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CANADIAN CIVIL ENGINEER
L'INGÉNIEUR CIVIL CANADIEN

2015 | SPRING/PRINTEMPS

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L'INGÉNIEUR CIVIL CANADIEN

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Sustainability in Developing Countries – Lessons for Canada

India has a significant challenge when it comes to sustainability. It has been noted that India makes up 2.4% of the world's land, but supports 16% of the world's population. The Foundation for Sustainable Development has expressed that "…the compounding result is a severely unsustainable use of natural resources for several generations. India is experiencing rapid and widespread environmental degradation at alarming rates. Tremendous pressure is placed upon the country's land and natural resources to support the massive overpopulation."

In the face of this situation, industry and government leaders at an India Economic Summit a number of years ago noted the country has an opportunity to take the lead in creating the infrastructure of sustainable growth. The creation of a Climate Change Council and other task force initiatives by the Prime Minister were identified as demonstrations of a high level of government interest in the issue. The co-chair of the Summit noted the promotion of renewable energy production – such as wind and solar – can also increase economic and environmental efficiency. It can be a driver of sustainable, equitable growth, particularly in India's rural population.

A leading industrial executive at the Summit commented that "…we are not going to stop urbanization, so we have to be prepared for it and plan for the next 50 years. We need smart urbanization policies. Urbanization is about zoning, transit and housing. If you see the way it has been done in the past, the understanding of energy consumption was never part of the planning process."

India clearly has made some efforts to achieve sustainability and still has a long way to go. What is important is the fact that it has recognized that as a developing country it cannot create infrastructure for growth in the same fashion as current developed countries.

Whether it is India or Canada, or any other country for that matter, economic growth is paramount. Economic policies challenge, and often trump, policies for environmental and social sustainability. It is critical to understand that we cannot continue to develop infrastructure in the same way we have in the past if we are going to seriously address global sustainability. Does it need a developing country like India to show the way? It is critical that Canada takes a "high level of interest" in policy direction with a balanced approach to the economic, environmental and social issues associated with growth.

Nowhere in Canada does this issue have the potential to be more critical than in the development of the north. Climate change is providing the opportunity to access the natural resources in the Arctic. Development in the next 50 years is inevitable. Economic development opportunities for Canada are immense. How we develop the infrastructure to support the growth that will take place in a relatively untouched Arctic environment is paramount. What type of energy will support northern development? What type of transportation infrastructure will move the natural resources from the north to global markets? How will we

build new cities in the north?

Perhaps the larger challenge is how to mobilize the key stakeholders to focus on this issue. Civil engineers have a critical role in the debate and discussions that will ultimately lead to sustainable solutions. Civil engineers must find their way to the table and hold fast to our obligations and responsibilities as stewards of the resources of the world and of our use of resources to improve the economic and social well-being of all global citizens. ■

Reg Andres is vice-president of R.V. Anderson Associates Limited in Toronto.

La durabilité dans les pays en développement – Des leçons du Canada

En matière de durabilité, l'Inde doit faire face à un énorme défi. Il est à noter que l'Inde compte pour 2,4 % de la surface terrestre de la planète, alors qu'elle doit subvenir à 16 % de la population mondiale. La Fondation pour le développement durable (Foundation for Sustainable Development - FSD) s'est exprimée à ce sujet : « ...l'addition de ces constats se solde par une utilisation assurément non viable des ressources naturelles pour plusieurs générations à venir. L'Inde subit présentement une dégradation environnementale rapide, à grande échelle et alarmante. Une pression insoutenable repose sur la terre et les ressources naturelles du pays afin de soutenir une surpopulation massive. »

Face à cette situation, les leaders de l'industrie et des représentants gouvernementaux se sont rencontrés il y a quelques années lors d'un Sommet économique sur l'Inde et ont noté que le pays avait l'occasion d'aller de l'avant en créant les infrastructures d'une croissance durable. La création par le premier ministre d'un Conseil des changements climatiques et d'autres initiatives impliquant des groupes de travail ont été identifiées comme des démonstrations de l'intérêt marqué du gouvernement pour cette question. Le coprésident du sommet a noté que la promotion de la production d'énergie renouvelable, telles que les énergies éolienne et solaire, peut également améliorer l'efficacité économique et environnementale. Cela peut devenir un moteur pour une croissance durable et équitable, particulièrement au sein de la population rurale de l'Inde.

Un représentant majeur de l'industrie a émis ce commentaire lors du sommet : « ...nous n'allons pas mettre un frein à l'urbanisation, donc nous devons être prêts à y faire face et à la planifier pour les 50 prochaines années. Nous avons besoin de politiques intelligentes d'urbanisation. L'urbanisation comporte des aspects de zonage, de transit et de logement. Si vous examinez comment l'urbanisation s'est faite par le passé, vous constaterez que la compréhension de la consommation de l'énergie n'a jamais fait partie du processus de planification ».

L'Inde a clairement fait des efforts en matière de durabilité, mais a encore beaucoup de chemin à faire pour atteindre ses objectifs. Le plus important est le fait que l'Inde reconnaît qu'en tant que pays en voie de développement elle ne peut créer des infrastructures de croissance de la même manière que les pays développés peuvent le faire.

Qu'il s'agisse de l'Inde, du Canada ou de n'importe quel autre pays, la croissance économique demeure d'une importance capitale. Les politiques économiques confrontent, et souvent prennent le pas sur les politiques environnementales et de durabilité sociale. Il est primordial de comprendre que nous ne pouvons continuer de développer des infrastructures de la même façon que nous l'avons fait dans le passé si nous souhaitons régler une fois pour toutes le problème du développement durable mondial. Est-ce que l'on a besoin d'un pays en voie de développement tel que l'Inde pour nous montrer la voie à suivre? Il est primordial que le Canada porte un « niveau élevé d'intérêt » à l'orientation des politiques grâce à une approche équilibrée des questions économiques, environnementales et sociales associées à la croissance.

Ces enjeux ont le potentiel d'être encore plus décisifs lors du développement du nord du pays, comme nulle part ailleurs au Canada. Les changements climatiques nous donnent l'occasion d'accéder aux ressources naturelles de l'Arctique. Le développement est inévitable d'ici les 50 prochaines années. Les occasions de développement économique sont immenses pour le Canada. La façon dont nous développerons les infrastructures qui soutiendront la croissance se produisant dans un environnement arctique relativement vierge est de première importance. Quel type d'énergie soutiendra le développement de la région nordique ? Quel type d'infrastructures de transport servira à rediriger les ressources naturelles du nord vers les marchés mondiaux ? Comment construirons-nous de nouvelles villes dans le nord ?

Le plus grand défi sera peut-être la manière d'amener les parties prenantes clés à se concentrer sur ces enjeux. Les ingénieurs civils jouent un rôle primordial dans ce débat et dans les discussions qui mèneront finalement à des solutions durables. Les ingénieurs civils doivent trouver une façon de participer au débat et de faire respecter nos obligations et responsabilités en tant que gestionnaires des ressources mondiales et en matière d'utilisation de ces ressources de manière à améliorer le bien-être économique et social de tous les habitants de la Terre. ■

Reg Andres est le vice-président de R.V. Anderson Associates Limited à Toronto.

Western Region: Building Synergy

D. Phillip Alex,
VICE-PRESIDENT, WESTERN REGION, CSCE

Like every other region, the Western Region works actively with the sections to build and sustain initiatives that are in alignment with the strategic directions and visions of the CSCE national office. Over the last year, the region has been actively working with the respective sections to promote three strategic directions.

Enhanced Services to Members: The sections are actively involved in the civil engineering community by providing numerous services to the members. Each section hosts programs that involve projects in the areas and are presented by industry practitioners, These programs include technical programs, tours of infrastructure projects and student activities, such as poster contests, popsicle bridge contests, and scholarship and bursary programs, which help to further relationships and connections with other civil-related societies. The Calgary section hosted a panel discussion that was based on the recent floods in Southern Alberta.

Growing with Youth: The sections have been actively taking an interest in youth. Young professional activities include industry and professional nights, mentorship programs, involvement of technologists and the creation of the student chapter at the University of Victoria. The Edmonton section also hosted the first "speed mentoring" event, which had a great turnout from both the industry side as well as the youth side.

