SEABC NEWSLETTER

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- SEABC's Newsletter is both edited and managed by The Communications Committee. newsletter@seabc.ca
- Submissions to the newsletter are encouraged and all members of the SEABC are asked to actively participate in contributing to our newsletter. Submissions letters to the Editor, questions and comments can be sent to: newsletter@seabc.ca
- 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

August 2013

By Cameron Kemp, P.Eng.,
SEABC President

Just Because We Can Doesn't Mean We Should

Recently I have seen a spate of tall buildings with unusual geometries written up in the architectural/ engineering publications and have seen some of them on the news. Some of them are quite elegant, both architecturally and structurally, and in my mind represent a step forward in the design of tall buildings. However, some make no sense to me at all. They are weird geometries for geometries sake. More often than not they require structural heroics to make them work. Their structural framing systems are inefficient and often require a brute strength approach to address inherent structural problems created by the geometry. Buildings that fundamentally change shape as their height increases can create huge asymmetries resulting in the need for complex gravity and lateral systems to resist the buildings tendency to twist, lean or demonstrate poor seismic or wind performance due to large eccentricities and structural discontinuities. Don't get me wrong, I'm not suggesting that we should only be building slab-sided rectangular buildings but I do believe that structural engineers should have much earlier input to a buildings overall massing and geometry to ensure that the geometries chosen can be built efficiently and with no inherent tendencies to perform poorly under gravity or lateral loads.

Often the architects on these "weird" projects develop their massing model concepts with little or no input from structural engineers and are often married to their concept by the time the structural engineer gets a chance to look at them. At that point the structural engineer has been dealt a bad hand and is usually left trying to make the best of a difficult situation.

As Vancouver continues to grow and gain recognition as a world-class city our projects are starting to attract better-known international architects some of whom have a penchant for designing buildings with very unusual geometries. Some interesting geometries can be supported vertically and laterally by efficient and, in some cases, elegant structural systems. These buildings are the ones that move the architectural and engineering profession along. The others in my mind are "showing off" just because we now have the sophisticated analytical and graphics tools to be able to design and build these structures.

Our two most recent AGM keynote speakers both spoke about their concerns for this trend. In fact the opening line in this message is attributable to one of them. As structural engineers working internationally both of them have seen a significant increase in complex geometry buildings. Where they have had meaningful early input to the buildings massing and geometry they invariably have been able to come up with efficient, predictable and safe structural solutions. As a profession structural engineers operate at the grandest scale of all of the disciplines and their work has the largest impact on the worlds built environment. This role carries with it a responsibility to work more closely with architects to ensure that our joint projects efficiently use our increasingly scarce resources and result in interesting and hopefully "elegant" buildings both architecturally and structurally.

"Just because we can doesn't mean we should".

Education Committee

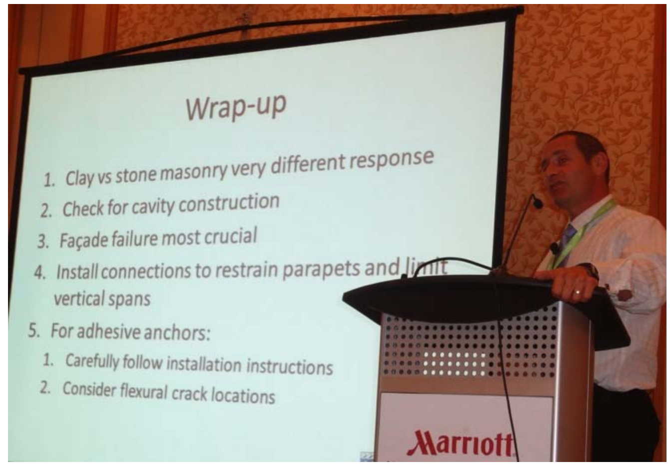
By Tejas Goshalia, P.Eng., Director SEABC

The Education Committee endeavors to provide opportunities for continuing education and professional development to structural engineers throughout BC.

With combined enthusiasm of its committee members, assistance from the Masonry Institute of BC, and co-sponsorship funding from Fibrwrap and Hilti, the Education committee organized a half-day seminar on the Seismic Retrofit of Masonry Structures. The event, held on June 6th at the Vancouver Marriott Pinnacle Hotel, was attended by over 100 SEABC members and students, in-person and via live web-cast hosting.

Four renowned speakers, each an expert in the field of masonry retrofitting, provided a comprehensive overview of current knowledge on various aspects of seismic retrofit or masonry construction. Below is a summary of the speakers and their discussion topics:

Dr. Jason Ingham, Professor of Structural Engineering at the University of Auckland in New Zealand discussed the findings and lessons learned from recent Christchurch earthquakes, responsible for destroying 80% of all existing masonry structures in Christchurch. His slide-show presentation could not over-emphasize the importance of a well-balanced seismic lateral force resisting system. One essential lesson to take home from this seminar was the importance of testing diaphragm anchor installations to ensure they would deliver the promised capacity during a design event.



Dr. Jason Ingham presenting lessons learned from the Christchurch earthquakes.

Michael Schuller, President of Atkinson-Noland & Associates in Boulder, Colorado, brought to us the special expertise with nondestructive evaluation and repair procedures that he has developed over the past 25 years from experiences on projects spread all over America. He provided a comprehensive overview with photos of the various innovative tools, clever techniques and practical methods that are available today to engineers who are frequently faced with the task of determining inherent properties, strength and integrity of existing masonry materials, structures and construction.

Michael Schuller presenting on nondestructive evaluation and repair procedures.

Dr. Ken Elwood, P.Eng., Associate Professor of Structural Engineering at UBC, is a key member in developing the FEMA and ATC standards that eventually became the ASCE 41 Standard for Seismic Evaluation and Retrofit of Building Structures. Within the limited time available to him, Dr. Elwood lucidly described the key parameters, ductility-related principles, flow-chart procedures and evaluation techniques to determine the inelastic capacity and demands contained in the ASCE 41. This was an invaluable lesson for any engineer faced today with seismic evaluation and retrofit design of existing masonry structures.

Dr. Ken Elwood presenting on the inelastic capacity and demands contained in the ASCE 41.

Bret Lizundia, Principal at Rutherford + Chekene in Oakland, California, has spearheaded many challenging seismic retrofit projects. Notable amongst these and presented at the seminar was the upgrade of Unreinforced Masonry Buildings that comprise dormitories for students at Stanford University. This project and similar others presented by him provided a well-rounded overview of how to weave together the evaluation procedures presented by Dr. Elwood, with material testing methods presented by Mr. Schuller, to deliver safe, efficient and successful designs that incorporate the lessons presented by Dr. Ingham.

