eng., MBA Struct. Eng.

rsimpson@glotmansimpson.com

Key Words: Seismic Engineers; Specialty Engineers; Seismic Restraint; Design Responsibility; Field Review; Design-Build; Design by Contractor; Stamp.

Wide differences in service exist in the industry for structural design and field review of seismic restraint by Specialty Engineers. This task force is charged with the following objectives:

-

- Determine the status of the industry and the reasons why different levels of service exist within the same general scope of the industry.
- Determine gaps that exist in the chain of responsibilities between various professionals in the industry.
- Consider various alternative levels of service that might be appropriate within the industry and whether different approaches might be appropriate in some segments of the industry.
- Include opinions from other industry participants including Mechanical, Electrical and Geotechnical Engineers, Architects, General Contractors, Mechanical and Electrical contractors and any others pertinent to the field of seismic restraint.

- Establish a consensus for a basic level of service and minimum requirements for professional service in this industry.
- Propose appropriate protocol for the industry.

Those interested in working on the committee are encouraged to contact Rob Simpson to express their interests. Anyone with concerns about this area of our industry or with examples of issues that they have faced, please also contact Rob Simpson at: rsimpson@glotmansimpson.com

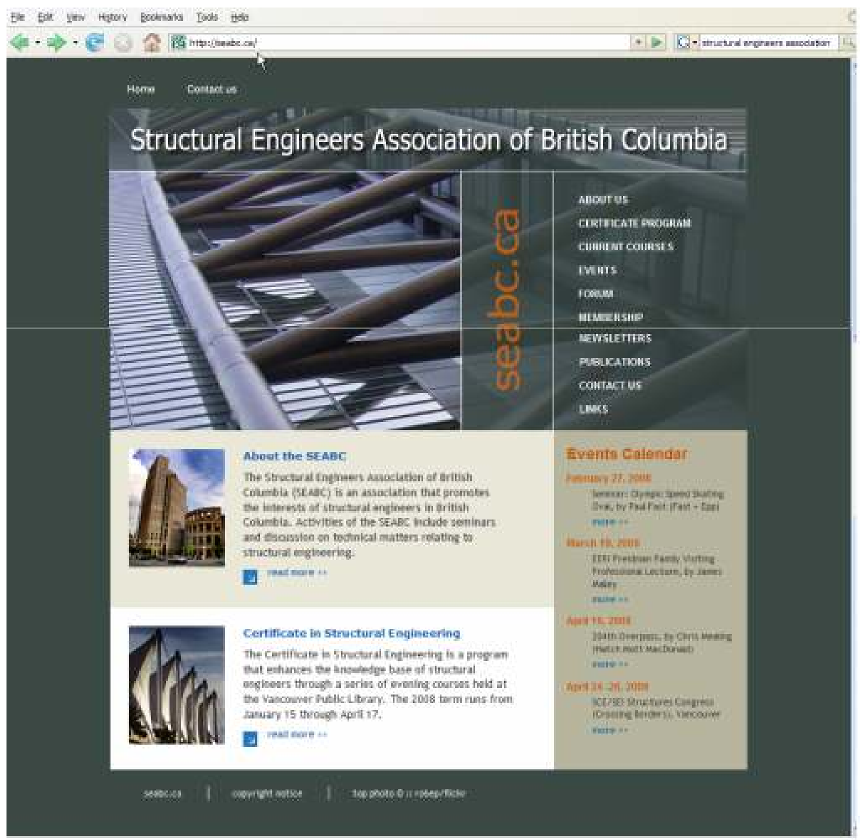
On the Web

By Stephen Pienaar; SEABC Webmaster

The new SEABC website is online at www.seabc.ca. The website went live in January, two weeks after the official formation of the SEABC. Credit goes to the previous VSEGS webmaster, Tom Abbühl, for leaving us a great base to work from.

The SEABC executive has great plans for the Association's online presence, and recognizes the opportunity of improved communication, not only to members, but also between members. The new Communications Committee is already making things happen:

- We have an electronic mailing list system in place for distribution of quarterly newsletters and other information.
- The SEABC Discussion Forum makes conversation possible about matters relating to structural engineering, our Association and the website itself. The various committees also each have a space where they can discuss internal matters.



A lot more content and many more website features are in the pipeline. Amongst others, we are looking at online membership management and annual fee payments. The sky is the limit (that is, apart from our available time).

We would love to hear what you think of the SEABC website. Do not hesitate to send us your comments and suggestions for improvement. You can either post your ideas in the SEABC Discussion Forum or send them to webmaster@seabc.ca.

Stephen Pienaar, P.Eng.
SEABC Webmaster

Structures Congress in Vancouver

By David Harvey; Director, SEABC

For the first time in its 40 year history, the ASCE/SEI Structures Congress will be held outside of the United States, when the City of Vancouver hosts the Congress on April 24-26, 2008, at the Hyatt Regency Hotel. The premier annual structural engineering event in North America, the Structures Congress draws over 1000 delegates from across the world. The 2008 Congress has been planned for the last three years by a local Steering Committee, which includes Directors Carlos Ventura, Leslie Mihalik, myself, and several other members of SEABC.

The Steering Committee has put together a mouth-watering technical program. The Congress features ten tracks and 100 technical sessions over the three days. There are several prominent speakers including winner of the Nobel Prize for Physics, Dr Carl Wieman; Vice President of Construction for the 2010 Olympic Games, Dan Doyle; and the creator of the world-famous Millau Viaduct, Michel Virlogeux. There are also two pre-tour presentations and technical tours to the Canada Line project and the Olympic Speed Skating Oval, and two pre-congress workshops. All told, delegates can earn up to 24 Professional Development Hours at this one event. In addition, there are vendor demonstrations, poster sessions, a packed exhibit hall, the Grand Opening Reception, and for the first time, a Structures Congress Banquet.

The structures congress is widely supported internationally, and is being co-sponsored this year by the Canadian Society for Civil Engineering, the Institution of Structural Engineers, the International Association for Bridge and Structural Engineering, and the Council of American Structural Engineers. Members of these organizations can register at the same rate as ASCE members. As a recognition of the effort put in by the local structural engineers, members of SEABC an also register at the ASCE member rate, a saving of $150 compared with the non-member rate!

If required, accommodation at the Hyatt at the conference rate is currently available. Note the early-bird cut-off date of February 28, after which registration increases by $100. Daily registration, and transferable corporate passes are also available. There is truly "something for everyone" at the 2008 Structures Congress, and this is a great opportunity to visit the event on "home turf". The committee expects this Congress to sell out and set new standards for future events.

For full details of the conference and to view the preliminary technical program, visit the Congress web site at:

http://content.asce.org/conferences/structures2008/

Applied Technology Council Report

By Steven Kuan; Senior Seismic Engineer, Office of Housing and Construction Standards

I am pleased to be the SEABC representative for the WCSEA membership on the Board of Directors of the Applied Technology Council (ATC). WCSEA selects its representative from its member organizations on a rotation basis, and it is currently SEABC's turn to provide the representative.

ATC is a non-profit organization headquartered in Redwood City, California for the development and promotion of state-of-the-art engineering resources for use in mitigating effects of natural hazards on the built environment. It is guided by a Board of Directors comprising representatives from various structural engineering associations in the U.S., including WCSEA, National Council of Structural Engineering Associations (NCSEA), Structural Engineering Association of California (SEAOC), and recently Structural Engineering Association of New York (SEAONY).

Since 1973, ATC has conducted a wide variety of projects to advance the practice of earthquake and structural engineering. It has published over 100 technical reports and has conducted many seminars and workshops on current and emerging issues in structural engineering.

One of the popular products by ATC is the ATC-20 series for post-earthquake building damage evaluation. Many engineers and non-engineers in British Columbia have been trained on the concepts and procedure from this document that is used also in other countries.

The emphasis of ATC over the years has been on earthquake engineering. However, it has been increasing its involvement in wind, flood and blast engineering. Similar to the ATC-20, the ATC-45 field manual provides guidance on procedures for safety evaluation of buildings after windstorms and floods. These hazards are of relevance to us in British Columbia following our experiences with floods and high winds in recent years. Also coming this year is the updated Wind Design Guide 2: Basic Wind Engineering of Low-Rise Buildings.

The following active ATC projects are of special interest to structural engineers in B.C.:

- developing practical performance-based seismic design guidelines
- establishing a new methodology for reliably quantifying building system performance and response parameters (i.e. the R-factors) for use in seismic design
- updating practical guidelines for design and construction of non-structural components in new and existing buildings
- developing guidelines on modeling and acceptance criteria for seismic design of tall buildings and on selecting ground motions for use in seismic design of tall buildings

In 2006, as part of its second ATC Awards Dinner, ATC presented the Top Seismic Engineers, Projects, and Products of the Last 100 Years (with 13, 9, and 10 winners in the three categories, respectively). Familiar names such as Nathan Newmark, Ray Clough and Joseph Penzien were among the top engineers cited. Top products included the response spectrum method and the SEAOC Blue Books.

ATC has established the Henry J. Degenkolb Memorial Endowment Fund. This fund has been used to implement several useful projects on important issues. The ATC-45 project is one example. ATC welcomes financial support from organizations to this fund. Any person or organization wishing to contribute could contact me for further information.

My participation so far has been very enjoyable and worthwhile. It is interesting to exchange knowledge and experience and to learn of relevant issues that are similar in both Canada and the U.S., as indicated by the list of active projects above. Particularly, I have been able to bring to the awareness of ATC some of the many interesting structural engineering activities and situations currently happening in British Columbia. I am proud to mention the Olympic construction boom and the upcoming ASCE/SEI Congress in Vancouver.