Leadership in Sustainable Infrastructure: All the activities that have been initiated within the region have taken this strategic direction into account. Selection of topics for the various technical programs, the Regional Lecture Tour (RLT) and the student activities are in line with this strategic direction. The region hosted a lecture tour on the Glacier Discovery Walk in Jasper National Park, presented by Dr. Simon Brown from Read Jones Christoffersen.

Although there are significant challenges with respect to an aging workforce, the current economy in Alberta and succession planning within the sections, there is excitement within the Western Region as the Vancouver section works hard towards hosting the CSCE Annual Conference in 2017. The region continues to build synergies among the sections as we move forward in achieving the CSCE's vision and strategic directions.

The Western Region core committee consists of the regional vice-president (Dinu Philip Alex), treasurer (Dr. Rishi Gupta), regional coordinator (vacant) and the chairs of the four sections that comprise the region (Sid Lodewyk – Edmonton, Kristoffer Karvinen – Calgary, Stanley Chan – Vancouver, Kevin Baskin – Vancouver Island). ■

La région de l'Ouest : le développment d'une synergie

D. Phillip Alex,
VICE-PRÉSIDENT, RÉGION DE L'OUEST, SGCG

Tout comme les autres régions, celle de l'Ouest travaille activement avec les sections afin de développer et soutenir des initiatives qui correspondent aux orientations stratégiques et à la vi-

Western Region's annual face-to-face meeting with section representatives./
Réunion annuelle de la Région de l'Ouest avec les représentants des sections

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sion du Bureau national de la SCGC. Au cours de la dernière année, la région de l'Ouest a travaillé d'arrache-pied avec les sections respectives afin de promouvoir trois orientations stratégiques.

La bonification des services aux membres : Les sections sont activement impliquées dans la communauté du génie civil en fournissant de nombreux services aux membres. Chaque section a mis sur pied des programmes impliquant des projets dans leur secteur respectif et qui sont dirigés par des praticiens de l'industrie. Ces projets incluent des programmes techniques, des visites de chantiers d'infrastructure et des activités étudiantes, telles que des concours d'affiche, des concours de ponts en bâtonnets glacés (popsicles), ainsi que des programmes de bourses d'études, le tout visant à contribuer à tisser davantage de relations et de liens avec d'autres sociétés reliées au monde du génie civil. La section de Calgary a organisé un groupe de discussion basé sur les récentes inondations dans le sud de l'Alberta.

Croître avec les jeunes : Les sections ont véritablement fait preuve d'intérêts pour les jeunes. Les activités des jeunes professionnels incluent les soirées de l'industrie (industry nights) et les soirées de rencontres professionnelles (professional nights), des programmes de mentorat, l'implication des technologues et la création du chapitre étudiant de l'Université de Victoria. La section d'Edmonton a également accueilli le premier speed mentoring (ou mentorat express), événement qui a rassemblé un grand nombre de participants, autant du côté de l'industrie que chez les jeunes.

Leadership en infrastructures durables : Toutes les activités qui ont été initiées dans la région ont pris cette orientation stratégique en ligne de compte. Le choix des thèmes des divers programmes techniques, de la tournée régionale de conférences (RLT - Regional Lecture Tour) et des activités étudiantes correspondent à cette orientation stratégique. La région a accueilli la tournée de conférences sur la Promenade de la Découverte-du-Glacier dans le parc national Jasper, présentée par le Dr Simon Brown de Read Jones Christoffersen.

Bien que nous devions faire face à de nombreux défis comme le vieillissement de la main-d'œuvre, l'état actuel de l'économie albertaine et la planification de la succession dans les sections, il règne une saine animation dans la région de l'Ouest alors que la section de Vancouver se prépare à accueillir le congrès annuel de la SCGC en 2017. La région continue de développer une synergie entre les sections alors que nous faisons avancer la vision et les orientations stratégiques de la SCGC.

Le comité de base pour l'Ouest comprend le vice-président régional (Dinu Philip Alex), le trésorier (le professeur Rishi Gupta), le coordonnateur régional (présentement vacant) et les présidents des quatre sections de la région : Sid Lodewyk, Edmonton ; Kristoffer Karvinen, Calgary ; Stanley Chan, Vancouver ; et Kevin Baskin, île de Vancouver. ■

Breaking New Ground – UBC Civil Engineering Student Chapter

Bradley Ho
2015 UBC CONCRETE CANOE TEAM CAPTAIN
Charles Noftall
PRESIDENT, CSCE STUDENT CHAPTER, UBC

The University of British Columbia (Vancouver) CSCE Student Chapter is proud of the progress it has made over the current academic year. The revival continues. The chapter has seen an increase in membership exceeding 150% (in addition to last year's 400% increase), and expects to see more new members participate in chapter activities during the winter semester. One of the key components of this increase has been the chapter's increased support of UBC's civil engineering teams. This year, the UBC CSCE Student Chapter is proud to support the UBC Concrete Canoe Team's quest to become the only Western Canadian team at the Canadian National Concrete Canoe Competition (CNCCC) in Toronto.

Each year, teams from across Canada are invited and challenged to design, build and race a concrete canoe. This involves engineering and designing a canoe hull that fits the very strict dimensional constraints, performance demands, and aesthetic expectations of the competition. The competition also exposes civil engineering students to some essential non-technical skills such as planning, organizing, teamwork, fundraising and communication. The completed canoe is expected to have the required endurance to be raced by up to four team members. Race results, presentation, display and a design paper are combined for an overall score.

This year, it is the team's goal to participate in the CNCCC in Toronto in May and compete against other Canadian schools. The team is working very hard towards securing the much-needed financial assistance to enable them travel to the competition. They will be the first team to represent Western

UBC's concrete canoe./Canoë de béton de l'UBC

Canada at the competition. By successfully making it to Toronto, the team hopes that future UBC engineering students will be encouraged to pursue similar challenges.

The generosity of sponsors, including the UBC CSCE Student Chapter, provides the team with the opportunity to compete. With the 2015 competition quickly approaching, the team is seeking additional sponsorship to help achieve their goal of competing in Toronto. If you are interested in partnering with the team, have any questions, or would like further information, please feel free to communicate with the team captain, Bradley Ho, who can be reached at ubcconcretecanoe@gmail.com. Also, queries regarding the UBC CSCE Student Chapter can be directed to the chapter president, Charles Noftall, at ubc.csce@gmail.com ■

Du nouveau pour le chapitre étudiant en génie civil de l'UBC

Bradley Ho
CAPITAINE DE L'ÉQUIPE DE CANOË DE BÉTON 2015 DE L'UBC
Charles Noftall
PRÉSIDENT DU CHAPITRE ÉTUDIANT DE LA SCGC DE L'UBC

Le chapitre étudiant de la SCGC de l'Université de Colombie-Britannique (Vancouver) est fier des progrès effectués au cours de l'année scolaire en cours. La relance continue. Le chapitre a vu son nombre d'adhésions augmenté de plus de 150 % (en plus de l'augmentation de 400 % de l'an dernier), et s'attend à voir plus de nouveaux membres participer aux activités du chapitre durant le semestre d'hiver. Un des éléments clés de cette augmentation a été la recrudescence du soutien du chapitre auprès des équipes de génie civil de l'UBC. Cette année, le chapitre étudiant de la SCGC de l'UBC est fier de soutenir l'équipe de canoë de béton de l'UBC dans sa quête visant à devenir la seule équipe canadienne de l'ouest du pays au Concours national canadien de canoë de béton (CNCCB) à Toronto (Ontario).

Chaque année, des équipes de partout au Canada sont invitées à relever le défi de concevoir, de construire et de faire une course avec un canoë de béton. Ceci implique l'ingénierie et la conception d'une coque de canoë qui correspond à de très sévères contraintes dimensionnelles, demandes de performance et attentes en matière d'esthétique exigées par ce concours. Le concours confronte également les étudiants en génie civil à certaines aptitudes non techniques essentielles, telles que la planification, l'organisation, le travail d'équipe, la collecte de fonds et la communication. Une fois la construction du canoë terminée, il doit avoir l'endurance nécessaire pour participer au concours avec à son bord jusqu'à quatre membres de l'équipe : les résultats de la course, la présentation, l'exposition et les documents de conception sont évalués pour obtenir le score final.

Cette année, l'objectif de l'équipe est de participer au CNCCB à Toronto le 8-10 mai et de se mesurer aux autres écoles canadiennes. L'équipe travaille très fort pour obtenir le soutien financier nécessaire à son déplacement à Toronto. Elle sera alors la première équipe à représenter l'ouest du Canada à ce concours. En réussissant à se rendre à Toronto, l'équipe espère que de futurs étudiants en génie de l'UBC seront poussés à relever des défis similaires.