Bret Lizundia presenting on the upgrade of Unreinforced Masonry Buildings comprising Stanford University dormitories.

The Education Committee is steadfast in bringing many such interesting seminars and events. As a start, look out for an evening presentation on Push-Over Analysis Procedures planned for upcoming fall session.

As always, we appreciate feedback from members including comments on past events, suggestions for future topics, and proposals for presentations. Please contact us at education@seabc.ca.

Young Members Group

By Grant Fraser

On August 8th, Duane Palibroda of Fast and Epp led a group of 20 SEABC members on a tour of the breathtaking VanDusen Gardens Visitor Centre. This award-winning building demonstrates the beauty and elegance that can be achieved with wood, concrete, and steel working together. From the prefabricated timber roof panels to the rammed earth wall, there was no shortage of structural engineering eye candy to enjoy. Thank you to Duane for being an excellent tour guide, and thanks to all those who attended.

Duane Palibroda describes the VanDusen Gardens structure to attendees.

The VanDusen Visitor Centre won the 2012 Award for Best Community or Residential Structure.

The VanDusen Visitor Centre features a dramatic oculus.

Communications Committee

By David Harvey, P.Eng, Struct.Eng., Director SEABC

The Newsletter, website and broadcast emails are our primary means of communicating with the SEABC membership. We work hard to keep these current and informative. If you take a look at the Newsletter content you will see that there is good coverage of SEABC activities and some excellent contributions from members. A big thank you to researchers (especially those at BCIT and UBC) who have provided us with details of some cutting edge research that will help shape future structural designs.

So how about you? Please remember to send us details of your latest project. All we need is a photograph and a short description, but we welcome full articles of interesting projects. We'll do our best to include as much coverage as we can and are happy to edit submissions on your behalf. Please keep up the excellent contributions and keep your fellow members well informed.

Corporate Committee

By David Harvey, P.Eng, Struct.Eng., Director SEABC

The Corporate Committee offers meetings which cover non-technical areas of particular interest to our corporate members. Past topics have included Supervisory Skill Development, Generation Y Employees, and Insurance, and have been well attended.

In June 2013, SEABC co-hosted a two-part training workshop with the Western Canada Group of Chartered Engineers. The workshops were prepared by Asia Pacific Gateway Skills Table, which are sponsored by Human Resources and Skills Development Canada. Held at the VanCity Community Stage in Metrotown, the workshops were entitled 'Successful Interviewing'. Following on from the previous two Corporate Committee events, the presenter was Wilma Marais, a Vancouver-based Human Resource Consultant. Wilma's experience includes holding training sessions for engineering consultants in the Lower Mainland and other local employers.

The workshop introduced the successful interviewing guide, a comprehensive document aimed at supervisors but relevant to interviewers and interviewees. Those participating in the workshop sessions found the information to be very useful as most had never been trained in interviewing techniques.

APGST is producing more training material in the area of supervisory skill development. We may host further training sessions – so let us know if this opportunity is of interest to you or your colleagues and look out for announcements.

APGST's mission is to ensure that the Asia Pacific Gateway has enough people with the right skills and training to meet its needs. Its goals are:

- To provide relevant and unique labour market information.
- To serve as a clearinghouse between industry sectors for labour market information, project information, common issues and best practices, successful strategies and solutions.
- To assist industries to promote the APG as a place to work.
- To research and provide awareness of the future of work in the APG.
- To assist industry sectors to address skills gaps.

More information on APGST is available at www.apgst.ca.

Wilma Marais, CHRP, workshop trainer is introduced by David Harvey.

Technical Committee

By Renato Camporese, , P.Eng., Struct.Eng., Director SEABC

The Task Group investigating the Seismic Design of Basement Walls is currently the only active task group. The non-linear analysis by graduate students at UBC under the direction of Dr. Mahdi Taibat appears to be complete and they have published a paper of the results. The committee is expecting to receive a copy of the paper for their review and to establish if design guidelines can be provided for wall design.

Draft documents regarding requirements for Fire Rating of Seismic Bracing and a Guardrail Design Guideline have been submitted to APEGBC for their review, endorsement and publication. The association has yet to respond to these proposed documents.

On the Web

**By Stephen Pienaar, P.Eng.,
Webmaster SEABC**

Summer has not left our website without activity:

- Online registrations are currently accepted for the **September Term of the Certificate in Structural Engineering (CSE) Program.** Registrations close on September 10.
- The Young Members Group is currently accepting registrations for their tour of the **Granville Bridge Bearing Replacement**.

Membership Drive

The Board recognises that there are many structural engineers in B.C. that are aware of SEABC and even occasionally partake in our activities, but who have not yet committed to membership. It would be wonderful to see all eligible individuals join our association. **The Board encourages all members to invite and encourage their non-member colleagues to join SEABC.** The benefits of membership are many: free or discounted seminars and courses, free access to past video recordings of seminars, opportunities to partake in technical task forces, and participation in many other professional development, networking and social events. As an incentive, new members that join during August or September will be granted membership for the last three months of 2013 at the regular annual rate of $75. Please direct your colleagues to *www.seabc.ca/membership* for more information.

Website Feedback

We welcome your feedback and suggestions for the SEABC website and online services. Please send your submissions to *webmaster@seabc.ca*. If you have not done so yet, please bookmark www.seabc.ca and check in regularly for upcoming events, seminars and courses.

IStructE News

By Bill Alcock, P.Eng., Struct.Eng., Director SEABC and Victoria Janssens, PhD.

As your SEABC representatives on IStructE Council, we attended the Institution's 2013 Council Away Days at the Kia Oval in London on July 25 and 26. Our summary of issues discussed follows:

International Interest Group (IIG) Meeting.
As previously reported, the IIG has undertaken to study the requirements for structural engineering registration in the various countries represented on the IStructE Council. The ultimate goal of this process is to improve the portability of structural engineering registration from one jurisdiction to another, where possible. Bill presented on registration requirements in Canada and the United States for both new graduates and foreign applicants. A presentation on the changing registration requirements in Malaysia was also made by David Lau, the Malaysian delegate to the IIG. Of interest was the fact that Malaysia is opening up its registration to allow much easier access to the Malaysian market for both foreign companies and engineers. Please feel free to contact Bill for more details on this matter.

IStructE Council
During the session, Council focused on the role of two primary issues in supporting membership: Diversity in Action and Regional Groups.