You could learn more about ATC and could purchase their publications from www.atcouncil.org. Feel free to contact me if you have any questions regarding any of their projects. As always, I will be happy to relay to ATC any concern or comment that you may have.

IStructE Centenary Conference

By David Harvey; Director, SEABC

I had the distinct privilege of recently attending the IStructE Centenary Conference, held at the new Hong Kong Convention and Exhibition Centre. Fellow SEABC members Patrick Lam and John Peddle also attended, as did 400 delegates from across the world. The conference proved to be a breathtaking summary of some of the last century's major structural engineering achievements along with a glimpse of what the future may hold for structural engineers.

The presenters were a veritable "Who's Who" of structural engineering. Attending the conference were many significant names from IStructE ranks, including the President, Sarah Buck, Chief Executive, Keith Eaton, eight past presidents, three vice presidents, and two gold medallists. Donald Tsang, Chief Executive of the Hong Kong Special Administrative Region, opened the Conference, underscoring its importance locally.

A number of leading Chinese engineers were invited, six of whom were awarded IStructE Fellowships. A rare Honorary Fellowship was awarded to Huang Wei, Deputy Minister, Ministry of Construction, Peoples Republic of China. All were delighted to receive their fellowships, especially Mr. Wei, who is now in the select company of the Duke of Edinburgh, and several members of the House of Lords!

It was a distinct honour for me to chair the session of bridge engineering. Notable presentations were made by Man-Chung Tang, Chairman of TY Lin International, San Francisco; and Holger Svenssen of Leonhardt, Andra and Partner, Germany who provided interesting perspectives into developments in modern bridge engineering. Equally fascinating was the talk by Naeem Hussain of Arup, Hong Kong, who described the tremendous achievements in design and construction of the nearby Stonecutter's Bridge, a world class cable-stayed bridge with a 1018 m main span, currently under construction. The conference technical program included a sold-out guided tour of the Stonecutter's Bridge.

There were many other notable presentations, including one on sustainable development in Shanghai from Arup Fellow, Peter Head. Michael Cook of Buro Happold, fascinated us by reviewing the history of lightweight structures, and describing how grid-shell structures had moved from adventurous experiments into a valid solution for free-form long-span roofs. Tristram Carfrae of Arup, Australia amazed us with some inspired solutions for building structures made possible by current analytical capabilities. He also described the challenges of surveying the Sidney Opera House to provide accurate as-build records, so that much needed interior modifications could take place.

Dr John Roberts, of Jacobs, UK, reviewed the design of entertainment structures, covering developments starting with the London Eye and moving to the Brighton i360 project. (His presentation will also be delivered here in Vancouver at the ASCE Structures Congress in April). Other presentations described building structures for the Beijing Olympic Games, including the revolutionary "soap-bubble" Aquatic Centre, and the National Stadium, commonly referred to as the "Bird's Nest".

The session on risk reduction included insights into earthquake damage and other major structural failures by Dr Allan Mann of Jacobs, UK; a state-of-the art address on soil-structure interaction, designing for robustness, by Professor John Burland of Imperial College; and a study of the performance of the World Trade Centre Buildings by lead FEMA investigator Dr Gene Corley. The session on disaster mitigation included some interesting insights into the wind engineering of tall and wind-sensitive structures by Professor William Melbourne of Monash University; and mitigation measures for coastal communities exposed to wind, waves and tsunamis by Professor Paul Grundy, also from Monash University. His talk included a considerable amount of information gleaned from the aftermath of the Indian Ocean tsunami of December 26, 2004, and reference to much lager historic tsunamis.

The wrap-up presentation was given by William Baker, Partner in charge of structural design in London and Chicago for Skidmore, Owings and Merrill. Bill covered some historical trends and made some bold projections for the next 100 years of structural engineering. Perhaps best known as the lead structural engineer for the record-breaking building, Burj Dubai, he pointed out that population densities in most major cities had plenty of scope for increase, noting that the density in Hong Kong is ten times that of Tokyo, and thirty times that of New York. Bill then predicted that the 800 m height of Burj Dubai would be passed by other record-breaking structures within a few years, and that the historic dream of mile-high buildings are perfectly achievable with current technology.

One of the great benefits in attending 'block-buster' conferences is the opportunity to rub shoulders and dialogue with the living legends of structural engineering. Naturally, I took full advantage of that and talked with an amazing group of people, two of whom spring to mind. My discussion with John Burland was a particular delight. Perhaps best known as the designer of the foundation strengthening system that rescued the Leaning Tower of Pisa, (and a rare IStructE and ICE double Gold Medallist) John is approachable and humble when you discuss his achievements. To my delight, John explained why the prediction for the lean of the Big Ben clock tower, associated with the construction of London's House of Commons Underground Car Park, constructed over 30 years ago, was very accurate, but 180 degrees out! (Current three-dimensional soil-structure interaction modeling can now handle these former computational inaccuracies).

Equally memorable was sitting down with Bill Baker over breakfast and enjoying an extended discussion on the design of tall buildings. Bill is most approachable, and it was like being in a design brainstorming session. Bill drew out on the back on an envelope, framing systems for Burj Dubai and several other iconic buildings! To me, discovering how structural engineers conceive structural solutions is endlessly fascinating, and my experiences in this regards contributed strongly to the enjoyment of this unique event. I'm sure that the second centenary conference will be even better, and it would be interesting to see how many of Bill's predictions actually come to pass.

Olympic Speed Skating Oval - Roof Structure

By Martin Bollo, M.Eng, S.E., P.Eng.
Instructor - Department of Civil Engineering
British Columbia Institute of Technology

Fast + Epp was retained by Cannon Design to provide full structural engineering services for a unique roof structure for the Long Track Speed Skating venue in Richmond – also known as the Richmond Oval - for the 2010 Winter Olympics.

The one-of-a-kind five acre roof structure features hollow, triangular-shaped composite wood-steel arches, which span 310 feet and conceal mechanical ducts, electrical conduits and sprinkler pipes. Spanning between the arches are novel, prefabricated “wood wave” panels consisting of pine beetle kill 2 x 4’s and plywood. The panels not only provide an economical structural solution but also a stunning aesthetic quality and enhanced acoustic performance.

See the **Mark Your Calendars** section on page 28 for more details on the *Olympic Speed Skating Oval – Roof Structure Seminar*

Massive Pile Test at Pitt River Bridge

By David Harvey, Director SEABC

One of the largest conventional, externally-reacted pile tests was recently completed by contractor, Peter Kiewit Sons, for the new Pitt River Bridge. Part of a $190M design/build project which includes a new Mary Hill Bypass / Lougheed Highway interchange, the bridge will be a novel triple-pylon, eight-lane, cable-stayed fixed crossing of the Pitt River, to replace the aging swing spans. The contract is the first stage of BC's $4 billion Gateway transportation project.

The new three-span cable stayed bridge will be 380 m long with a 190 m main span. The width varies from 36 to 46 m, and with approach spans, the overall length is 506 m. PKS's winning bid was significantly more economical than the other team's bid. The main bridge consists of steel girders acting compositely with precast concrete deck panels, while the approach spans use precast girders. The cable-stayed design permitted a lower highway grade line to be adopted, assisting with design of the approaches. The increased navigation opening and reduced in-stream work were significant additional benefits. There are major design challenges to be overcome including deep soft subsoils, high seismic performance requirements, and significant vessel impact loads.

The main bridge is supported on 26 steel pipe piles of 1.8 m diameter, and 25 mm wall thickness, which are concrete filled to a depth of around 30 m. Eleven of the piles are beneath the west tower, which stands in 18 m of water. The piles were driven open-ended to dense glacial till with lengths of 100 m to 108 m, making them among the longest piles that have been installed for bridge foundations. The test pile reacted against a test frame, which connected to four adjacent piles, centered 9 m from the test pile, all of which are production piles supporting the east tower. The piling hammer was a Delmag D180, rated at 615 kNm maximum driving energy. (The approach spans are supported by a number of smaller diameter piles from 70 to 85 m deep).

The pile test arrangement consisted of a cluster of twelve 600 ton hydraulic jacks bearing on a 150 mm thick cap plate. The test load was cycled over two days up to a peak load of 44.9 MN. The test was successful, as a minimum result of 40 MN was required by the design. The maximum pile deflection was 84 mm, less than predicted. Calculated stress in the pile shell were high, but less than the yield stress of 310 MPa. The test was discontinued when the uplift on the adjacent piles approached 20 mm.

(Greater uplift deflections carry a risk of unseating the reaction piles).

The overall project engineer is MMM, who retained Associated Engineering for design of the Pitt River Bridge. AE retained IBT as sub-consultant for the cable-stayed superstructure. All Span Engineering designed the test pile reaction frame. The project is scheduled for completion in the fall of 2009.

Pile test underway.

Artist rendering of Pitt River Bridge

Ask Dr. Sylvie

Photo: Normand Cadorette

By kind permission of the Canadian Institute of Steel Construction, reprinted from their magazine Advantage Steel *of Summer 2007 and Fall 2007.*

Sylvie Boulanger, P.Eng. Ph.D
Ask Dr. Sylvie is a column for Advantage Steel aimed at readers seeking technical information on steel structures. Questions are welcome on all aspects of design and construction of steel buildings and bridges. Suggested solutions may not necessarily apply to a particular structure or application, and are not intended to replace the expertise of a professional engineer, architect or other licensed professional. Questions for Dr. Sylvie, or comments on previous questions, may be submitted by e-mail to sboulanger@cisc-icca.ca.