C'est grâce à la générosité des commanditaires, incluant le chapitre étudiant de la SCGC de l'UBC, que l'équipe aura l'opportunité de participer au concours. Celui de 2015 approchant à grands pas, l'équipe recherche des commandites supplémentaires pour l'aider à participer. Si vous souhaitez être partenaire de l'équipe, si vous avez des questions ou désirez obtenir davantage d'information, veuillez contacter le capitaine de l'équipe, Bradley Ho, au ubcconcretecanoe@gmail.com. Les requêtes concernant le chapitre étudiant de la SCGC de l'UBC peuvent être adressées au président du chapitre, Charles Noftall, au ubc.csce@gmail.com. ■

Young Professionals Across Canada: Western Region

D. Phillip Alex, vice-president, Western Region, CSCE

The Young Professionals group within CSCE was established in 2011, and since then this group has taken an active role in bringing young professionals to the table across Canada. Here are some of the highlights of the Young Professionals movement in the Western Region.

Edmonton - Matt Liu

The YoPro group, as the young professionals so proudly call themselves in Edmonton, has been moving forward with many initiatives. In addition to the usual technical events, the group hosted Young Professional Nights, a curling night and the first ever "speed mentoring" session. These sessions allow young professionals and students to connect with the industry and network with them.

Speed mentoring event, Edmonton

Calgary - Hadi Aghahassani and Annie Wang

The Calgary section has also been actively involved in engaging the young professionals in the south of Alberta. Social media (specifically LinkedIn and Facebook) has played an integral role in bringing these professionals to various events, such as technical tours (the Calgary Saddledome), pub nights and career-focused workshops like the one titled "Navigating Your Career."

Navigating Your Career session, Calgary

Vancouver - Carl Wong

The Vancouver section has been building up its activities as it prepares to host the 2017 CSCE Annual Conference. The BCIT CSCE student chapter hosts Professional Night in February each year. The purpose of this event is to give professionals the opportunity to network and discuss career paths with students. The section supports the BCIT ice hockey intramurals league in addition to supporting students at events like the Troitsky bridge building competition.

Vancouver Islands - Zachary Bye

Recently formed, and with the guidance of faculty representative Dr. Rishi Gupta, the University of Victoria's CSCE Student Chapter has gained a lot of momentum in the last year. Some of the key events of the past year include a BBQ Mixer, tour of the Johnson Street bridge, the popsicle stick bridge building competition, and the Fresh Minds Symposium, which involved giving high school students a quick overview of the civil engineering field.

Popsicle stick bridge building competition, University of Victoria

Photo: Armando Tura

The array of events and the enthusiasm of the young professionals and the students within this region have developed a sense of camaraderie between the areas. The sections continue to work with the region to build on initiatives with the young professionals and students as they develop themselves as the engineers of the future. ■

Les jeunes professionnels au Canada: région de l'Ouest

D. Phillip Alex, Vice-président, région de l'Ouest, SCGC

Le groupe des jeunes professionnels au sein de la SCGC fut établi en 2011, et depuis lors, ce groupe a joué un rôle actif en introduisant de jeunes professionnels autour des tables de discussion à travers le Canada. Voici quelques faits saillants du mouvement des jeunes professionnels dans la région de l'Ouest.

Edmonton - Matt Liu

Le groupe YoPro, comme ils se surnomment fièrement eux-mêmes à Edmonton, a mis de l'avant plusieurs initiatives. En plus des habituels événements de nature technique, le groupe a organisé les Soirées des jeunes professionnels, une soirée de curling et, une première, une session de speed mentoring (ou rencontre de mentorat express). Ces sessions permettent aux jeunes professionnels et aux étudiants de rencontrer les gens de l'industrie et de réseauter avec eux.

Calgary - Hadi Aghahassani et Annie Wang

La section de Calgary a également été témoin de l'implication active des jeunes professionnels dans le sud de l'Alberta. Les médias sociaux (LinkedIn et Facebook) ont joué un rôle primordial dans la présence en grand nombre de ces professionnels aux divers événements, tels que les visites techniques (au Saddledome de Calgary), les soirées au pub et les ateliers axés sur la carrière, par exemple l'atelier Navigating Your Career.

Vancouver - Carl Wong

La section de Vancouver s'affaire à préparer ses activités dans le cadre du Congrès annuel de la SCGC qu'elle accueillera en 2017. Le chapitre étudiant de la SCGC du BCIT organise une soirée de rencontres professionnelles (Professional Night) chaque année au mois de février. L'objectif de cet événement est de donner l'occasion aux professionnels de réseauter et de discuter de cheminement de carrière avec les étudiants. La section accorde son appui à la ligue de hockey sur glace intra-muros du BCIT en plus de soutenir les étudiants lors d'événements tels que le concours Troitsky de construction de ponts.

L'île de Vancouver - Zachary Bye

Tout récemment constitué, et encadré par le représentant de la faculté, le Dr Rishi Gupta, le chapitre étudiant de la SCGC de l'université de Victoria a pris véritablement son envol au cours de la dernière année. Certains des événements clés de 2014 incluent une rencontre BBQ, une visite du pont de la rue Johnson, le concours de construction de ponts en bâtons de pop sicle et le symposium Fresh Minds, lequel offrait aux étudiants du secondaire un rapide aperçu du domaine du génie civil.

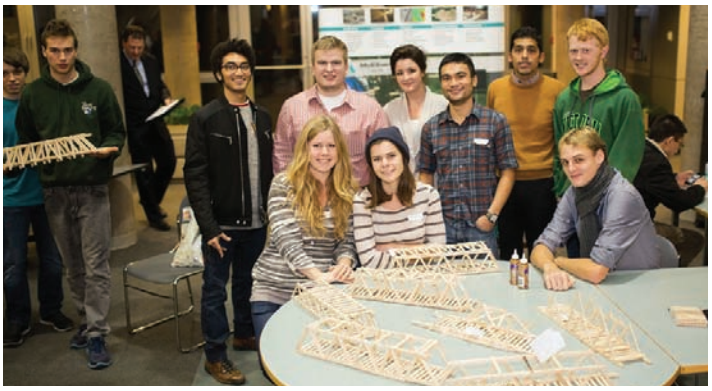

Photo: Armando Tura

Le concours de construction de ponts en batons de pop sicle, l'université de Victoria.

La gamme d'événements ainsi offerts et l'enthousiasme des jeunes professionnels et des étudiants au sein de la région ont permis de développer un agréable sentiment de camaraderie entre les divers secteurs. Les sections continuent de travailler avec la région pour mettre sur pied des initiatives impliquant de jeunes professionnels et des étudiants alors que ceux-ci sont en passe de devenir nos prochains ingénieurs. ■

Why am I a CSCE Member? Selfish and Philanthropic Reasons

Vic Perry, FCSCE, FEC, FEIC, MASc., P.Eng.
PRESIDENT, V.ICONSULT INC., CALGARY, AB

My work and my personal travels over the years have taken me to all parts of Canada and to many other countries around the world. When I meet other civil engineers I am often asked, "Why did you join CSCE and if I join, what's in it for me?" As someone who has contributed to CSCE for more than 35 years, in a wide range of roles, including that of president in 2009-10, I wish to provide my answer to these questions. But first, let me take you back a few years, actually quite a few years.

As a young lad always interested in how things worked and who enjoyed building a tree house, a go-cart or a mini-bike, I discovered at an early age that being an engineer would enable me to learn how all of these structures worked and, more importantly, would be a great way to make a living doing what I enjoyed. I was very fortunate to have great mentors who guided me in the right direction in those early years. I also had access to a local civil engineering school. At university I was able to learn all about civil engineering, because of the accumulated knowledge and experience created by generations of civil engineers who came before me. This engineering knowledge was communicated, studied and documented by the many civil engineers who were my seniors. Once I graduated, I was able to make a very comfortable living for my family because of my access to this accumulated knowledge. Thanks to my civil engineering education and all those civil engineers who preceded me, I entered into a career that I found intellectually stimulating and rewarding.