Diversity in Action. The Institution aims to ensure that members and supporters are attracted from a wide range of backgrounds. Currently, however, the IStructE does not collect data to confirm whether its past endeavours in this regard have been successful. In light of this, the topic of diversity was selected for discussion at the Away Days. These discussions took the form of a number of small focus group sessions, the results of which were then presented to all attendees and further debated.

In general, structural engineers tend to come from a skewed distribution of the population. This situation has improved considerably in recent years but it was acknowledged that more work can be done. With regard to this, a number of suggestions were made as to how to improve diversity within the Institution. Amongst these suggestions were:

- The provision of support for structural engineers to take career breaks, allowing individuals to take time out to raise a family, do charity work etc., and later return to the workplace with relative ease.
- The development of a support structure for those with physical/mental disabilities and their employers.
- Continued education of school children and parents about the role of a structural engineer, ensuring the message is delivered to a diverse audience.
- The creation of opportunities for those from disadvantaged backgrounds so that they receive the necessary support should they wish to enter into a career in structural engineering.
- Provision of support for international mobility of structural engineers.

Furthermore, it was decided that the Institution would start to collect some information about their members so that the services provided by the Institution could be better tailored to suit its members. This will also allow the Institution to identify minority group amongst members, if any, and identify any unintentional bias within the Institutions activities.

Regional Groups. As a representative of a Regional Group, the proceedings were of considerable interest. At present, BC is represented on IStructE Council, and currently receives a small dues rebate from the Institution. The relationship between the Institution's Head Quarters (HQ), the Regional Groups and the expectations/rights of individual members were discussed. Following are comments provided:
Expectations of members from their Regional Group:

- Members should expect to have a voice at HQ through their Regional Group.
- The Regional Group should be responsible for holding some technical courses / lectures.
- Exam control and Professional Review Interviews should be at the Regional Group level.
- The Regional Group should hold meetings that will assist their members to network with each other.

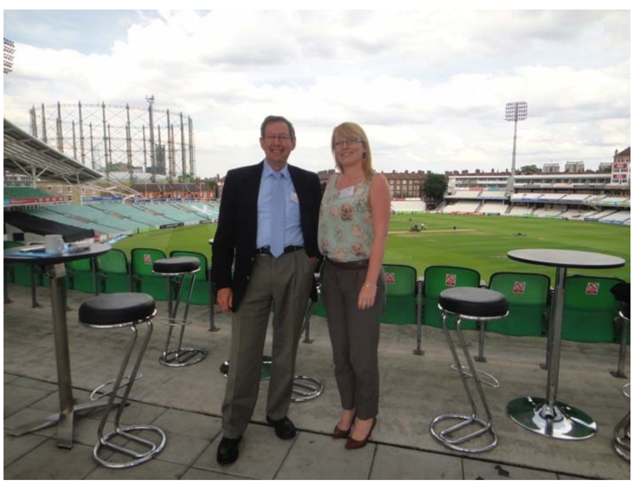
What should HQ provide?

- HQ should provide technical and non-technical information on the world of structural engineering that will keep members up-to-date.
- HQ should assist the Regional Groups by providing names of potential speakers for courses/ lectures.
- Presentations by HQ staff at road shows.
- A conduit from Regional Group Awards to the annual Institution's Awards.
- Communication with members through journals, e-mails, etc.
- A handbook for the Regional Groups.
- Expenses for Professional Review Interviews.
- More recognition for Regional Group officers.
- ``More assistance / less interference".
- Links to Regional Group websites from the Institution's website.
- More information on what Regional Groups are doing.

Media Representation: It was acknowledged that the Regional Groups need media savvy representatives with planned media events, and that HQ could assist by providing training. There was also a lot of discussion about the need to promote engineering (not just structural) in schools from an early age. Worldwide, it was agreed that engineering is generally considered a second-class profession compared with medicine, dentistry, accounting and the legal profession.

On support for future members and graduates: Very few of the Regional Groups currently offer training for the IStructE Exam and this, together with mentoring, was considered important. Regular visits to the universities by Regional representatives to promote the benefits of IStructE membership would be useful in encouraging young engineers to join. Lastly, regular visits to the Regions and their universities (yearly, if possible) from the President and / or Vice Presidents would encourage new members to join.

Please feel free to contact either Victoria or Bill if you would like to know more about the Institution of Structural Engineers.



Bill and Victoria at the Kia Oval, London, UK.

Editor's Note:

- *In BC, APEGBC surveys of professional rankings place engineering second only to medicine.*
- *APEGBC offers an annual IStructE Exam training workshop.*

Lhomond River Bridge, Haiti

By Julien Henley, P.Eng., Associated Engineering

The natural terrain in British Columbia results in a need for large numbers of bridges to access our vast natural resources. As a result we have over 100,000 bridges on our rural and industrial roads, most of which span watercourses. In Haiti, a much smaller and impoverished country of 7 million people, rural bridges are rare and local communities must ford the rivers. Haiti occupies the western portion of the island of Hispaniola in the Caribbean and is still recovering from the devastating M7 earthquake of 2010 near Port-au-Prince. Haiti is heavily reliant on help from the developed world for its earthquake recovery.

In BC we have an industry which supplies bridges which are specially designed for the resource industries. A high degree of prefabrication is involved so that bridges can be installed rapidly in remote locations with readily available equipment. The available designs include steel portable spans that can be inventoried, easily moved by truck and quickly installed when needed. The steel portable spans are custom-designed orthotropic girders with thin a bonded wearing surfacing to minimize weight.

With the help of a list of generous sponsors, bridge fabricator Rapid-Span Structures of Armstrong, BC, recently supplied and installed a bridge across the Lhomond River in rural Haiti. The project was headed up by Tamer Akkurt, M.Eng., P.Eng., Rapid-Span's Vice President, Marketing. The steel portable span design was attractive because it could be almost completely prefabricated in Canada and shipped to Haiti for installation. Over 20 years ago, Associated

Engineering had developed the steel portable bridge design which is now in widespread use in BC. Working closely with Rapid Span, Associated custom designed the steel orthotropic girders which were used for the Lhomond River Bridge. The six girder segments were 2.15 m wide by 11.6 m long in order that they could be containerized for shipment. When assembled using field bolting, they created a 4.3 m wide by 35 m long single-lane bridge, sufficient to accommodate the river under flood conditions.

The concrete foundations were mixed and placed in Haiti using Canadian cement. End slopes were protected from scour using local rock placed in imported gabion baskets. All other components were steel. The steel ballast walls did double duty as a low level footbridge and one of the shipping containers was used as superstructure erection falsework.