WINDING ROUTE TO CRANE LOADS

The route one takes through the Code [National Building Code of Canada] and Standard [CAN/CSA-S16-011 to arrive at the crane loading is confusing. Taking into account that CSA is a Standards Development Organization (SDO) and the NRC/IRC is a government agency (NBCC 2005 becoming the law once it is adopted by provincial statute), does the Guide supersede the NBCC and CSA-S16? - A.L.

Here is a historical answer. You know, the kind of answer engineers like to hear! We'll call it a *"work in progress"*. Indeed, your question generated a long thread of discussion between Alfred Wong, Bob MacCrimmon, Richard Vincent, Mike Gilmor and myself. I have tried to provide an answer that reflects the situation at publication time! Basically, the winding route starts at Paragraph 24 (Part 4 -Commentary A) of NBCC 2005 which refers to CSA-S16-01 for certain crane loading conditions. CSA S16-01 refers to Appendix C which is mandatory. Paragraph C2 of Appendix C refers to the *"Guide"* - CISC Guide for the Design of Crane-Supporting Steel Structures by Robert MacCrimmon - available as a downloadable PDF from our web site:

www.cisc-icca.ca/publications/technical/design/craneguide/

Normally, one would expect all loads to be treated in the NBCC rather than in a material design standard, but crane-supporting structures require supplementary rules and that is one reason why they cannot be treated like other structures. Thus, S16 is probably the most appropriate place to address the issue, as almost all crane runways are designed using S16. In fact, much of the minimum requirements found in NBCC 2005 date back to NBCC 1953. Incidentally, these minimum requirements are those stipulated for impact factors and for the horizontal forces as a function of the lifted load and the crane trolley. Other important considerations outlined in Appendix C of S16 and the Guide are not addressed.

Alfred Wong recalls that in the last code development cycle, the CSA-S16 Committee recommended NBCC 2005 drop these requirements and reference S16 that would mandate the CISC Crane Guide that was in development. At the end, the dated requirements remained in NBCC 2005 as published. Because the NBCC's Part 4 Committee recognizes that this area needs attention, a task group, chaired by Richard Vincent, is looking into issues related to live loads, including crane loads. The Part 4 task group on Live Loads Due to Use and Occupancy has agreed in principle to refer to S16 for the load combinations involving cranes.

S16 has formed a subcommittee to study the load combinations including crane loads, and this subcommittee has prepared the following draft for Appendix C, Clause C2.

And since I often have something to add, those who use both French and English versions of CSA S16-01 should note that the French version states that Appendix C is not mandatory, which is a mistake. Appendix C is mandatory.

GALVANIZING OF A490 BOLTS

I know that we are not allowed to hot-dip galvanize A490 bolts but can we use mechanical plating?

No. Clause 4.3 of ASTM A490-06 on Protective Coatings is quite clear: *"The bolts shall not be coated* *by hot-dip zinc coating, mechanical deposition, or electroplating with zinc or other metallic coatings."* One major Canadian bolt supplier tells me that many engineers do not know about this prohibition.

This prohibition exists due to concerns over possible hydrogen embrittlement: the *"sealing-in"* of the hydrogen (produced in the pickling operation) by the hot-dip process and may result in a delayed brittle fracture in service. It is not allowed for A490 bolts because the ultimate tensile strength is marginally close to the critical value where this behaviour is observed whereas the ultimate tensile strength of A325 bolts is considerably below this threshold. And don't think that this doesn't happen. There are threads of discussion where some people were proposing a *"baking out"* process to alleviate the problem, but it cannot be relied upon for structural applications.

C.2 Factored Loads for the Ultimate and Fatigue Limit States
The factored load combinations shall be taken as follows:

CASE	PRINCIPAL LOADS	COMPANION LOADS
1	1.4D	
2	1.25D + 1.5C +1.0L	1.0S or 0.4W
3	1.25D + 1.5L + 1.0C	0.5S or 0.4W
4	1.25D + 1.5S	(1.0C + 0.5L) or 0.4W
5	1.25D + 1.4W	(1.0C + 0.5L) or 0.5S
6	1.25D + 1.0C_7	
7	0.9D + 1.4W	(0.5L + 1.0C) or 0.5S
8	1.0D + 1.0E	1.0 C_d + 0.5L + 0.25S
9	1.0D + C_f	

where C is any one of the crane load combinations defined in the "Crane-Supporting Steel Structures Design Guide", Second Edition, to be published by the Canadian Institute of Steel Construction, C_d is the dead load of all cranes positioned for maximum effect, C_f is the fatigue load, and C_7 is the bumper impact load.

In addition, many think that the mechanical deposition process should be allowed, as it does not involve the same process: ASTM A153 for the hot-dip galvanizing process and ASTM B695 for the mechanical plating process. Here, the Research Council on Structural Connections (RCSC) is reference: *"The application of zinc to RNE ASTM A490 bolts by metallizing or mechanical coating is not permitted because the effect of mechanical galvanizing on embrittlement and delayed cracking of ASTM A490 bolts has not been fully investigated to date."*

Perhaps with more research, more stringent requirements on the hot-dip galvanizing process and a more controlled upper limit on the tensile strength of ASTM A490 bolts, this restriction could be revisited.

We talked about not galvanizing A490 bolts. But if you want to galvanize A325 bolts, you need to know what you ore doing! Although galvanizing A325 bolts does not have an effect on F_u and F_y, it does have an effect on the ability to tighten the fastener assembly, the nut stripping strength (depending on the dyer-tapping), the effort required for pretensioning (if needed) and the shipping requirements. ASTM A325 requires the fastener assembly to pass a capacity rotation test. In widening the Leaside Bridge in the 1960's, Dr. Laurie Kennedy discovered that stick bees' wax was the most reliable lubricant for the threads of hot-dipped galvanized A325 nuts and bolts. For more information, see page 7 of the *"Specification for Structural Joints using ASTM A325 or A490 Bolts"* published by the RCSC - a must for your library: www.boltcouncil.org/2004_RCSC_Specification.pdf

SEAM STRENGTH OF HSS

I am trying to find information about the mechanical properties of the weld seam in hot-formed hollow structural sections without much success. Can you help? - M.C.

To my knowledge, we consider the weld seam to have the same resistance as the rest of the material but that is probably not completely true. There are some papers that have looked at fatigue or the notch-toughness of hollow structural sections, such as this one:

Notch Toughness of Internationally Produced Hollow Structural Sections
J. Struct. Engrg., Volume 131, No. 2, pp. 279-286 (February 2005)
N. Kosteski, J. A. Packer, F.ASCE; and R. S. Puthli

I've asked one of the authors to comment! Jeff Packer of the University of Toronto confirms that the weld seam in **hot-finished** (hot-formed) HSS can be assumed to have the same mechanical properties as the material in the rest of the HSS. The weld seam in **cold-formed** HSS has not been found to have lower static or fatigue resistance.

However, there is a trend to develop a next-generation manufacturing specification for HSS that would contain more stringent or additional requirements than the present ASTM A500 or CSA G40.20/21 standards. They would include upper limits on F_y and F_y/F_u ratios. a Charpy toughness rating, larger corner radii, making it more apt for applications in which dynamic loads govern. Such a movement is not so dissimilar to what has happened to the W shapes, with the ASTM A992 being more stringent and better suited for high-performance dynamically loaded structures than the older ASTM A572 standard steels.

STEEL AT ELEVATED TEMPERATURES

We are proposing an investigation to ascertain the repairs required at a plastics facility after a fire. Is there information or documents that can help us evaluate the adequacy of this facility? - B.R.C.

"If it is still straight after exposure to fire - the steel is OK". That is a statement that has been around the industry for ages. And if it isn't straight, moderate to even significant deformation is usually not a sign of modified mechanical or metallurgical properties. Your worries should occur only if you can identify that some members have been exposed to fire exceeding 650°C (1200°F). At or just below that temperature, steel loses 50% of its strength but its metallurgical profile does not change. Remember how steel is made! Interestingly, firms familiar with steel production and fabrication procedures have often repaired or straightened fire damaged steel. They know that during a fire, metallurgical changes ore predominantly temporary (although some may be permanent). In fact, "rehabilitation or replacement of [noticeably deformed] members is usually dependent on expediency, economics or overcoming the human psychological rejection of what appears to be damaged steel" writes Raymond Tide, not on lack of strength.