CSCE had a leadership role in the development of civil engineers in Canada well before I arrived on the scene. From its beginnings in 1887, CSCE has taken on the responsibility for collecting the accumulated knowledge of civil engineers and for passing this knowledge on – to young engineers just starting out on their careers, as well as to more experienced practitioners and academics. I personally wish to thank all of those great civil engineers and CSCE, who had the foresight to blaze and maintain a path to knowledge that made my career possible. Once I had started my own career, and in recognition of the debt I owed those civil engineers who preceded me, I realized I had an obligation to contribute to the body of knowledge they had bequeathed to me. It was payback time! So I committed to contribute to the vision and operation of CSCE, my professional society.

CSCE is a learned society, committed to the collection and dissemination of civil engineering knowledge. As a volunteer member of CSCE, however, I quickly realized that CSCE was more than a learned society. Volunteering with CSCE put me in a position to get back as much as I was able to contribute to the profession – and more! From the beginning of my participation in CSCE activities I was given a great networking opportunity and critically important training in "soft skills." As a committee volunteer, I learned how to present my opinions in a group setting and I learned teamwork. As a committee chair, I learned how to lead. All of these soft skills are essential to success in the world of business. Without communication and leadership skills my technically clever engineering solutions would never have seen the light of day. Being a volunteer on a CSCE committee allowed me to acquire these skills in an unthreatening environment, along with other volunteers, away from the eyes of my employer. I am convinced that these soft skills were as important to my career and my career satisfaction, as my technical skills.

The network of contacts I developed by volunteering on CSCE committees has enabled me to advance my career in a significant way. Over my 35+ years in civil engineering, I have been approached by many potential employers with job opportunities and every career change I made was the result of networking. I have changed employers several times and not once did I apply for the position. In every case I was approached by the potential employer because they knew

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me through networking. CSCE provided me with that network.

As a senior engineer, who has continued to volunteer with CSCE, I have been able to use my networking opportunities to observe young civil engineers as potential employees. Observing potential employees who have volunteered on CSCE committees gives me much more insight into their character and capabilities than a resume or third-party references.

I am not the only one who has benefited from a relationship with CSCE. I have witnessed many other civil engineers who have advanced their careers as a direct result of their volunteering on CSCE committees. My experience is not unique. Contributing to CSCE frequently leads to career growth and opportunities.

As a final comment, my commitment to CSCE has given me an opportunity to influence the future of civil engineering. CSCE volunteer leaders work hard to ensure that our profession continues to evolve, that it responds to the needs of society at large and that future generations of civil engineers are able to enjoy a financially, socially and intellectually rewarding career.

Bottom line? Compared to the benefits of membership, the cumulative cost of my annual CSCE dues is insignificant. To come back to questions we started with, "Why did you join CSCE and if I join, what's in it for me?" the answer is very simple: "It was my obligation and membership pays back many times over." ■

Vic Perry is a past-president of the Canadian Society for Civil Engineering (2009-2010). Mr. Perry joined CSCE as a student member in 1977 and has been a member since. He has held numerous roles in the Society, some of which include, Nova Scotia section chair, Atlantic regional vice-president, honorary treasurer, board member representing corporate members and several board appointments to special committees. He was bestowed a Fellow of the CSCE in 1998.

Pourquoi suis-je membre de la SCGC ? Pour des raisons égoïstes et philanthropiques

Vic Perry, FCSCE, FEC, FEIC, MASc., P.Eng.
PRÉSIDENT, V.ICONSULT INC., CALGARY, AB

Mon travail et mes déplacements personnels au cours des années m'ont amené aux quatre coins du Canada et dans plusieurs autres pays. Lorsque je rencontre d'autres ingénieurs civils, on me demande souvent : « Pourquoi êtes-vous membre de la SCGC ? Et si j'en deviens membre, quels sont les avantages pour moi ?» En tant qu'individu ayant apporté ma contribution à la SCGC depuis plus de 35 ans, et ce, dans dans diverses fonctions, incluant la présidence en 2009-2010, je souhaite répondre à ces questions. Mais avant tout, laissez-moi vous ramener quelques années en arrière. En fait, plusieurs années en arrière.

Quand j'étais jeune garçon, j'étais continuellement intéressé par la façon dont les choses fonctionnaient et par la construction d'une cabane dans un arbre, d'une boîte à savon ou d'une mini-moto. J'ai découvert très jeune que si je devenais un ingénieur je pourrais apprendre comment toutes ces structures fonctionnent, et plus important encore pour moi, ce serait une excellente façon de travailler dans un domaine que j'aime. Je fus très chanceux de pouvoir compter sur deux grands mentors qui m'ont guidé dans la bonne direction dès mes premières années. J'ai également eu accès à une école locale de génie civil. À l'université, j'ai appris tout ce qu'il y avait à savoir sur le génie civil grâce à la somme de connaissances et l'expérience créées par toutes les générations d'ingénieurs civils qui m'ont précédé. Ces connaissances en ingénierie ont été communiquées, étudiées et documentées par les nombreux ingénieurs civils qui m'ont enseigné. Dès que j'ai eu mon diplôme, je fus en mesure de procurer une vie confortable et agréable à ma famille en raison de mon accès à ces connaissances accumulées. Grâce à ma formation en génie civil et à tous ces ingénieurs civils qui étaient mes aînés, j'ai poursuivi une carrière que je trouvais intellectuellement stimulante et très gratifiante.

Bien avant mon arrivée dans le domaine, la SCGC jouait déjà un rôle de leader dans le développement professionnel des ingénieurs civils au Canada. Depuis ses débuts en 1887, la SCGC a pris la responsabilité de colliger les connaissances accumulées des ingénieurs civils et de transmettre cette connaissance aux jeunes ingénieurs débutant leur carrière ainsi qu'aux enseignants et ingénieurs plus expérimentés. Je désire personnellement remercier tous ces excellents ingénieurs civils, ainsi que la SCGC, qui ont eu la prévoyance de forger et de maintenir un accès aux connaissances qui ont rendu ma carrière possible. Une fois que j'ai débuté ma carrière professionnelle, et que je me suis rendu compte que j'avais une dette envers les ingénieurs civils qui m'avaient précédé, j'ai réalisé que j'avais l'obligation de contribuer au bagage de connaissances qu'ils m'avaient légué. Le temps était venu de rembourser ma dette! J'ai donc décidé de contribuer à la vision et aux activités de la SCGC, ma société professionnelle.

La SCGC est une société savante engagée dans la collecte et la diffusion de connaissances dans le domaine du génie civil. En tant que membre bénévole de la SCGC, j'ai cependant réalisé rapidement qu'elle était plus qu'une société savante. Le bénévolat au profit de la SCGC m'a permis de recevoir autant que ce que je pouvais donner à la profession,

et encore plus ! Dès le début de ma participation aux activités de la SCGC, j'ai vécu d'excellentes occasions de réseautage et j'ai reçu une formation importante et essentielle en matière de « compétences non techniques ». En tant que bénévole au sein d'un comité, j'ai appris à faire part de mes opinions dans un groupe et à travailler en équipe. En tant que président de comité, j'ai appris à diriger un groupe. Toutes ces compétences générales sont essentielles pour obtenir du succès dans le monde des affaires. Sans compétences en communication et en leadership, mes solutions d'ingénierie techniquement astucieuses n'auraient jamais vu le jour. Le fait d'avoir été bénévole sur un comité de la SCGC m'a permis d'acquérir ces compétences dans un environnement non menaçant, avec d'autres bénévoles, et loin des yeux et des oreilles de mon employeur. Je suis convaincu que ces compétences générales ont été aussi importantes que mes compétences techniques pour ma carrière et ma satisfaction professionnelle.

Le réseau de contacts que j'ai développé en étant bénévole sur les comités de la SCGC m'a permis de faire cheminer ma carrière de façon importante. Au cours de plus de 35 années en génie civil, j'ai été approché par plusieurs employeurs potentiels me proposant des occasions d'emploi et chaque changement de carrière que j'ai effectué était le résultat de ce réseautage. J'ai changé d'employeur plusieurs fois et jamais je n'ai eu à faire moi-même une demande d'emploi. Dans tous les cas, j'ai été approché par les employeurs potentiels parce qu'ils me connaissaient grâce à mon réseau de contacts. La SCGC m'a procuré ce réseau.