Rapid Span supplied the bridge through St. Boniface Hospital, a local charity. Construction of the bridge attracted many curious locals, while the official opening celebration for the handsome new structure drew dignitaries and the whole of the local community. Construction of the customized new bridge provides the opportunity for economic development to take place and quality-of-life improvement for rural Haitians.

Support bents installed.

Steel girder segments in position.

Foundations underway.

Internal splice bolting underway.

Railing installation.

Scour protection under construction.

Installation nearing completion.

The community tries out the new bridge.

Donkey crossing the new bridge.

Bridge in service Haitian style!

RECENT RESEARCH AT UBC

Using Parallel and Cloud Computing for Efficient Performance Based Design of Buildings and Structures

Carlos E. Ventura and Armin Bebamzadeh
Department of Civil Engineering, University of British Columbia


Introduction

Advances in performance-based design (PBD) methodologies and capacity design principles allow engineers a more direct, non-prescriptive, and rational approach for the analysis and design of buildings and other structures. However, PBD generally requires a detailed investigation of how a structure will most likely perform during different types of earthquakes. For instance, the 2011 edition of the Los Angeles Tall Buildings Structural Design Council (LATBSDC 2011) document, "An Alternative Procedure for Seismic Analysis and Design of Tall Buildings Located in the Los Angeles Region," provides an alternative procedure for the seismic design of tall buildings using a PBD methodology. This document, and others of similar nature, shows that performance-based seismic analysis of tall buildings increasingly uses nonlinear analysis of a three-dimensional model of the building.

In today's practice, lateral-force-resisting components of the building are modeled as discrete elements with lumped plasticity or fiber models that represent material nonlinearity and integrate it across the component section and length. Gravity framing elements may be also included in the nonlinear models so that effects of building deformations on the gravity load resisting system, as well as, the effects of this system on the lateral response of the building can be accounted for. The variation of the seismic demands on the building is usually characterized in terms of the probability of the ground motions that are likely to occur during the lifetime of the building. As an illustration of this, LATBSDC requires the inclusion of a three-step seismic analysis and design procedure with the intent of providing the following characteristics:

1. Well-defined inelastic behaviour where nonlinear actions and members are clearly defined and all other members are designed to be stronger than the elements designed to experience nonlinear behaviour (Capacity Design Approach).
2. 43-Year Return Period - The building's structural and nonstructural systems and components remain serviceable when subjected to frequent earthquakes (50% in 30 years).

3. 2500-Year Return Period - The building has a very low probability of collapse during an extremely rare event (2% in 50 years with deterministic cap).

A well-developed computer model of a building can be used to get a best-estimate response at the various levels of earthquake demands, such as those specified above. However, large-scale simulations and data processing tasks that are needed to support the design can take an unreasonably long time to complete or require a lot of computer memory. One can speed up these tasks by taking advantage of high-performance computing resources, such as multicore computers, GPUs, computer clusters, and grid and cloud computing services.

High Performance Computing (HPC) may be used by structural engineers to solve complex problems using applications that require high bandwidth, low latency networking, and very high computer capabilities. Typically, engineers must wait in long queues to access shared clusters or acquire expensive hardware systems. However, taking advantage of cloud computing services, engineers can expedite their HPC workloads on elastic resources as needed and save money by properly selecting the “cloud services” that match utilization needs.

What is Cloud Computing?

The cloud is a metaphor for the Internet, based on how it is depicted in computer network diagrams (see Fig. 1). Instead of a direct connection to a server, the resources are retrieved from the Internet though web-based tools and applications. Data and software packages are stored in servers. The cloud computing structure allows access to information as long as an electronic device has access to the web, so one can work remotely. We can then say that Cloud Computing is about the delivery of computing resources from a location other than that from the user. All the user needs to access a public cloud is an Internet-connected computer.

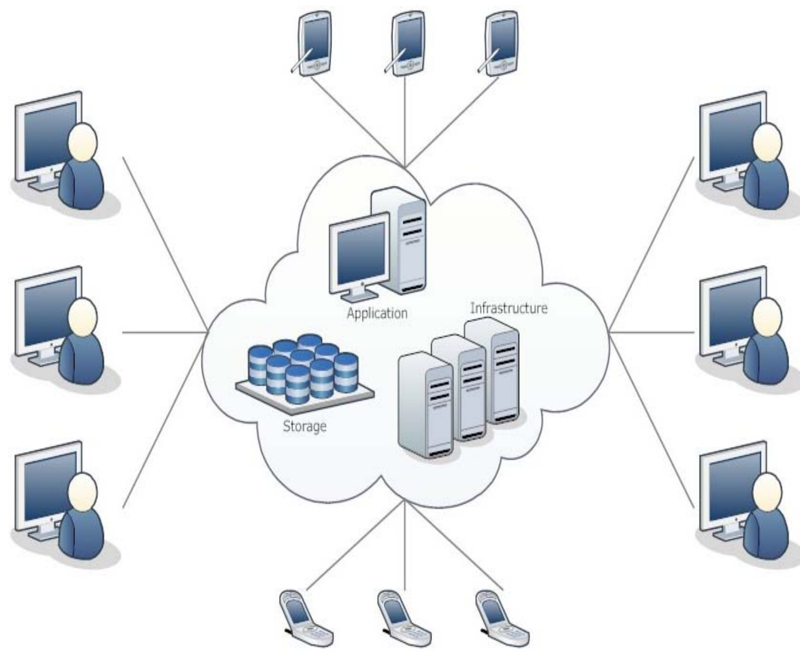


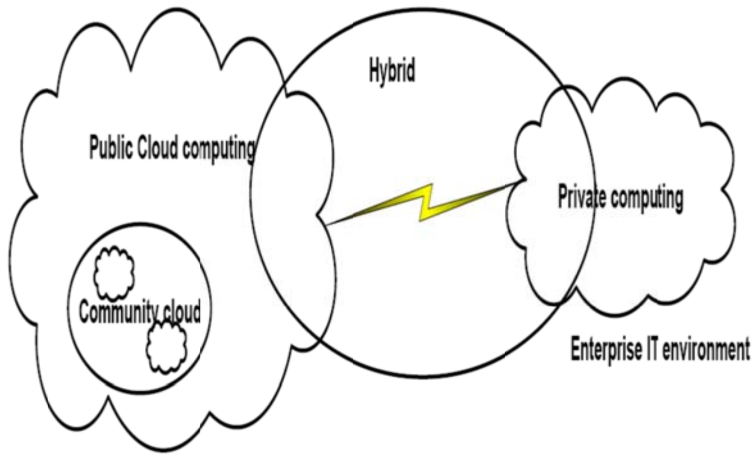
Figure 1. Conceptual idea of Cloud Computing

Cloud computing can be broadly defined as delivering hosted IT services over the Internet (Whatis.com 2010). According to the U.S. Institute for Standards and Technology, Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable resources (networks, servers, storage, applications, and services) that can be rapidly provided and released with minimal management effort or service provider interaction” (Haber 2010). Cloud computing differs from traditional hosted services in that: it is a metered service that is sold on demand; it is a scalable, elastic service that stretches or shrinks in response to demand; and it is managed by a service provider, so the infrastructure is transparent to users.