My colleague George Frater, our fire engineering resource, gets Questions related to the behaviour of steel at high temperatures often. He usually provides four references to help the enquirer:

- A 13-page Engineering Journal (EJ) article (1998: Q1) entitled "Integrity of Structural Steel After Exposure to Fire" by Raymond Tide, Senior Consultant at Wiss, Janney, Elstner Associates, available from the AlSC website: www.aisc.ora/ej
- A publication by British Steel (now Corus) entitled "The Reinstatement of Fire Damaged Steel and iron Framed Structures" whose main conclusions ore accessible at: www.corusconstruction.com/en/design_and_innovation/structural_design/fire/fire_damage_assessment/
- Part 8.6 of the Manual for Railway Engineering, Chapter 15 (Steel Structures), by AREMA (American Railway Engineering and Maintenance-of-Way Association) which deals with "Guidelines for Evaluating Fire Damaged Steel Railway Bridges" available from the AREMA website but very expensive: www.arema.org
- Appendix A of a book entitled "The Principles of Fire Investigation" written by Roy A. Cooke & Rodger H. Ide. The appendix deals with "Estimation of Temperature Attained" and provides "tempering colours" of oxide layers formed on steel due to elevated temperatures. The book is published by IFE (Institution of Fire Engineers) and is available for purchase from amozon.com or from their own website: www.ife.ora.uk

The EJ article is a must for your library. Raymond Tide shores his knowledge in an exemplary manner. I read through it and found many answers to my questions. Let me paraphrase or quote some chunks, of information that I think you might find useful but remember to go to the source for more detail and proper referencing:

Material - Because of their relatively low carbon and other alloying content, structural steels usually regain close to 100 percent of their pre-heated properties provided the steel temperature does not exceed approximately 720°C (1330°F). AISC, AASHTO and AREMA hove all adopted 650°C (1200°F) as a threshold. Not so surprisingly, this is true independent of steel grade.

Members - Steel expansion is temperature dependent and as the temperature of the steel increases, an unrestrained member will elongate. A member fully restrained in the axial direction will develop axial stresses as the temperature increases. Either a member has significant room for unrestricted expansion or significant compressive forces will develop when restrained. Buckling is likely to occur when the temperature is in the 650-750°C (1200-1400°F) range because of the reduced F_y, and E under these conditions.

Bolts - High-strength bolts warrant a separate mention because of their special manufacturing requirements. Experimental work and post-fire examination of bolts removed from a building indicate that, with one exception, exposure to fire does not alter high-strength bolt properties. After the bolt cools to ambient temperatures, the original bolt strength is essentially regained.

Welds -Weld metal exposed to elevated fire temperatures can be treated the same as the adjoining base metal when examining the metallurgical aspects. The temperature increase resulting from a fire is comparable to post-weld heat treatment.

Creep - Large deflections due to creep are a consideration if the elevated temperature and load are sustained for o period of time. However, stress levels and fire duration in most building occupancies do not result in appreciable creep deflection due to the limited fire load and exposure time. Estimates of creep con be determined from published research data (see references in EJ article by Tide). Although if some creep occurs, its effect on an essentially straight member is unlikely to be significant or affect the performance of a refurbished building.

Assessment - Many procedures are available to assess structural steel integrity after fire exposure, including visual observations, non-destructive testing and destructive testing (removing samples). See EJ article for more detail. I've run out of space in my column!

BRACING AT TOP FLANGE OR WEB

I am designing a curved box-girder bridge. Could you tell me if it is better to attach the "top flange lateral bracing" to the top flange or to the web? - N.V.

As you know, CAN/CSA-S6-06 lets you do either but the answer is "the web" and is independent of the fact that the bridge is curved.

According to David Stringer, a consultant with many years of bridge engineering experience with Dominion-Bridge and Canron, the top lateral bracing of box-girders is usually attached to the web for the following reasons:

1) Fillet welds rather than groove welds may be used for the horizontal gusset plates.
2) By keeping the lateral bracing approximately 250 mm below the top flange, space is available for the formwork for the concrete deck.

The location of the lateral gusset plates should coincide with the location of an intermediate stiffener or a cross frame so that a load path is available to transfer bracing forces to the flanges of the box girder. Where necessary for fatigue reasons, a large radius must be provided to the lateral gusset plate to improve the fatigue detail.

Satisfied? I hope so. I was very convinced.

Curved steel box-girder bridges are aesthetically pleasing and functionally effective, particularly at highway interchanges with curved alignments. Hence, I'm pleased to see you design box-girders in the context you have to deal with: strong curvature (R=120m), long spans (47m-53m-36m) and challenging but decent site access in an urban environment. I see the inside depth of the girder is 1.65m which is sufficient for maintenance reasons. We know the ministries of transport do not like them if they are too shallow. I'm sure you are having fun dealing with the seismic provisions. In general, you should find the curved box-girder design (example 4) in the CISC Bridge Design Notes very useful. To obtain a copy of the notes:

www.cisc-icca.ca/publications/educational/bridgcourse/

TORSIONAL CONSTANT

How is the torsional constant J calculated for W sections, C sections, rectangular and round HSS? - LP

Have we got an answer for you. Whether you want to calculate the St. Venant torsional constant, the warping torsional constant, the shear centre, the monosymmetry constant, the shear constant and properties of open cross sections or closed cross sections, Charles Albert has this link to help enquirers:

www.cisc-icca.ca/resources/tech/updates/torsionprop

SEISMIC CORNER

Alfred Wong

I wish to use Limited-Ductility Plate Walls, in accordance with S16-01, as the Seismic-Force-Resisting System for a building project but I cannot find the identical description for this system in Table 4.1.8.9 if NBC 2005. Is this system referred to as Moderately Ductile Plate Shear Walls as tabulated in NBC? – R.B.

Yes, the Commentary to Clause 27.8.3 of S16-01 clarifies this inconsistency in description. In addition, the Commentary to other parts of Clause 27 clarifies that Tension Compression Concentrically Braced Frames besides Chevron Braced Frames are referred to as "Concentrically Braced Frames (having) Non-Chevron Braces" in NBC.

How to use Conventional Construction

Charles Albert, P.Eng.

Conventional Construction is an advantageous design option for many low-rise buildings in regions of low seismic hazard. This structural system features traditional design and construction practices, and can be used for steel braced frames, moment frames and plate walls.

In which regions can this be used without height limitations?

According to the National Building Code of Canada (NBCC) 2005 Clause 4.1.8.9, the height limitation depends on the specified short-period and one-second spectral acceleration ratios of the site. In regions where I_E F_v S_a (1.0) > 0.3, the building height is limited to 15 m. IE is the earthquake importance factor and Sa(T) is the 5% damped spectral response acceleration for period T in seconds. Fa and Fv are the acceleration-based and velocity-based site coefficients, respectively, which are functions of Sa(T) as well as the Site Class (based on soil profile).

Assuming IE = 1.0 and Site Class = C (very dense soil and soft rock), Canadian regions where Conventional Construction may be used without height limitations include the Prairie provinces, most of Ontario (including Toronto but excluding Ottawa), and the Atlantic provinces except for some areas of New Brunswick. As a side note, single-storey industrial steel structures are exempt from height limitations (NBCC 2005 Structural Commentary J, paragraph 143).

What are the general design requirements?

Conventional Construction must meet the requirements of CSA Standard S16-01, Clause 27.10. Since this system is designed using ductility-related and overstrength-related force modification factors of R_d = 1.5 and R_O, = 1.3, respectively, the resulting member sizes may be larger than for other, more ductile, systems. However, connection details are often simpler because the other provisions of Clause 27 do not apply.

In regions where $I_E F_a S_a(0.2) > 0.45$, diaphragms and connections must either be proportioned to ensure a ductile failure mode in the connections, or be designed to resist the gravity loads together with the seismic load multiplied by R_d. See Clause 27.10 and the CISC Commentary for further information.

What is meant by a ductile failure mode?

Details that are considered to achieve ductile failure modes include welded connections consisting of fillet welds loaded primarily in shear and bolted connections in which the governing failure mode corresponds to bolt bearing failure. The CISC Commentary provides additional guidance for selecting appropriate connections for braced and moment-resisting frames.

STEEL AND OTHER MATERIALS

THREE-PART SERIES

By kind permission of the Canadian Institute of Steel Construction, reprinted from their magazine Advantage Steel of Summer 2007 and Fall 2007.

PART ONE: STEEL AND GLASS

By John Leckie; Advantage Steel

Successful marriages of steel and glass have led to the creation of some of the most striking, visually appealing and spiritually uplifting buildings in the world.

The combination of slim, elegant steel structural elements with a transparent glass facade has long provided strong visual appeal. New technological developments have both increased the options available and reduced the difficulties in providing steel and glass buildings. For Ian Ritchie, architect, *"Their aesthetic values have been associated with the beauty inherent in precise machine-mode elements and the importance of the connection, or joint, between the various parts"* - a high-tech architectural style that has been associated with an engineering renaissance.

HISTORY

Many of the early examples of metal and glass construction were greenhouses, where the slimmer and stronger metal elements were a major improvement on the heavy wood previously used and allowed a greater expanse of glass which allowed more light to reach the plants inside. It was hardly coincidental that one of the first metal and glass buildings to catch the public fancy -- London's Crystal Palace -- was designed by a gardener, Joseph Paxton. Paxton's design was selected for the Great Exhibition of 1851 in Hyde Park. Despite its public appeal, the building had to wait until the mid-20th century before it became fully accepted as an architectural break-through.

In more recent years, the breakthroughs have involved using glass as a structural element in the buildings. An early example is the design of the glass facades of the greenhouses at Parc La Villette in Paris, constructed in 1986. Glass panes butt against each other, supported by cable trusses for wind loading. Special glass supports are used to secure the facade, maximizing the transparency. The Kempinski Hotel in Munich took the process several steps further, using a single-layer, prestressed cable net to provide the structural support with the glass facade secured at nodes rather than by bolts through holes in the glass. This system provides greater transparency with minimal intrusion from the structure. It also exhibits significant deformation during heavy wind loads, which some find disconcerting.

Same current Canadian examples include the pyramidical skylights of Edmonton City Hall (1992), BCE Place in Toronto (1992), the CDP building in Montreal (2002), and the Vancouver Convention Centre scheduled to open in 2009! In the last decade,

photo: Terri Meyer Boake

Glass fins of the Caisse de dépôt et placement Capital Centre, Montreal most airport expansions across Canada are also unique illustrations of steel and glass structures.