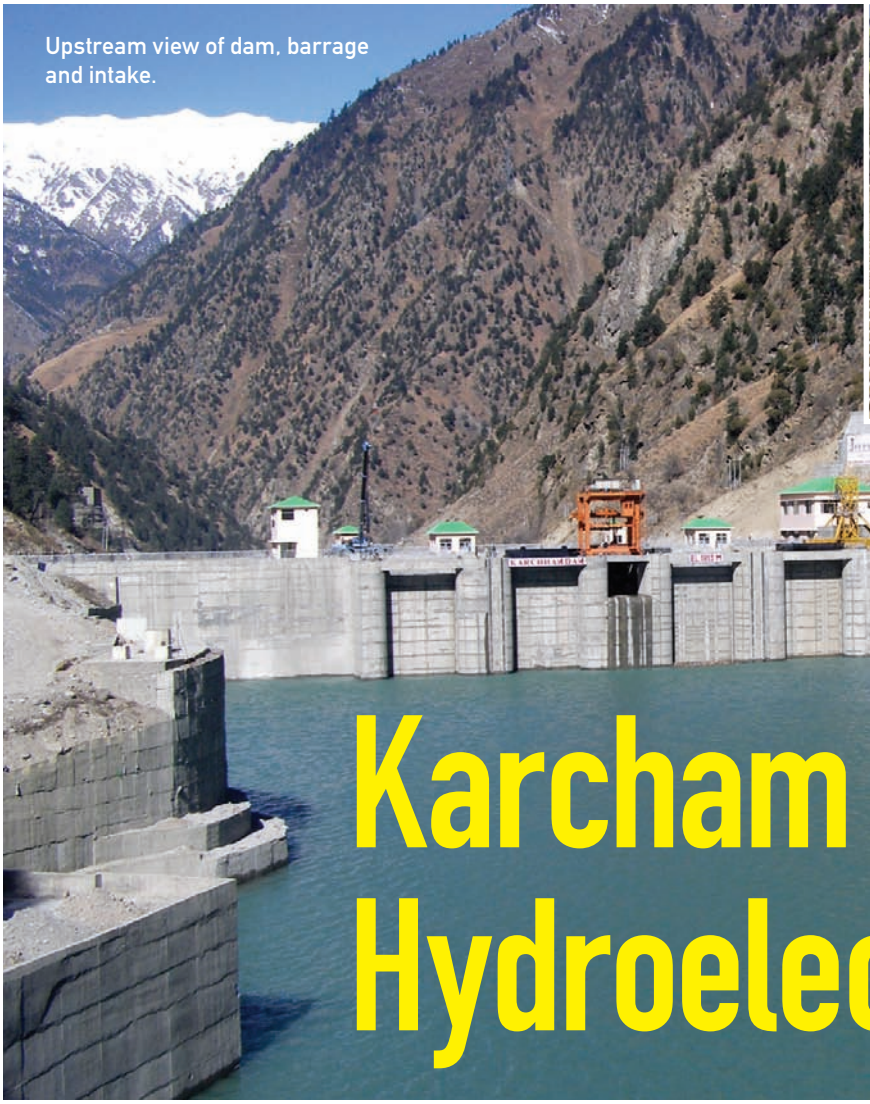
En tant qu'ingénieur principal qui continue à faire du bénévolat auprès de la SCGC, j'ai été en mesure d'utiliser mes opportunités de réseautage pour observer de jeunes ingénieurs civils pouvant éventuellement devenir mes employés. L'observation d'employés potentiels alors qu'ils sont bénévoles sur les comités de la SCGC me donne un bien meilleur aperçu de leur personnalité et de leurs capacités qu'un curriculum vitae ou une référence par une tierce partie.

Je ne suis pas le seul à avoir pu profiter de mes liens avec la SCGC. J'ai été témoin de plusieurs autres ingénieurs civils qui ont fait avancer leur carrière respective grâce à leur bénévolat au sein des comités de la SCGC. Mon expérience n'est certainement pas unique. Contribuer à la SCGC mène fréquemment à des opportunités d'emploi et à une croissance professionnelle.

En terminant, mon engagement envers la SCGC m'a donné l'occasion d'influencer l'avenir du génie civil. Les bénévoles de la SCGC travaillent fort afin de s'assurer que notre profession continue d'évoluer, qu'elle répond aux besoins de la société en général et que les générations futures d'ingénieurs civils sont en mesure de profiter d'une carrière gratifiante sur les plans monétaire, social et intellectuel.

Résultat net ? En les comparant aux avantages d'être membre, les coûts cumulés de ma cotisation annuelle à la SCGC sont minimes. Pour en revenir aux questions du début de cet article, « Pourquoi êtes-vous membre de la SCGC ? Et si j'en deviens membre, quels sont les avantages pour moi ?», la réponse est très simple : « C'était mon obligation et le paiement de mon adhésion m'a été remboursé au centuple. » ■

Vic Perry a déjà été président de la Société canadienne de génie civil (2009-2010). Il s'est joint à la SCGC en tant que membre étudiant en 1977 et a toujours été membre depuis. Il a occupé de nombreux postes au sein de la Société, dont celui de président de la section de la Nouvelle-Écosse, v-p, Région de l'Atlantique, trésorier honoraire, membre du conseil d'administration en tant que représentant des membres d'entreprise et fut nommé par le conseil d'administration à plusieurs comités spéciaux. Vic Perry est devenu Fellow de la SCGC en 1998.


Upstream view of dam, barrage and intake.


Downstream view during construction.

Photos: Hatch

Karcham Wangtoo Hydroelectric Dam

Canadian engineers reviewed the design and other aspects of a 1,000-MW hydroelectric project in the Himalayan Mountains of Northern India.

By David Rupay, P.Eng., HATCH

Hatch (formerly Acres International) was retained by ICICI Bank, India's second largest bank, to act as the lender's technical and project advisor for the 1,000 MW Karcham Wangtoo hydroelectric project on the Sutlej River in Himachal Pradesh State in Northern India. The project was developed by Jaiprakash Associates, one of the premier hydroelectric contractors in India, under a build-own-operate concept.

Hatch's initial scope of services included the design review of the proposed new facilities, an assessment of supply and construction contracts, and the review of construction costs and schedules. Also included were reviews of the power purchase agreement, the construction methodology and facilities, and financial pro forma. This work was undertaken to provide assurances to the lenders that the project would meet the performance guarantees and generate the revenue necessary for the repayment of the loans.

Construction began in 2006 and was completed five years later. During the construction period, Hatch staff visited the site every three months. A final visit was made by Hatch staff after the facility had been operating for 12 months. Hatch last inspected the site in October 2012.

Excavation and tunneling in difficult terrain

The project is located in the rugged terrain of the Himalayan Moun-


Intake under construction.

PROJECT FEATURES

DIVERSION BARRAGE:
- 83 m x 194 m long with five radial gates, with separate intake to power tunnel/sedimentation chambers.

DESANDING CHAMBERS:
- Four continuously flushing desanding chambers 410 m long x 16 m wide.
- Designed to exclude sediments greater than 0.15 mm.
- Maximum intake 521 m^3/s, maximum flushing discharge 104 m^3/s.

POWER TUNNEL:
- 17.3 km long, 10.48 m dia circular, concrete-lined power tunnel, accessed by six adits.
- Design flow 417 m^3/s.

SURGE SHAFT:
- 142 m high x 16 m dia, restricted orifice type, open to the surface.

PRESSURE SHAFT:
- Four underground, steel lined, 4.75 m dia.

POWERHOUSE:
- Underground complex.
- Machine hall 187 m long x 21.6 m wide x 51 m high, with 4 x 250 MW Francis turbo-generators, gross head 276 m, generating 4463 GWh in an average year.
- Transformer gallery 116.5 m long x 15 m wide x 23 m high with single-phase power transformers and SF6 switchgear.

TAILRACE:
- 1,278 m long x 10.48 m dia circular tunnel.

TRANSMISSION:
- Surface take-off yard to six separate 400 kV transmission lines.

tains. The region is characterized by steep-sided, precipitous gorges and mountains that rise to more than 5,000 m above sea level. Local relief in the project area ranges from 300 m to more than 1,000 m. Access to the site is along NH 22 from Shimla, which was featured in the TV series "World's Most Dangerous Roads."

An excavation of approximately 40-50 m depth was needed in the riverbed to ensure that the dam is founded on bedrock. Ground water control was essential in the highly permeable riverbed alluvium to ensure a successful dry excavation and maintain reasonable slopes. A series of jet-grouted holes (1.2 m dia. @ 1 m c/c) was completed in the upstream and downstream cofferdams to ensure a dry excavation.