Cloud Service Models

NIST further breaks the service models down into four interrelated discreet categories (see Fig. 2):

1. **Private cloud:** The cloud infrastructure is operated solely for an organization.
2. **Community cloud:** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns.
3. **Public cloud:** The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
4. **Hybrid cloud:** The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.



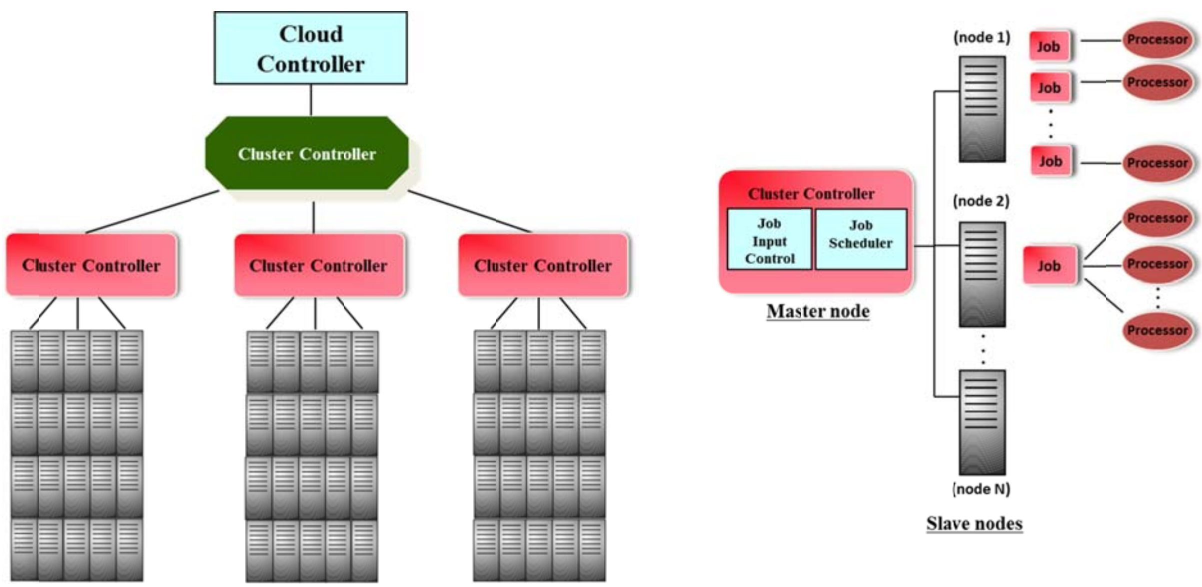
Some details about Cloud Computing Architecture

The majority of cloud computing infrastructure currently available consists of services delivered through data centers that are built on servers with different levels of virtualization technologies. The services are accessible anywhere in the world, with the Cloud appearing as a single point of access for all the computing needs of consumers. It is sold on demand (*automatic approach to scaling in cloud environments*), typically by the minute or the hour; a user can have as much or as little of a service as they want at any given time (elastic service); and the service is fully managed by the provider so that the consumer needs only a personal computer and the Internet access. Egwutuoha et al. (2013) provie a good review of the concept of Cloud computing, its challenges and potential solutions.

An example of a model of cloud services is the NEEShub (http://nees.org). NEEShub is a platform for research, collaboration and education in earthquake engineering in the US. NEEShub is a cyber-infrastructure for NEES, which is based on HUBzero technology developed at Purdue University, and provides a platform to browse experimental data, seminars, and courses. In addition, NEEShub provides cloud based computing to earthquake engineers by giving them the capability of running sophisticated applications remotely on the NEEShub machines (McKenna et al. 2013) such as the OpenSees computer analysis program for PBD. OpenSees stands for Open System for Earthquake Engineering Simulation (OpenSees 2006, 2012), and is an open source software that has been developed for simulating the seismic response of structural and geotechnical systems.

OpenSees is also available in two parallel applications at PEER and NEEShub including: OpenSeesSP and OpenSeesMP (McKenna and Fenves 2007). These parallel applications are based on MPICH (2013) technology developed at Argonne National Laboratory, which is a portable implementation of Message Passing Interface (MPI) to program parallel applications. The SP version is based on parallel determination of elements and solving the equations. This application is suited for complex and large models such as 3D soil-structure interaction problems. In contrast, the MP version is an application for both large models and parametric studies, which a model with different input parameters is run in parallel. This application is useful for sensitivity analyses and optimization designs. OpenSees parallel applications on clusters, grids, and clouds provide a high performance computing tool in terms of efficient execution speeds for large models or repetitive runs.

Figure 3a shows some of the key components of a cloud's infrastructure. A cloud's underlying architecture can be relatively simple or extremely complex. At a minimum, a cloud must have cloud controller and ***compute-nodes***. All requests for cloud resources will be made to the cloud controller. The compute-node runs the virtualization technology and handles the actual processing. A compute-node may consist of one or more clusters. Each cluster can consist of one or more ***nodes*** (Fig. 3b), and each node by itself can contain of one or more ***virtual machines*** (or virtual PCs). Each cloud instance allows a large number of compute-instances fairly easily. High performance computing tools can be developed by implementing parallel applications in the large cloud virtualized resources (Fig. 3b).