THE OTHER MATERIAL: GLASS

These recent designs would not be possible if Alastair Pilkington had not invented the float glass process in the early 1950s. This process, in which the melted raw materials for glass are floated on a bed of molten tin to produce a ribbon of glass, dramatically reduced the cost of producing high-quality flat glass. Added to that were developments in tempering glass by heating it to 650-to-700 degrees C and rapidly cooling it so the centre retains a higher temperature than the surface. As the centre cools, the resulting contracting induces compressive stresses at the surface and tensile stresses in the core which can produce a pane of glass four or five times stronger than annealed or float glass. Protection against breakage can be enhanced by laminated units where multiple layers of glass are bonded by a layer of plastic sheet material.

Benoît Cloutier of CPA Inc. in Montreal says the combination of different layers improves post-breakage behaviour of the glass, which give designers and building owners more confidence to use it in larger applications.

CHALLENGE AT THE INTERFACE

Many of the steel and glass structures now are signature elements of a building, making up a portion of the overall structure while the rest of the building tends to have more conventional structural systems and facades. The steel interface elements of these signature structures transfer portions of the wind loads to the steel superstructure, hence the interface elements are generally small but a much higher emphasis is placed on their visual appeal. The steel fabricator retained must be familiar with architecturally exposed Structural steel (or AESS) as the finishes and interface tolerances are more stringent than standard structural steel.

Welding

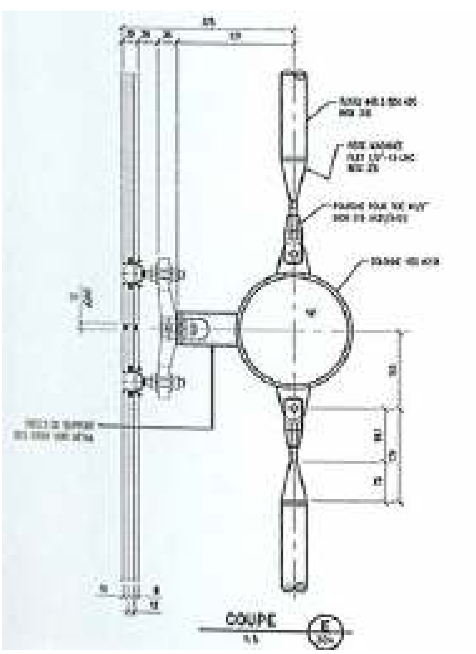
Precision in the welding of the steel elements is particularly important. *"Any welding will cause distortion,"* Cloutier says. *"When you weld, it heats up the surface and when it cools down it tends to shrink. When you have a long piece and you are always welding on the same side, you con soon wind up with a banana effect on the whole piece. You ore forced to make the piece straight again or live with the distortion."*

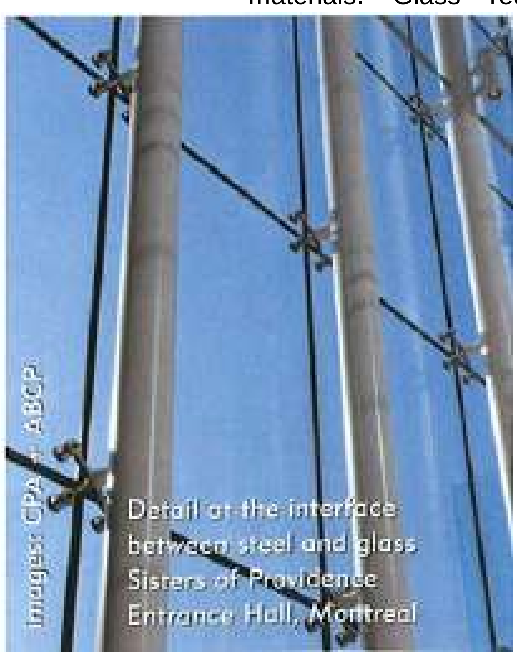
"Care during the initial welding process can minimize the distortion," he says.

One of the problems of working with steel and glass is the relative tolerances in producing the materials. Glass requires higher precision with tolerances of ±2 millimetres while the tolerances for steel are ±5 millimetres. The differences have to be accommodated during the installation in order to keep the glass panels properly aligned. And, because the glass panels tend to line up with the steel elements, poor alignment will be quite apparent.

Connections

There are a number of methods of connecting the glass panels to the structural supports. Cloutier's firm favours a spider bracket which has one to four arms





Detail at the interface between steel and glass
Sisters of Providence
Entrance Hall, Montreal

coming out of a central hub. Bolts through the glass panels are secured to the arms and the brackets are attached to the support structure. Angle brackets, single brackets, pin brackets or clamping devices are all alternatives that are used on occasion. The panels are usually secured at the four corners with an additional pair of bolts in the middle of each side for larger panels. In Europe, particularly, bolted systems are slipping from favour and designers there are tending to use a clip system where the panels are supported on the side, removing the need to drill holes in the glass.

DESIGN PROCESS

To carry out the design of these structures, a new type of specialized engineering firm is developing. These specialists will bring their focused engineering skills to the project to work in collaboration with the architect and the structural engineer to ensure the design vision is upheld while a structurally sound system is installed. In essence, this is what Cloutier's firm has become.

"Before we finalize the details on any drawing, we usually have discussions with the erector to determine if it is appropriate or efficient to do it that way," Cloutier says. *"Sometimes the erector will come back with a better idea or something that will better suit his equipment or the way he sets up the geometry in his shop."* It often works better when people who have worked together on previous projects are involved because everyone knows the capabilities of the other members of the team.

"For these projects, the detailed engineering has to be part of the price of the job," Cloutier says. *"On our jobs now, we bill the architect and the client to develop concepts or to establish a feasible project The detailed engineering, basically the shop drawings of the specialized facade and the supporting steel elements, will come at the time the order has been given."*

"Because the glass and steel structure is likely the signature element of the building, something the architect has had to fight for through budget cuts and constraints, the architect tends to be a strong ally when choices have to be made between saving money and retaining the design intent of that part of the project," Cloutier says.

CASE STUDY THE CDP BUILDING

One project Cloutier's firm worked on was the Caisse de Depot et du Placement Capital Centre in Montreal. Working for the curtainwall contractor, CPA provided a portion at the base of the building's atrium which was designed as a glass fin system, where the glass fin served as the backbone for the structural elements of the facade.

"It was a suspended system, meaning that the glass fins that are resisting the wind load are hanging from the top portion to a steel beam," Cloutier says. *"At the base, the fins are only sliding up and down into a square shoe-box-like element so the fin is free to move vertically but is blocked laterally. That allows it to accommodate thermal movement in the building."*

When the steel was erected, CPA ensured it was installed according to plan and made adjustments for any variations. The system the firm designed had to be flexible enough to handle these adjustments as well as allow for the changes in loading that would occur as the project advanced. Once the panels were installed, silicon was used to fill the gaps between panels.

BEST PRACTICES

"There are several keys to success in this type of project," Cloutier says. *"Good communications is a must. The architect, structural engineer, specialty engineer, glazing contractor, steel fabricator and steel erector all have to know what is happening with that portion of the project. There also has to be a commitment to quality from all members of the team in order for the project to work."*

"Fortunately," Cloutier says, *"this type of project tends to attract firms and individuals who ore looking for a challenge, something a little more difficult than routine construction."*

Europe tends to be leading the way in innovative uses of steel and glass in buildings.

"That is not surprising," Cloutier says, *"because the attitude there is less to receive a quick return on investment than to build something that will last for more thon 50 years. As well, higher energy costs provide greater incentive to develop energy efficient buildings."*

Although it is true that much is possible with glass construction, it is dependent upon the steel superstructure. Glass continues to be very brittle and sensitive to local stress concentrations. Hence, much attention has to be spent designing the interface between glass and steel to resolve issues of material compatibility, and reach the desired aesthetic objective.

THE FUTURE

Where are these structures headed? There is ongoing experimentation with glass as a structural element in the buildings. Double facade structures, with up to a metre of air space between the two glass facades have been built and there has been some use of photovoltaic panels.

At present, steel and glass contribute elegant and striking design elements to a number of buildings but the potential of the combination of the two materials has not been fully tapped, particularly in North America. Future developments could both increase the energy efficiency of our buildings and provide new aesthetic choices for building design.

CPA STRUCTURAL GLASS INC

When CPA Structural Glass started in 2000, it was a subsidiary of Cloutier Powney and Associates, a consulting engineering firm. At the time, CPA was licensed as a grazing contractor by the Regie du batiment du Quebec and was capable of providing a full turnkey solution. The firm would do the detailing for the project but would also hire the steel fabricator and supervise the erection process. In 2004, Cloutier Powney merged with Saia, Deslauriers, Kadanoff, Leconte, Brisebois, Blais and Associates and CPA dropped its involvement in the construction process. That involvement proved valuable, however, because the firm has gone through many of the problems encountered onsite, and that has provided greater insight into the problems faced by installers. By designing with that in mind, the firm can avoid many potential problems. CPA has been involved in a wide range of projects, from small signature project to large high-profile projects such as: the CDP building, les Soeurs de la Providence, la Maison Simons in Laval and Le Windsor.