Tunnel construction was the largest and riskiest component of the Karcham Wangtoo project and required the correct assessment of and planning for the geotechnical risks. The 17.3-km headrace tunnel had an excavated diameter of approximately 11.5 m. The use of six access adits and relatively short reaches of tunnels between the adits provided good flexibility in coping with unexpected delays at any one of the headings. This measure assisted in enabling the project to be completed three months ahead of schedule.

Earthquake risks and high sediment loads

The project is located in a highly seismic area. According to the National Earthquake Information Center (NEIC), there had been 92 earthquakes within 100 kilometres of the project site in the previous 30 years prior to the start of construction. Most of the earthquakes were M4.0 to M5.6 events. A detailed seismicity study was carried out by University of Roorkee in India that was used to develop the design criteria for the project.

High sediment load exists in the Satluj River, which can cause significant erosion of the turbine runner and moving parts if these sediments are not removed prior to entering the power tunnel. Four intake tunnels lead from the intake structure to four separate and independent sedimentation chambers. The chambers are designed to reduce the velocity of the flow, such that 95% of the particles greater than 0.2 mm settle to the bottom below where the flow enters the power tunnel. At the bottom of each chamber is a series of 64 hoppers, below which is a flushing tunnel to discharge the sediments back into the river downstream of the dam. Erosion protection coating was applied to the turbine runners and four spare runners were supplied. The powerhouse layout facilitates the removal of the runners without the need to dismantle the entire turbine.

Karcham Wangtoo is one of the largest hydroelectric projects to be registered under the Clean Development Mechanism of the United Nations Framework Convention on Climate Change. ■

CLIENT: ICICI Bank
TECHNICAL & PROJECT ADVISOR: Hatch (David Rupay, P.Eng., Brian Sinclair, P.Eng., Ron Pietrobon, P.Eng., Ron Jackson, P.Eng.)
OTHER KEY PLAYERS: Andritz Hydro, Voith Hydro
DEVELOPER-BUILD-OWN-OPERATOR: Jaiprakash Associates

Worli-Lovegrove wastewater treatment facility on the west side of Mumbai. The plant is basic, with an influent pump station, raw sewage screening, air de-gritting, effluent pump station, and drop shaft with an underground connection to the Arabian Sea.

Photo: RVA

CONSORTIUM APPROACH IN MUMBAI

A Canadian company shares lessons it has learned as a key partner in a consortium to complete one of the largest wastewater design and construction projects in India.

By Alan Perks, P.Eng. and Sanjay Devnani, P.E.
R.V. ANDERSON ASSOCIATES

India is currently at the cusp of an infrastructure boom. With a new government in place, the country is in the process of enacting policies that support infrastructure spending and expedite the implementation of critical urban infrastructure projects across all sectors.

Considering the size and scale of cities in India, almost all projects end up being large infrastructure projects. However, the projects in India's six mega-cities tend to overshadow the scale of urban projects elsewhere in the world.

R.V. Anderson Associates has been involved as a key member of a consortium that was retained by the Municipal Corporation of Brihan Mumbai (MCBM) to complete one of the largest wastewater design and construction projects in India. Our company has been engaged in the practice of civil, municipal and environmental consulting engineering internationally since 1990, with a focus on projects in India.

The current scope of the Brihan Mumbai project is over $1 billion (CAD) worth of capital upgrades. RVA, along with the consortium, is responsible for the project management, construction management and design for the work, which includes the installation of primary and secondary treatment at seven wastewater treatment facilities; 10 new sewage pumping stations; new tunnel sewers; and 10 kilometres of transfer tunnels to a new 4.5-km ocean outfall.

RVA and the consortium are currently involved in completing the final phases of design and are responsible for delivering the program for these priority works.

Strength and adaptability

Because of the size and scope of such projects, a consortium approach is usually the most suitable way to manage and execute the work as it ensures the availability of resources and range of expertise required. This trend of partnering is now prevalent and even some of the largest consulting firms prefer to adopt a consortium approach.

On large and complex projects such as Mumbai's, the strength and adaptability of a multi-firm consortium can be more effective in addressing changes, and the result can be lower overall design and contract administration costs, as well as new and innovative technical solutions.

Creating a consortium is usually the easier part; operating them successfully under difficult and challenging project conditions over long durations is altogether a different matter. The challenges are often in dealing with work sharing, changes in personnel, unforeseen client issues, and determining applicable standards for the team.

Creating a consortium that is fair and equitable to all parties and encourages cooperation becomes the key to success.

Project management

One successful approach to manage a consortium requires the creation of a project management team with representation from all firms. The project manager reports to the management team. The management team meets regularly to assist and provide an agreeable solution to the project manager on difficult issues.

This approach ensures open communication and buy-in by all members, thus minimizing the possibility of costly disputes. Most importantly, the consortium team can develop and apply mutually agreed upon project management, quality management, scheduling, risk management, and client communications and stakeholder engagement protocols. This approach is perhaps one of the most valuable benefits of a true work-share consortium.

Project teams must then follow local codes and standards as much as possible and adapt international "best practices" where local codes may not address the issues. Experienced consortium team members are in a position to fill in any gaps and conduct discussions with the client about the agreed-upon codes.

Each firm is significantly involved at the conceptual stage to ensure the concept is acceptable to all. Design changes can be readily addressed to deal with any potential cost overruns. As well, detailed designs prepared by one partner team can be reviewed by the other as a quality assurance mechanism — a very important mechanism in large scale infrastructure projects subjected to intense client and public scrutiny at every stage.

Sharing the workload with local firms

A multi-firm consortium can share the workload in terms of professional person-months of effort over the entire project. For example, each of the partners would be responsible for a certain percentage of the estimated inputs and the corresponding professional fees.

Most importantly, this approach includes the local firms who may be participating in the project, especially as an increasing share of internationally financed project work in countries like India is now performed by local firms. As reported elsewhere, the ratio of international "expats" to local professionals has reduced from 1:4 twenty years ago, to about 1:15 now.

Above: operator's garden at Worli-Lovegrove being watered using the plant's effluent water.

This level of effort-sharing needs to be established on an equitable basis, taking into consideration the strengths of each of the firms and the level of detail defined in the scope. If the level of effort for a certain task is underestimated, it is necessary to resolve such issues at the start of the bidding process. This approach generates trust and an open dialogue policy, and it helps ensure the effort remains balanced.

Higher cost structure

In a bidding process, a consortium generally experiences a higher cost structure than a single firm, considering the costs of managing a consortium and mitigating the different nature of risks of the member firms. However a consortium can be motivated to explore new ways to reduce costs and be more competitive. ■

Alan Perks, P.Eng. is a senior engineering consultant with R.V. Anderson Associates' Ottawa office. Sanjay Devnani P.E. is a senior engineer and business manager with RVA's Mumbai office.

Illustration: Thinkstock

ARE WE STARTING TO GET IT?

By Nick Larson, MEPP, P.Eng.,
CHAIR, INFRASTRUCTURE RENEWAL COMMITTEE, CSCE

In one of my first CSCE meetings, almost four years ago now, someone raised their hand and asked "What do we mean when we say sustainable infrastructure?" Since that time we have used this column, among other CSCE initiatives, as a way to engage our civil engineering community in an open-ended discussion to see if we can provide an answer to that question. After only a few short years I think we are starting to get it; now let me try to convince you.

Over that past few years we have heard from a wide range of infrastructure stakeholders about how the principles of sustainability apply to our industry. There have been several common themes that have surfaced over the past few years, which I have summarized in the following paragraphs, to demonstrate what we mean when we say sustainable infrastructure.

Intergenerational equity

The inaugural column in the Summer 2012 issue, by our executive director Doug Salloum, kicked off the conversation with his ideas around building our infrastructure systems to endure the test of time. This idea – that the collective infrastructure industry needs to shift to thinking about infrastructure over multiple generations – was, without exception, reiterated in every single column.

The term intergenerational equity was repeated in a number of columns. This is a phrase that I think captures one of the basic concepts of sustainability from the famous Brundtland Report: meeting current needs without compromising the ability to meet the needs of the future. The infrastructure systems that support our current society were built by previous generations, and similarly the infrastructure that we are currently building will support our society in 2050 and beyond. Sustainable infrastructure needs to consider the ability to meet the needs of all of the people that it will support over its life, not just the immediate generation. The importance of intergenerational equity should be a motivator for all of us to always try and do better with our daily efforts in the infrastructure business.