(a) (b)

Figure 3. (a) Cloud and (b) Cluster architectures

Implementation of Parallel Computing in PBD at UBC

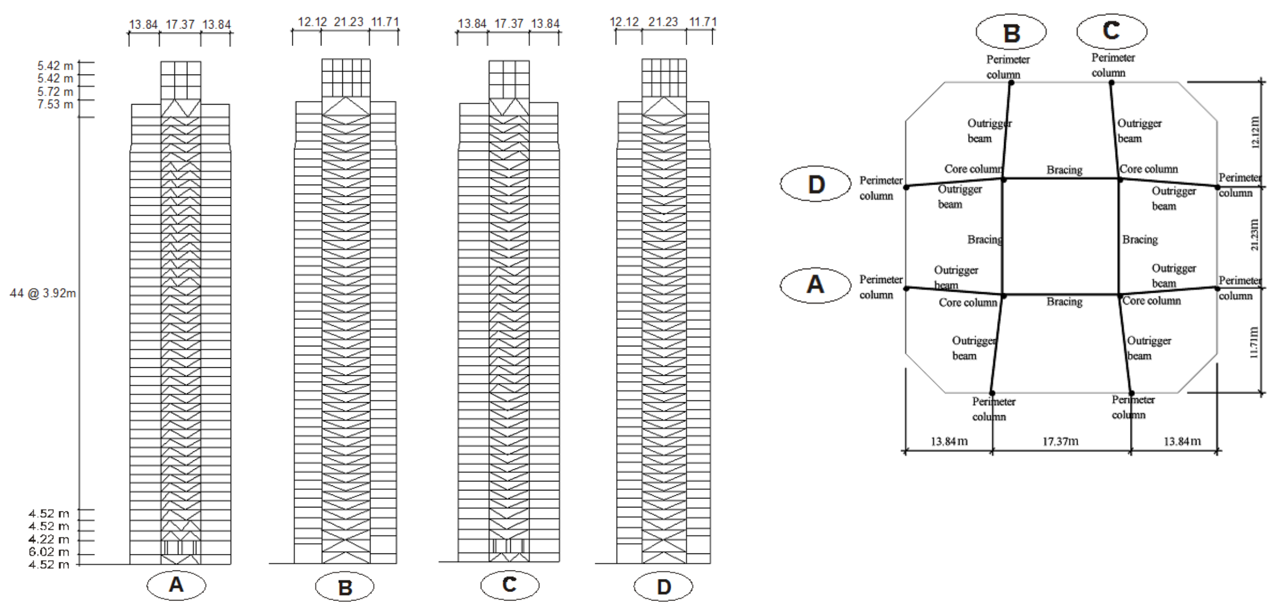
At UBC we have implemented a methodology to take full advantage of high-performance parallel computing using the cloud architecture described above. The methodology that we have developed has been implemented for various structural and geotechnical programs and used for the seismic analysis of buildings and bridges. For the case of buildings, a simple to use graphical interface has been developed to integrate the computer model with the input ground motions, and to load this information into the Cloud

Controller shown in Fig. 3. At the present time we are using the compute-nodes of the Amazon EC2 Cloud Center (AWS 2013http://aws.amazon.com/). Amazon EC2 is a cloud service which allows users to rent virtual computers to run their own computer applications. Each virtual computer is called an "instance." EC2 provides instances, which are optimized for high performance computing (HPC), giving customers very high CPU capabilities and the ability to launch instances within a high bandwidth, low latency, and full bisection bandwidth network. For the computer programs that have not been developed specifically for parallel computing, each virtual machine runs a single instance of the program. In contrast, for programs suited for parallel computing, each virtual machine may be responsible for running a certain component of the building computer model.

The following case study illustrates how we are using the parallel computing capabilities of OpenSees for the incremental dynamic analysis of a tall building in Los Angeles. The purpose of this example is not necessarily to examine the seismic response of this building, but to illustrate the efficiency and flexibility of using cloud computing for PBD of buildings.

Los Angles 52 Storey Office Building

A 52-storey office building, one of the tallest buildings in downtown Los Angeles, has been selected to demonstrate the methodology for nonlinear response history analysis (RHA) using parallel computing. The building, called here FWT, is a 52-storey steel frame office tower with five levels of underground parking. The FWT was designed in 1988, constructed in 1988-1980, and instrumented by the California Strong Motion Instrumentation Program (CSMIP) in 1990. The structural system of the FWT consists of three main components as shown in Fig. 4 including: a braced-core, twelve columns (eight on the perimeter and four in the core), and eight 91.4 cm deep outrigger beams at each floor connecting the inner and outer columns. Ventura and Ding (2000), and more recently Kalkan and Chopra (2010, 2011 and 2012), have studied the linear and nonlinear dynamic response of this building.



(a) (b)

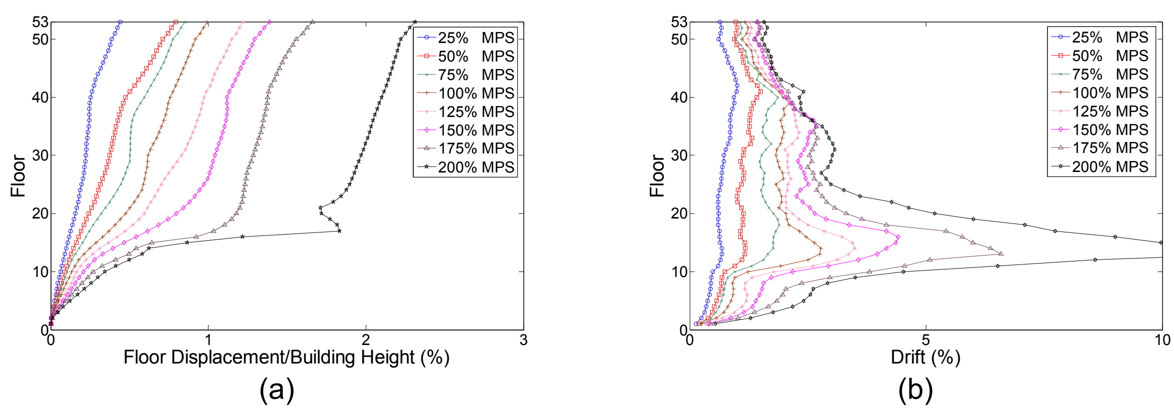
Figure 4. (a) Elevation of lateral force resisting frames (b) Typical floor plan

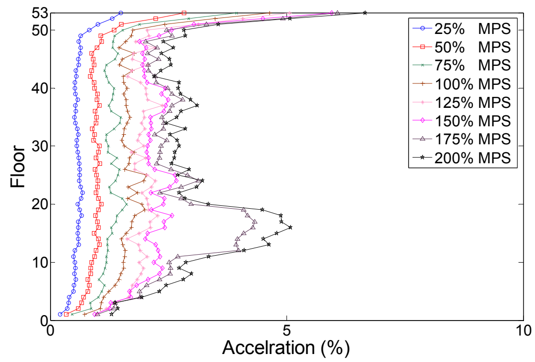
In this study, a 3-D model of the FWT building developed by Kalkan and Chopra (2012) in OpenSees is used. The model was originally developed to investigate a method of scaling the ground motions for tall buildings using the Modal Pushover-based Scaling (MPS) method (Kalkan and Chopra 2012). The model has been modified by the authors to perform parallel nonlinear RHA using the OpenSeesSP and OenSeesMP platforms. The building was modeled as a combination of nonlinear braced frames and moment frames consisting of 58 separate columns types and 23 different beam types. The modal periods of vibration and response of the model were verified with respect to those obtained from the recorded motions during the Northridge and Chino-Hills earthquakes.