STEEL AND OTHER MATERIALS

THREE-PART SERIES

PART TWO: STEEL AND WOOD

By John Leckie; Advantage Steel

Pairing steel and wood in a single project can lead to unique assemblies of sustainable and aesthetically pleasing hybrid structures. The strength of steel lessens the bulk and provides an economy of structure that would not be possible with an all-wood design. The warmth of wood can add a welcoming touch to an all-steel building. Steel and wood are two very different materials and combining them can be a challenge to designers. Steel is a manufactured product - strong, predictable and infinitely recyclable. Wood is a natural material - relatively weak, variable in strength but renewable. Temperature differentials cause steel to expand and contract but has little effect on wood; however, changes in humidity, which have little effect on steel, can cause wood to shrink and permanently change its dimensions.

HISTORY

In the late 1700s, the first cast iron bridge was built across the River Severn in Shropshire, England. With no precedent to go on, the designers turned to wood, basing the connections on carpentry, using mortise and tenon and blind dovetail joints to fasten the elements together. There is some irony in the fact that it is at the joints that steel now holds the greatest advantage over wood and, even in structures that are heavily weighted to wood, steel is used as the connecting link, greatly reducing the bulk of the structure.

In Canada, hybrid structures have been used in several ways. In Quebec and Ontario, there are hundreds of steel-wood bridges, where steel is used as the main structural system (steel girders) and wood is used as the secondary structural system (wood planks). This application is also common in buildings, where steel acts as the supporting frame and wood as the planar elements.

While the two materials have been used together across Canada, the prime area for bringing them together has been on the West Coast. In that port of the country, a tradition of wood construction has linked up with design firms and fabricators of both steel and wood who are willing to stretch beyond their traditional activities. The result is often hybrid frames where wood and steel share gravity and lateral load transfer.

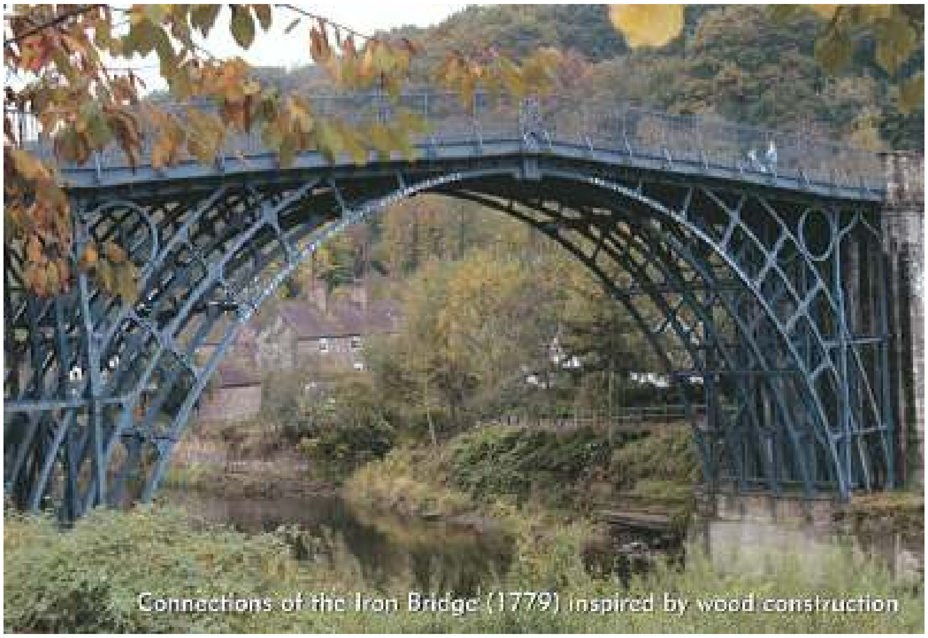
THE OTHER MATERIAL: WOOD

Wood is described as a heterogeneous, hygroscopic, cellular and anisotropic material. That means it is made up of a diverse range of different items, it attracts water molecules from the existing environment though absorption or adsorption, it has a cellular structure and its properties ore directionally dependent.

Most of the lumber used in construction is known as softwood lumber, coming from conifers (needle-bearing trees) such as pine, cedar, hemlock or spruce. Hardwood lumber (from broad-leafed trees) is used more for furniture making.

For building purposes, wood, in the form of lumber, timber, glulam (glue-laminated beams) and structural composite lumber can be used as primary

structural members and, in the form of plywood, oriented strandboard, waferboard and plank decking, is used as secondary structural members, such as sheathing and decking.



Connections of the Iron Bridge (1779) inspired by wood construction

Products such as glulam and structural composite lumber are considered engineered products because of the manufacturing process. While the gluing and lamination increases the strength and reduces the moisture content of the wood, it makes the products unsuitable for recycling and, as with many wood products, generates up to 30 per cent wasted wood, which counters some of the positive marks for green building that wood receives for being a renewable resource.

CHALLENGE AT THE INTERFACE

Because of their different properties, connections between wood and steel can be difficult.

"The big problem from a structural point of view is the different expansion/contraction coefficients when you have dissimilar materials, especially on a column-beam-wall type interface," says Martin Nielsen, a principal at Busby Perkins + Will architects.

Steel excels in tension while wood reacts much better to compression.

Paul Fast, a partner in Fast + Epp structural engineers says there are analytical programs available now to help set up the structure needed when combining the materials. In some cases, slotted holes in the steel can allow for some movement. The important thing in creating a hybrid structural system to remember the strengths of each material and in what context each of them works best, Fast says. "Steel is a much stronger material, so if you are going to create a hybrid wood/steel truss, you want to put the wood up on top of the truss (in compression) and steel at the bottom chord (in tension). That way you just need to butt the wood elements one against each other with very little bolting, and avoid large connections at the bottom truss since steel is transferring the high-tension forces."

Steel is subject to oxidation while wood is subject to decay.

There are other issues where wood and steel come into contact as well. Steel needs to be protected, by being galvanized or with a specific paint system, in order to resist the humidity changes in the wood. It also helps to use dry wood instead of green wood at the interface, if possible, because it moves less over time. Because it is important to limit the restraint that the steel connecting elements impose, a bolted steel connection should not span the full depth of a wood element. On bridges, where timber decking is used supported by steel girders, the two materials should be separated by a waterproof membrane.

DESIGN PROCESS

Steel is a crucial element in the design of these hybrid structures because it allows the use of slender, delicate profiles that would not be possible with wood alone. "In an all-wood structure, you are really limited in what you can do in terms of joinery," Nielsen says. "You are forced into a more traditional approach."

Using steel and wood together, the designer has to be very aware of balance. "Typically, they are a very different expression, so it can be quite visually jarring to see two different materials if they are not harmonious or balanced and it can be quite visually jarring at the interface between the two," he says. "If you look at Brentwood Station, for example, the ribs are a synergy between wood and steel where the right material has been selected for the right reason."

Fast says, while he doesn't have an exact rule of thumb for his projects, it is necessary to use enough of the complementing material to provide on appealing accent. On a primarily steel structure, there has to be enough wood to warm up the building and, on a primarily wood structure, there has to be enough steel to provide some interest.

CASE STUDY: THE SKYTRAIN STATIONS

Five of the 12 stations on the Vancouver SkyTrain Millennium Line have some combination of steel and wood. The Brentwood Station features a structure integrating steel and glulam timber beams, as do the Rupert and Renfrew stations and the Commercial station. The Gilmore Station features a cable and steel casting type system to create a roof of stressed plywood panels.

"We used Timberstrand on the Gilmore Station," Nielsen says. "It is really an engineered chipboard that comes in inch-and-a-half strips that can run as long as you want. We used a steel kingpost and a wire tensioner and that worked out really well. The panels were prefabricated in the shop and they could just be brought out on the site and dropped into place. They were preroofed so the membrane was already in place."

There was a learning curve for the steel fabricator on the remaining projects, however. It is all well and good to have a hybrid design but someone has to step up to the plate to put that in place and it fell on the steel fabricator to take charge. Rob Third of George Third and Son agreed to take delivery of the glulam beams from the wood supplier, marry them to the steel and erect them on the site. That meant a major leap into working with an unfamiliar material. It also led to some educational moments, when the steel fabricators learned that an SDS screw was not simply a self-drilling screw as they assumed, but a brand-name screw made by Simpson Strongtie. That lesson was not without cost because the SDS screw is more expensive than a self-drilling screw.

Working with wood brought some more lessons as well. There were concerns about damaging the wood in the shop, either through handling or by welding or heating steel too close to the wood in the structure. "With a minimal amount of care, it turned out to be not much of a problem," Third says. "You would have to get the wood really hot and keep the heat right up next to it for a long period of time before you start to scorch it. We were able to weld right up against the wood with a heat shield and it didn't seem to be much of a problem."

Making sure everyone in the shop was aware of the differences in the materials was an important factor. The large wood beams were on the floor of the shop. Had they been steel, there would not be any problem with people walking over them but that had to be discouraged for the wooden beams because they might be marked as a result and refinishing them would have been difficult.

To a degree, it was easier to get the message across because the workers had been used to dealing with architecturally exposed structural steel. Other efforts, such as covering saw horses with wood and carpeting and using nylon slings to move the wood beams rather than the chains and hooks usually used with steel, minimized problems.

BEST PRACTICES

Someone has to take charge.

The Brentwood station project featured a steel column base and a wood span. The two pieces had to be married together and erected on the site. Unless the wood supplier or the steel fabricator took charge, there would potentially be problems, Nielsen says.

"If something went wrong in terms of the fit, they would start pointing fingers at one another."