Measuring sustainable performance

The column by Bill Bertera, executive director of the Institute for Sustainable Infrastructure, showed us how evaluating projects through the "windows" that matter to society – namely the various social, environmental and economic considerations that are used in the Envision infrastructure rating tool that his organization promotes – leads to improved sustainable performance of our infrastructure systems. The need to have tools that can be used to quantify sustainable performance was reiterated in the column that I wrote with Sarah Young to present the CSCE's Sustainable Infrastructure Best Practices.

There is an often-repeated management phrase that goes something like "what gets measured gets done." The concept of being able to measure sustainable performance using explicit metrics that can be used to compare projects or alternatives has emerged as an essential element to achieving more sustainable infrastructure systems. Put simply, if we start to measure sustainable performance then we will get more sustainable infrastructure systems.

"I am not arguing that past experience is not relevant, but in my opinion, this fight against the status quo is the biggest challenge that our practitioners will experience as we try to operationalize the ideas of sustainable infrastructure."

Asset management

Another theme in the columns has been the need to develop structured asset (or infrastructure) management strategies to guide how information is collected and how decisions are made by the bureaucracies that manage our nation's infrastructure. Improving how we manage our infrastructure will enable the various stakeholders to influence what should impact the decision making process – namely, using explicit metrics that measure the sustainable performance of a piece of infrastructure as I mentioned in the previous two paragraphs.

These strategies will give our governments the ability to make transparent and defendable infrastructure investment decisions that will improve social and environmental considerations so that we don't just continue to end up with the lowest cost option.

Operationalizing sustainable infrastructure

Engineering is a practice – we should never forget this. The biggest challenge that faces our civil infrastructure systems is to operationalize the ideas of sustainable infrastructure into the practice of civil engineering. In the fall of 2014, Edwin Tam, a fellow CSCE committee chair, provided his thoughts about how we can operationalize sustainability in the practice of civil engineering. One of the big takeaways from this column is that there is a lot we can all do – right now – that will improve outcomes immediately. But the tricky part is that many of these strategies revolve around not doing things the same way we did it last time. This goes against the grain of our professional practice that is based on codes, standards and regulations that dictate exactly how things should be done based on past experience. Now, I am not arguing that past experience is not relevant, but in my opinion, this fight against the status quo is the biggest challenge that our practitioners will experience as we try to operationalize the ideas of sustainable infrastructure.

A new generation of civil engineers

Over the past decade a new generation of civil engineer has begun to emerge into influential roles in our industry. This generation became interested in civil engineering because of their concerns about the social, environmental and economic state of our society – and they understand the role that civil engineering plays in shaping this landscape. This is a generation that is not satisfied with the status quo of our industry. As these individuals advance their careers into leadership roles at organizations across Canada, they will have the ability to influence how our infrastructure systems are renewed for the future. This leads to the point emphasized by Dr. Catherine Mulligan in her 2013 column, that our civil engineering academic institutions need to implement multi- and inter-disciplinary education strategies to train the next generation of infrastructure stakeholders in how the principles of sustainability can apply to their careers.

Leadership

The 2012 Canadian Infrastructure Report Card, an initiative in which the CSCE played an active and influential role, estimated that there is $171 billion worth of civil infrastructure in Canadian municipalities that is in fair, poor or very poor condition. This figure is the most accurate perspective on the so-called infrastructure deficit in Canada – this is the value of our infrastructure systems that are at risk of not being able to provide their intended service to society. Governments at all levels in Canada recognize this problem and are taking steps to increase the financial investment in our infrastructure.

Infrastructure systems are the backbone of our society. They have a direct impact on our quality of life and our economic, social and environmental prosperity. Civil engineers have the ability to turn this problem into an opportunity – to bring innovation into the next generation of infrastructure systems that will support our future society. But this change will require strong leadership throughout our industry.

The CSCE and its members have the ability to provide this leadership role to our industry. And I think that is what makes us all maintain a relationship with the CSCE. We know that it is well-positioned to provide this leadership in Canada to achieve a sustainable future, because there cannot be a sustainable future without sustainable infrastructure systems. ■

Nick Larson works at GM BluePlan Engineering Ltd., Toronto.

If you want to share your ideas around Sustainable Infrastructure in this column please contact Nick Larson at nick.larson@gmblueplan.ca to discuss the opportunity.

In Awe of India's Technological Advances

Dr. Rishi Gupta,
DEPUTY CHAIR, INTERNATIONAL AFFAIRS COMMITTEE, CSCE

As I conclude two back-to-back trips to India in about a month, I remain awed by the great technological advancements taking place in that country. On my recent trip to India I was part of a Canadian delegation representing IC-IMPACTS, which is a centre established a few years ago to foster research collaboration between Canada and India.

The trip began with a visit to "Vibrant Gujarat Summit," a trade show and global summit hosted in the city of Ahmedabad. Canada was one of the partner countries for this summit and was represented by the Canadian Trade Office, among others. I was taken by surprise by the scale of this event; it had many acres of space showcasing the latest technologies in many sectors, including construction, consultancy, software, engineering, agriculture and sustainable energy.

Subsequent to visiting this well-attended summit, I visited Nirma University in Ahmedabad. CSCE and Nirma University have previously partnered to host joint conferences in India. During my short visit, discussions focused on promoting future student and faculty exchanges. What caught my attention was the current initiative undertaken at Nirma University to review the existing civil engineering curriculum and focus on outcome-based learning by considering graduate attributes. Similar initiatives are underway at all accredited universities in Canada offering engineering programs as this is now mandated by the Canadian Engineering Accreditation Board.

The final leg of my visit to India took me to a newly formed Indian Institute of Technology at Hyderabad, where I had the opportunity to present. The topic of the workshop was recent advances in structural engineering and materials. There were several lessons learned during this workshop and I was impressed by the ongoing initiatives in India to try and promote the implementation of sustainable materials while being on a path of rapid economic growth.

This brings me to this special issue of CIVIL. I believe readers who are interested in getting involved with infrastructure, water, and public health projects in India will find these articles very informative. ■

En admiration devant les avancées technologiques de l'Inde

Dr Rishi Gupta,
VICE-PRÉSIDENT, COMITIÉ DES AFFAIRES INTERNATIONALES, SCGC

Alors que je termine deux séjours consécutifs en Inde en moins d'un mois, je demeure ébahi par les extraordinaires avancées technologiques en cours dans ce pays. Lors de mon dernier voyage en Inde, je faisais partie d'une délégation canadienne représentant IC-IMPACTS, un centre mis sur pied il y a quelques années afin de favoriser la collaboration dans le domaine de la recherche entre le Canada et l'Inde.

Mon programme comprenait la visite du « Vibrant Gujarat Summit », une exposition commerciale et un sommet international organisé par la ville d'Ahmedabad. Le Canada fut l'un des premiers pays partenaires de ce sommet et était représenté entre autres par le Bureau commercial du Canada. Je fus surpris par l'ampleur de cet événement. Il remplissait plusieurs hectares d'espace présentant les toutes dernières technologies dans des domaines tels que la construction, les services-conseils, les logiciels, l'ingénierie, l'agriculture et l'énergie durable.

Après avoir assisté à ce sommet qui a attiré de nombreux participants, j'ai visité l'Université Nirma, toujours à Ahmedabad, dans l'État de Gujarat. La SCGC et l'Université Nirma ont déjà été partenaires lors de conférences conjointes en Inde. Au cours de ma brève visite, les discussions ont porté surtout sur la promotion des prochains échanges d'étudiants et entre facultés. Ce qui a attiré mon attention fut l'initiative entamée par l'Université Nirma visant à réviser le programme actuel de génie civil afin de mettre l'accent sur l'apprentissage axé sur les résultats en considérant les qualités requises chez les diplômés. Des initiatives similaires sont en préparation au sein de toutes les universités canadiennes agréées offrant des programmes de génie, comme exigé maintenant par le Bureau canadien d'agrément des programmes de génie.

L'étape finale de ma visite en Inde m'a mené à Hyderabad, au tout nouveau Indian Institute of Technology, où j'ai j'ai pu de faire une présentation. Le sujet de l'atelier était les avancées récentes en génie structural et des matériaux. Plusieurs leçons ont été apprises lors de cet atelier et j'ai été impressionné par les initiatives en cours en Inde visant à faire la promotion de l'utilisation de matériaux durables tout en tentant de conserver l'élan d'une rapide croissance économique.