The purpose of performing nonlinear RHA in this study was to investigate the efficiency of parallel computing analysis using clouds. Only six ground motions were selected for the nonlinear RHA using the MPS procedure. Table 1 lists the selected ground motion records and their scaling factors. Incremental Dynamics Analysis (IDA) was performed by varying the ground motions from 25% to 200% of their scaled values in 25% increments. Figs. 5a, 5b, and 5c show the change in the median of the displacement, drift, and acceleration respectively for a set of scaled ground motions as MPS factors percentage is increased. Fig. 6 shows the variation of drift at 15th floor for each ground motion and different percentage of MPS factors.

Table 1. Scale factors for the FWT buildings and for six ground motions according to the MPS method proposed by Kalkan and Chopra (2012)

No.	Earthquake Name	Recording Station	Scale Factor
1	Superstition Hills, Calif.	Parachute Test Site	2.2
2	Northridge, Calif.	Sylmar-Converter St East	2.9
3	Kobe, Japan	Takatori	3.6
4	Chi-Chi, Taiwan	TCU065	0.8
5	Chi-Chi, Taiwan	TCU102	1.3
6	Kocaeli, Turkey	Yarimca	2.3





(c)

Figure 5. Median of (a) displacement, (b) drift, and (c) acceleration of 6 ground motions at each floor of 52-storey building and at different percentage of MPS factors

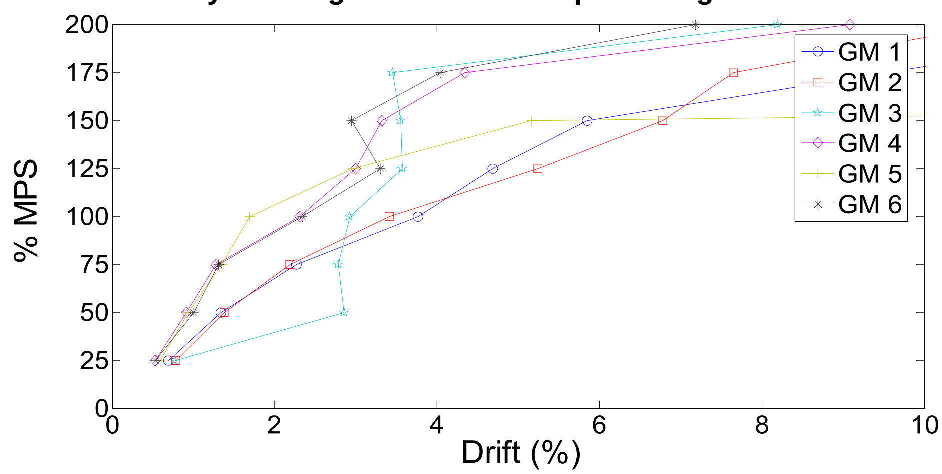


Figure 6. Drift at 15th floor for set of 6 ground motions and different percentage of MPS factors

All the nonlinear analyses were performed using the high memory cluster instances of the Amazon EC2 Cloud Center. Instances of this family provide proportionally high memory and CPU resources with 16 cores and are well suited for memory-intensive analytics and HPC.

Fig. 7 compares the CPU run time of the nonlinear RHA of the building for the Chi-Chi Taiwan ground motion using parallel commuting with 1, 4, 6, and 10 processors. The run time is reduced about 3 times using parallel nonlinear RHA and 4 processors. However, there is no significant reduction in run time observed when using more than 6 processors. This may be due to the complexity of the finite element model of the building and the order of parallel computation in the model. Fig. 8 shows the run time of nonlinear RHA analysis for a set of 6 ground motions using different number of processors. By using 6 processors, in which each ground motion was executed by one processor, the run time is reduced by a factor of 4. The run time can be reduced up to 9 times by using 16 processes and assigning 3 processors for each ground motion run.

The run time of IDA for a set of 6 ground motions and 8 levels of intensity using parallel computing is shown in Fig. 9. The runtime can be reduced from 78 hours using only one processor to about 1.5 hour using 128 processors in parallel. For this purpose, 8 high memory instances with total number of 128 processors were used to run the ground motions at 8 different levels of intensities. At each instance, 3 processors were used to run each ground motion.

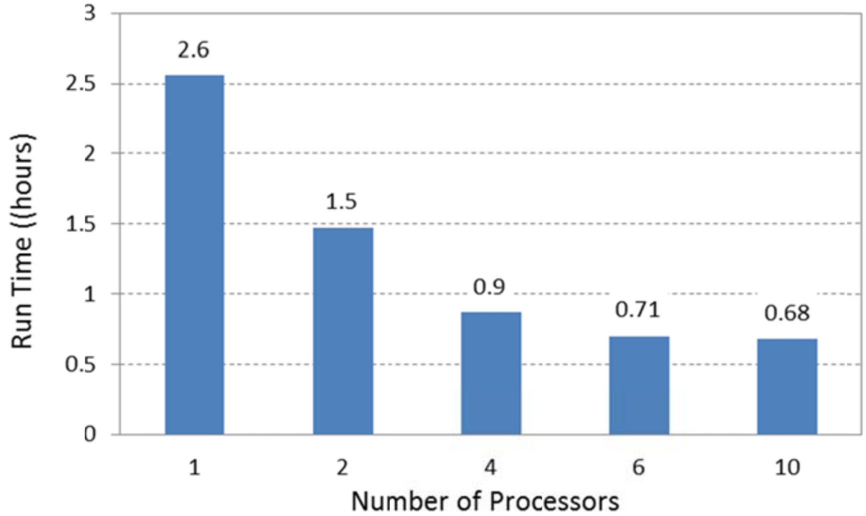


Figure 7. Runtime of nonlinear RHA of 52-storey building using Chi-Chi Taiwan and parallel computing with different number of processors