In this case, George Third stepped up and took responsibility for the whole effort, coordinating shop drawings, delivery schedules and erection. Despite the fact that they were not involved in the selection of the wood supplier, it was essential to establish direct contact with them rather than going through the general contractor, Third says.

An interesting aspect of steel and wood projects is that few wood suppliers and steel fabricators wish to face the unfamiliar challenges of hybrid construction. Since contractors involved in such projects are likely to be well skilled, their proficiency will help facilitate the construction process.

THE FUTURE

Projects involving steel and wood are not always easy to put together so they are likely never going to be an everyday occurrence. But projects like the SkyTrain stations, the Olympic speed skating oval in Richmond, B.C., Quest University in Squamish, B.C., the Surrey City Centre mall, have all demonstrated that appealing structures can be created by marrying steel and wood. Rob Third, who has taken on a few of these projects, is somewhat leery of turning half of his shop over to wood on a regular basis but likes the challenge of building something that breaks away from traditional roles. Both Martin Nielsen and Paul Fast have been designing and building hybrid structures for over a decade and they have confidence that the hybrid structures are here to stay.

NEW CIVIL ENGINEER

INTERNATIONAL EDITION 01.08

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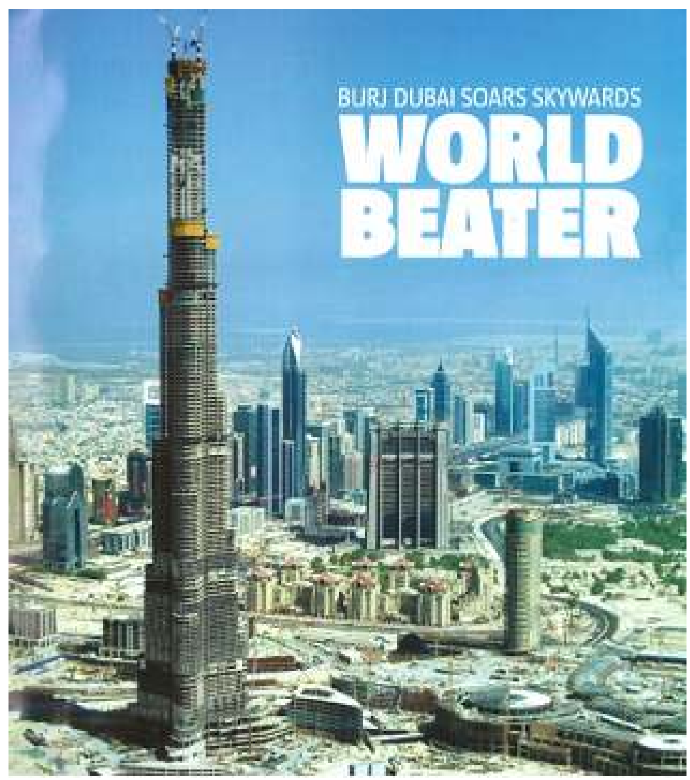


Contractors are battling the odds to bring the world's tallest building in on time.
***Mark Hansford** reports from the Buri Dubai.*

Dubai is a crazy, crazy place. Everything is big and brash from the vast man-made

Palm islands and the staggering Vegas-style recreation of the Seven Modern Wonders of the World, to the 10 skyscrapers in excess of 100 storeys set to be completed this year.

On the flipside, creating this Vegas-meets-Manhattan vision are 250,000 foreign labourers, many of whom live in conditions described by Human Rights Watch as being "less than human". Indeed 35,000 of them only recently returned to work on the Burj Dubai megatower after a two week strike over pay and conditions.

Put in this context the 800 m plus tall Burj Dubai tower is perhaps nothing extraordinary. But that is to seriously downplay the challenges being faced. Workers are unskilled and don't speak English or Arabic.

Materials are being shipped from around the globe and delivered to a site which – incredibly – has no room for storage. The cladding contractor went bust in February last year. The concrete floors have sagged and have had to be beefed up.

Temperatures often exceed 50°C. And the client has even now, with concrete pours complete, still not yet confirmed its final height, although the drawings hanging in the site office last week put it at 808m.

The tower is being built for developer Emaar Properties by South Korean company Samsung. Skidmore, Owings & Merrill (SOM) of Chicago leads the architectural, structural engineering and mechanical engineering design team. Hyder Consulting is the client's engineer and Turner International, the project manager. The total budget is set at around $0.3bn. Work began on site on 1 February 2005.

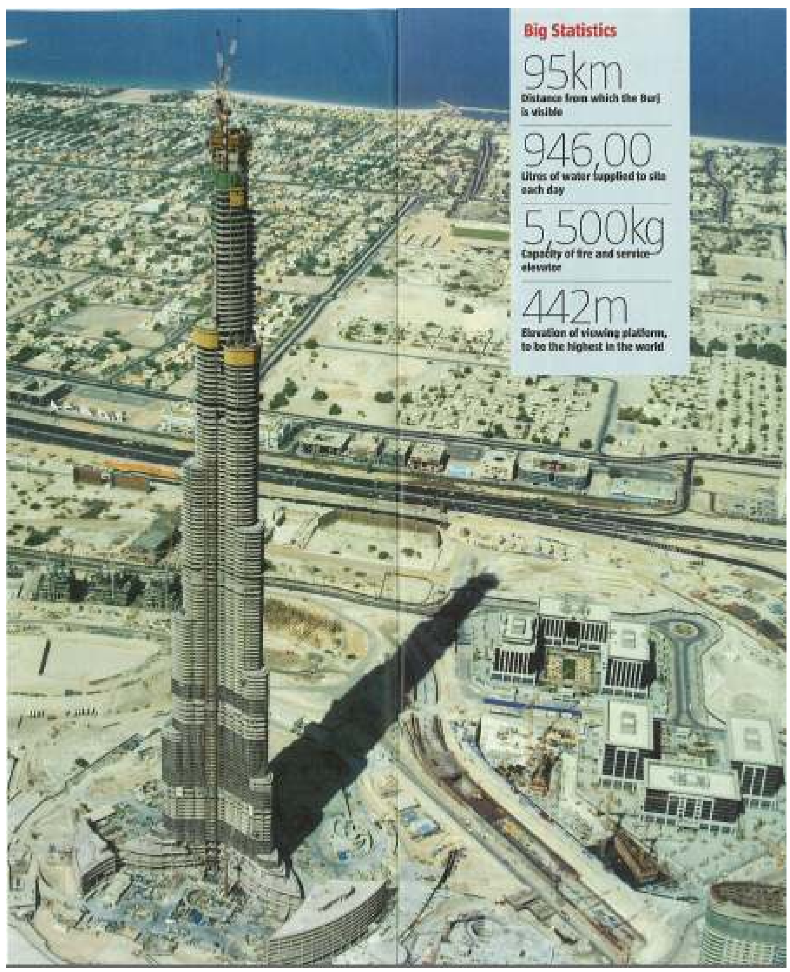
The structural shell of the Burj is already the tallest building on the planet (see box). Last week nce.co.uk broke the news that in-situ concreting works on the structural core were successfully completed at a height of 601m. Constructing this involved an unusually high proportion of wall-forming operations for a skyscraper. Its honeycombed design meant forming 430,000m2 of walls – twice the area of the floor-slabs. A typical storey was finished every three days.

Doka provided the formwork, and its system proved exceptionally robust.

"As the in-situ concrete core was being built ahead of the floor-slabs, construction progress on the whole building was entirely dependent on the self-climbing Doka formwork solution," says Samsung's project director Kyung-Jun Kim.

"The system functioned with machine-like precision, allowing us to complete the in-situ concrete core within the original timetable."

Climatic conditions encountered at the site were often extreme: the desert climate next to the open sea causes great temperature fluctuations between day and night, and this



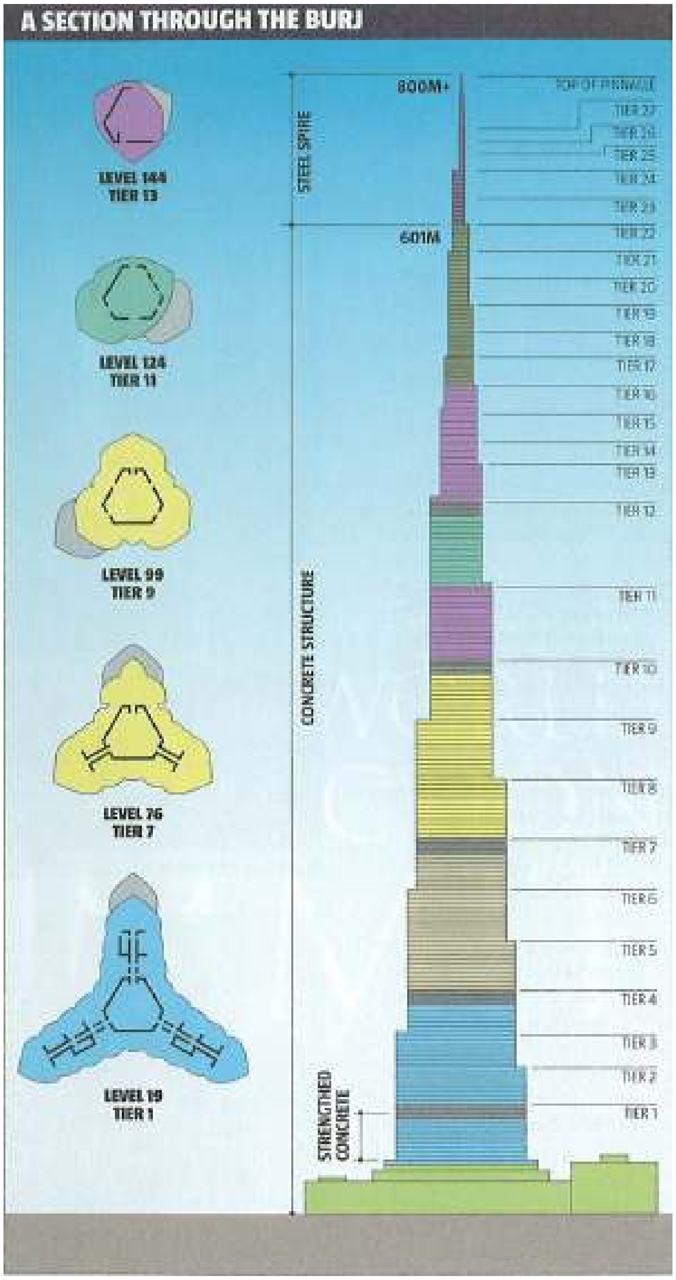
can lead to violent sandstorms with wind speeds of over 100 km/h.