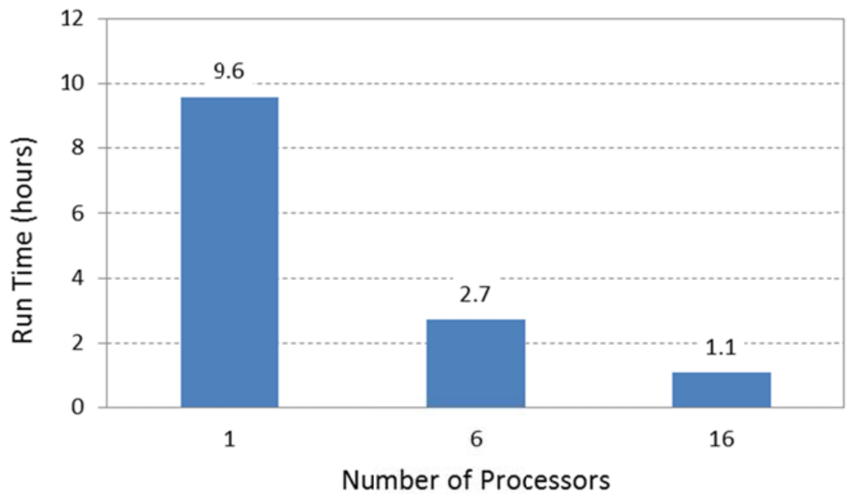


Figure 8. Runtime of nonlinear RHA of 52-storey building using a set of 6 scaled ground motions and parallel computing with different number of processors

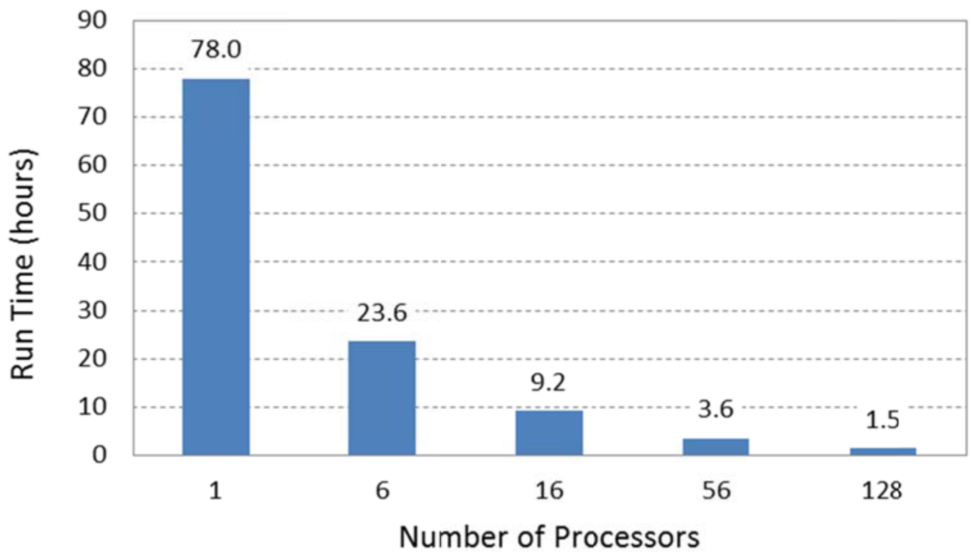


Figure 9. Runtime of IDA of 52-storey building using parallel computing with different number of processors

Discussion and Conclusion

The example presented above clearly illustrates the advantages of using parallel computing for the dynamic analysis of a tall building. The significant reduction in the time required to process a suite of ground motions, and the flexibility of cloud computing in assigning tasks to different processor, allow engineers to perform various types of analyses in parallel. Some of the perceived disadvantages of cloud computing are:

a) Availability – If the cloud service goes down unexpectedly, the user could be without important information for hours or more. Data mobility and ownership – Can the user get his data back after stopping the cloud service?
b) How can the user be certain that the service provider will destroy the data once the user has canceled the service?
c) Privacy – How much data are cloud companies collecting and how might that information be used?

However, the proposed methodology provides a tool that enables structural engineers to run high performance computer (HPC) applications very efficiently, and allows them to meet modern design code requirements for tall buildings. Its main advantages are:

a) Low Cost: Engineers can significantly reduce the cost and complexity of procuring, configuring and operating HPC clusters with low, pay-as-you-go pricing.
b) Elasticity: Users can add and remove compute resources to meet the size and time requirements commensurate with the size and type of building model being analyzed.

c) Run Jobs Anytime, Anywhere: By making use of simple applications (APIs) or management tools and automate workflows for maximum efficiency and scalability. User can increase the speed of producing results by accessing compute resources in minutes instead of spending time in queues.

We have used this methodology for a number of applications related to seismic response of structures. At the present time we have implemented this methodology using computer programs CANNY and OpenSees and we are using it for the analysis of schools buildings as part of the British Columbia Schools Seismic Retrofit Program. For this purpose, a web-based tool has been developed for performance-based seismic assessment and design of low-rise and mid-rise buildings in BC by taking full advantage of parallel and cloud computing technologies. This tool provides engineers web-based access to conduct extensive nonlinear dynamic analysis of low-rise and mid-rise buildings under suites of earthquakes of various intensities in a fast and computationally efficient manner. Other uses of the methodology include:

- Risk-based calculations of the response of various types of buildings
- Estimation of damage and losses in buildings to various types of earthquake mechanisms
- Incremental dynamics analysis
- Sensitivity analyses in the selection of ground motions
- Ground motion directionality effects on the response to tall buildings
- Design optimization and reliability analysis

We are presently working on the following further refinements:

1) Ability to incorporate appropriate design details specific to the building model being studied.
2) Extend the applicability of the methodology to a wide variety of building structural systems and hybrids of systems, as well as different configurations, and occupancies in use.
3) Identify a suitable hosting site for the tool, as well as maintenance, user support and updating as code requirements change
4) Conduct further verification tests to ensure that the tool leads to results similar to those obtained from laboratory shake table testing and those observed during earthquakes from instrumented buildings.
5) Implementation of the methodology using other commercially available computer programs like SAP2000, ETABS, PERFORM, ABAQUS and FLAC.

Acknowledgments

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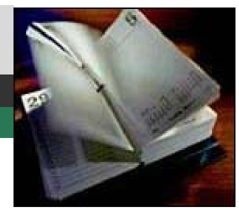

Seminars

Pushover Analysis

Date:	September 11, 2013
Venue:	Room C400, UBC Robson Square, 800 Robson Street, Vancouver.
Time:	Refreshments 6:00 p.m.; Presentation 6:30 p.m.
Presenter:	Saqib Khan, S.E., P.E., P.Eng., Senior Project Engineer, MMM Group Limited
Cost:	Free for SEABC Members. $75 + tax for non□members Registration is required: www.seabc.ca/pushover