Conditions such as these tested men and materials to the limits, which makes the safety record to date all the more impressive.

So far 29,333,100 manhours have been worked with just three reported lost time injuries.

The biggest drama of the project to date was in March when news leaked out that carbon fibre reinforcement was being used to strengthen defective floor slabs. Emaar denied at the time that there were any strength issues but it is widely reported that the floor slabs were designed as prestressed but in fact poured as simply reinforced. As a result they were too shallow and light on reinforcement, with the result that there was excessive sagging.

In total, floors five to 15 have now been beefed up with a combination of carbon fibre strips and blue steel I-beams.



But that is in the past and attention is now focused on erecting the final zoom tall steel spire and, more importantly for the program, the aluminium and glass cladding.

Cladding work got off to a terrible start when joint venture cladding contractor Schmidlin collapsed February last year, weeks before erection was due to start, leaving joint venture partner Arabian Aluminium utterly in the lurch.

“We trawled the world looking for someone to replace Schmidlin,” says Arabian Aluminium project director John Zerafa. "We lost 13 months before we signed up Far East Aluminium and have broken quite a few records getting back on track. We are endeavouring to finish on time - the original time – at the end 2008.

"Between 10 May and now we have clad 50 levels. Most of the work is done in China, with the cladding coming in pieces and assembled on site with local glass.”

"We are doing 100 panels a day - both making them in the factory and assembling and installing them. At any one time I've got up to 30, 40 ft containers en route to and from China." Installing the glazing is also going to be a major feat and again, safety is paramount. "Safety is very stringent here," says Zerafa. "There are 9,000 people on the job at the moment and our activity is on the perimeter - maximum high risk," he says.

Zerafa's men work from safety harnesses attached to safety rails his team has engineered itself. "It's for my piece of mind. You can't put a value to safety and you can't afford to lose your reputation for the sake of saving a dollar."

The glazing panels, up to 6.4 m tall, are hung off 25,000 Halfen cast-in fixings and slot together with no need for extra sealant. Because the Burj tower has a curved exterior. there is no tolerance for installation or construction errors.

"On square building you always lose 10 mm in the corner. Curved buildings are 30 times more difficult", says Zerafa. Fire safety on the Burj was Always going to be a top priority. The building has been designed to evacuate 35,000 people, more than twice its expected occupancy. Evacuation is by stairs, and it's a long way down from 160 storeys -so pressurised air conditioned refuge areas are being installed every 25 floors for evacuees to rest or await rescue.

To keep fires contained, exacting US standards are being employed, with Hilti firestops being used to plug the notoriously dangerous gaps between floor slabs and external cladding because the building is curved, and gaps can be "quite large" - up to 150 mm says Zerafa. Mineral wool 150 mm thick is being used to plug the gap. It is held in place by Hilti's CP672 sprayable fire-rated mastic, designed for joints with maximum movement.


Cladding the Burj: 100, 6.4m tall panels are being installed on the tower every day

Cladding is a seriously critical path activity, because only when a floor is clad can air conditioning be blasted through it and fit out begin. And on the Burj, even fit-out is a massive construction management exercise. Depa Dubai, the interior contractor responsible for fitting out the Burj's 899 luxury apartments, has as its project director a Hong Kong airport veteran in Bob Dixon.

A Record Breaker…But for How Long?

When completed, Dubai's landmark tower will be the tallest structure in the world in all four of the criteria listed by the Council on Tall Buildings & Urban Habitat (CTBUH) – height to the structural top, the highest occupied floor, height to the top of the roof, and to the tip of the spire, pinnacle, antenna, mast or flag pole.

Burj Dubai is billed to scale past the KVLY/KTHI television mast in Blanchard, North Dakota, which at 628.8 m is the world's tallest mast and technically qualifies to be the world's tallest structure, even though it is stabilized with a series of guy-wires.

But several other major projects in the region are already threatening to topple the Burj.

Kuwait has approved a plan to construct the 1,001 m tall Burj Mubarak Al-Kabir tower, part of the $88.6bn Madinat Al-Hareer project that will include not only the skyscraper but an airport and a bridge linking Madinat with Kuwait City, which sits across a bay.

And just down the road from the Burj on Palm Jumeirah, Emaar's chief rival Al Nakheel is planning a gazumping on a grand scale with Al Burj, a tower set to top 1,050 m and possibly reach 1,200 m.

But both of these pale into insignificance when you look across the border to Saudi – where plans have been unveiled for a 1.6 km-high whopper.

Mark Your Calendars

SEABC Education Committee

February 27, 2008

Seminar

Topic: Olympic Speed Skating Oval
Presenter: Paul Fast (Fast + Epp)
Venue: BC Hydro Building
333 Dunsmuir, 2nd floor
Time: 6:00 PM Light refreshments
6:30 PM Presentation

March 19, 2008

Seminar

Topic: EERI Freidman Family Visiting Professional Lecture
Presenter: James Malley
Venue: Vancouver Public Library, Downtown, Alice McKay Room
Time: 6:00PM.
Refreshments will be served.

April 24 to 26, 2008

ASCE/SEI Structures Congress

Hyatt Regency Hotel, Vancouver.
For registration and details see:
http://content.asce.org/conferences/structures2008/

February 27, 2008

Structural Engineers Association of B.C.

Seminar

Topic: Olympic Speed Skating Oval – Roof Structure
Presenter: Paul Fast, P.Eng., P.E., LEED AP
Venue: BC Hydro Building, 333 Dunsmuir
Time: 6:00 p.m. – Refreshments
6:30 p.m. – Presentation

Paul A. Fast, P. Eng. (B.C., Yukon, Germany), P.E. (Wash.), Ing. (Germany) LEED AP, Principal

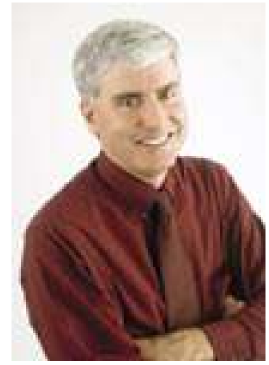
Paul obtained his Bachelor of Applied Science degree in Civil Engineering from the University of British Columbia in 1981. In 1985 he established his own company, Paul Fast Associates Ltd., and in 1989 the corporate partnership of Fast + Epp was formed. For the past twenty years he has been involved in the design of many challenging projects throughout British Columbia. Paul is currently Principal-in-Charge of the design of the 2010 Olympic Speed Skating Oval roof structure and numerous Canada Line Rapid Transit Stations.

March 19, 2008

Special Presentation

Topic: AISC Seismic Provisions for Structural Steel Buildings
Presenter: James Malley
Venue: Vancouver Public Library Downtown, Alice MacKay Room
Time: 7:00 p.m.
Refreshments will be served.

On March 19, 2008, SEABC is pleased to welcome James O. Malley, Senior Principal of Degenkolb Engineers (San Francisco, California) for a special presentation in Vancouver.



The American Institute of Steel Construction (AISC) document "Seismic Provisions for Structural Steel Buildings" has become the reference document for seismic design of steel structures throughout the United States. Mr. Malley's presentation will summarize the 2005 AISC Seismic Provisions and the use of the new moment connection pre-qualification standard. It will also address work that is underway to update the standard for the 2010 edition of the AISC Seismic Provisions.

James O. Malley received both his Bachelors and Masters Degrees from the University of California at Berkeley, and has over 25 years of experience in the seismic design, evaluation and rehabilitation of building structures. He has played a key role on many committees and initiatives including the SAC Steel Program, the AISC Specifications Committee, the ASCE Committee on Steel Buildings, the ASCE Seismic Effects Committee, and the Building Seismic Safety Council TS 6 on Structural Steel and Composite Construction. Mr. Malley has served as President of the SEAONC (2000-2001) and SEAOC (2003-2004), and is presently a member of the Board of Directors of NCSEA. He is the author of over fifty technical papers and the recipient of numerous distinguished awards.

Mr. Malley's visit to Vancouver is coordinated by the UBC Student Chapter of the Earthquake Engineering Research Institute (EERI), with funding by the EERI Friedman Family Visiting Professional Program, the UBC Department of Civil Engineering, and the SEABC.

Engineering Question of the Day…

Question: How much does a house weigh?

Answer: **More than a rural two lane bridge can hold!**