Tout ceci m'amène à cette édition spéciale de CIVIL. Je crois que les lecteurs souhaitant s'impliquer dans des projets d'infrastructures, d'eau et de santé publique en Inde trouveront ces articles très instructifs. ■

Photo: IC-IMPACTS

Nagpur, a city of 2.1 million habitants and a partner city of IC-IMPACTS, is the second capital of the Indian state of Maharashtra. It is the headquarters for the Hindu nationalist organization RSS and was identified as the Best City in India for liveability, greenery, public transport, and health care indices.

IC-IMPACTS – Successfully Collaborating with India

Nemy Banthia, SCIENTIFIC DIRECTOR, CANADA-INDIA RESEARCH CENTRE OF EXCELLENCE (IC-IMPACTS), AND PROFESSOR AND CANADA RESEARCH CHAIR, DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF BRITISH COLUMBIA

The Canada-India Research Centre of Excellence – IC-IMPACTS – is the first and only international Network of Centres of Excellence funded by the Tri-Council NCE Program. IC-IMPACTS is dedicated to the development of research collaborations and knowledge mobilization between Canada and India.

IC-IMPACTS focuses on three areas: infrastructure, water and public health. In the area of infrastructure, IC-IMPACTS is working towards a low carbon-footprint building material, condition assessment and structural health monitoring, and strengthening of structures against both a loss of capacity due to deterioration and earthquakes. In the area of water, IC-IMPACTS is developing novel water sensors and innovative treatment technologies. Finally, in the area of public health, the focus is on mobile health technologies with particular emphasis on infectious diseases affecting maternal and child health. In all these areas, the centre works very closely with India to create strategic partnerships, joint research programs, and capacity building initiatives.

Ambitious goals

In just two years since its creation in November 2012, IC-IMPACTS has grown from being a new centre with ambitious goals to a reputable research organization bringing together academic and industrial sectors. The centre has funded 13 international collaborative projects between Canada and India, has 85 institutional, industry and government partners, and has 158 researchers and 94 HQP enrolled in the program.

IC-IMPACTS has proven to be very successful at creating meaningful partnerships and at overcoming the challenges of doing business with a country more than 11,000 km away. These successes have come with invaluable lessons learned in building relationships, raising funds, respecting cultures and moving initiatives forward.

Relationships require resources

Large initiatives at an international scale require reliable sources of funding. Because IC-IMPACTS was established through the Canadian Networks of Centres of Excellence (NCE), the centre began by funding only the Canadian side of research collaborations. For its initiatives to be effective, IC-IMPACTS learned that funding from the Indian government at the national level was a necessity to secure meaningful engagement of the Indian scientific community.

By partnering with the Government of India, IC-IMPACTS has launched two successful initiatives where funds are available to Indian scholars collaborating with IC-IMPACTS researchers. For example, the Indian government's Department of Biotechnology (DBT) is providing funds with IC-IMPACTS for a $3-million joint call in the areas of water and health. Similarly, another $3 million call will provide funds from the Department of Science and Technology (DST), Government of India, to support joint research projects in the areas of infrastructure and water.

Implementing research outcomes in community context

The centre does not stop at research and has the stated objective of applying research findings to Canadian and Indian communities in the form of demonstration projects. In this pursuit, creativity, flexibility, and patience are must-haves. Collaborating organizations must be willing to start from the beginning to co-create an initiative that will work for partners and meet the unique needs of each community.

Photo: IC-IMPACTS

India needs 2 million kilometres of rural roads in places such as Tondebavi Village in the State of Karnataka (pop. 1,700).

In creating the demonstration projects, a great amount of effort is put into conceptualizing the initiatives, managing various stakeholders and remaining connected at all times. These efforts are proving worthwhile as IC-IMPACTS now has several such projects. One project of significance is a rural road development project near Bangalore where a 1-km stretch of advanced rural pavement will be laid with five new super-thin pavement technologies. In India, where two million kilometres of rural roads will be built in the next 20 years, one of the five "winning" technologies has the ability to completely revolutionize the rural pavements market in India and other emerging economies. This pavement project brought Indian and Canadian infrastructure companies to work together, which will significantly further enhance the trade between our countries.

While working with the rural road development project, the issues of code incompatibilities, varying design guidelines, differences in materials specifications and differing materials availability between Canada and India became apparent. Training of workers, the construction culture, and government involvement in procuring site clearances and other regulatory approvals, also surfaced as issues needing attention. Each project like this one requires a large network of scientists, industry leaders and governments to effect change.

One critical element of any successful community deployment is that of amicably engaging with the community. Trust needs to be built while keeping the processes transparent and the approach both respectful and humble. There are 22 major languages and more than 720 different dialects spread throughout India. Having local contacts that can communicate with different stakeholders and push initiatives forward is invaluable.

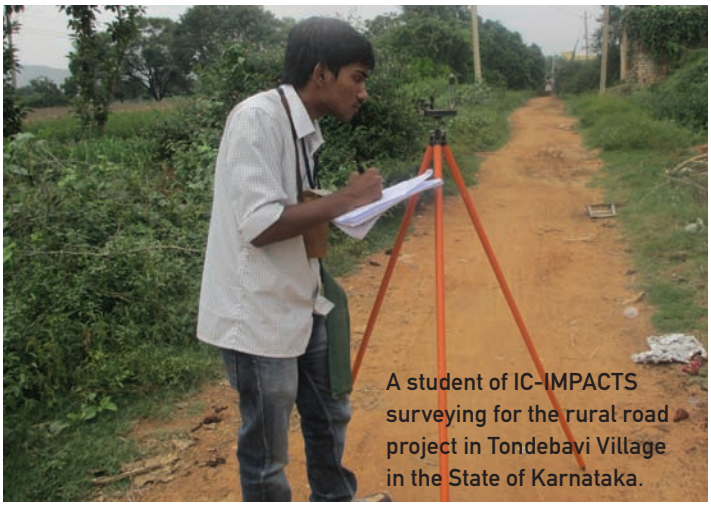
By being patient and persistent in building relationships, IC-IMPACTS has built a reputation and is now being tasked to help clean the Ganga River with the National Mission for Clean Ganga (NMCG).

Complementarity

No partnership can thrive if it is not based on principles of mutual respect and complementarity. Successful partnerships are symmetrical, where each draws from the strengths of the other. While Canada has expertise and strengths in numerous areas, so does India. For example, India has expertise in heritage structural restoration – an area in which Canada has limited expertise and experience. India has been innovatively maintaining heritage structures for more than two millennia and such expertise is of immense value to Canada while maintaining our heritage structures such as the Parliament building in Ottawa. IC-IMPACTS has designed all its projects with an equitable flow of information and expertise from either side, making it a true collaboration.

Persistence

Members of IC-IMPACTS travel to India four or five times a year to create initiatives with partners. These in-person meetings and workshops have led to meaningful collaborations with the Department of Science and Technology (Government of India), the Department of Biotechnology (Government of India), National Mission for Clean Ganga (NMCG), Reliance Industries, GMR Highways, ACC Cement, Indian Institutes of Technology, and many others.



A student of IC-IMPACTS surveying for the rural road project in Tondebavi Village in the State of Karnataka.

Photo: IC-IMPACTS

Moving initiatives forward

With partnerships created and funding in place, it's imperative to ensure initiatives continue to move forward. IC-IMPACTS has been able to progress successfully by having contacts in India full-time that help meet its objectives.

IC-IMPACTS' success in collaborating with India is a testament to the centre's understanding of cultural differences and its motivation to create positive change. With new initiatives and partnerships in the pipeline, the centre is blazing a path for companies wanting to make a difference on a global scale. ■

Photo: Thinkstock

Water and Wastewater Improvements in India – the Last 20 Years

For more than 20 years, R.V. Anderson Associates Limited (RVA) has been involved in developing and implementing new water and wastewater strategies to meet India's rapidly growing needs for infrastructure and services in both large and small municipalities. This iwork ncludes advances in technology, operations and maintenance, training and development, and construction. This paper provides a unique perspective on the lessons learned from more than 20 years of direct involvement with water projects in Mumbai and other Indian municipalities. New technologies and procurement strategies are being tried, projects have been implemented to maximize potential benefits for slum sanitation, and significant capacity-building efforts have been incorporated to utilize local Indian engineering skills and expertise. The authors have been continuously involved in the firm's work in India and based on this experience this paper endeavours to highlight some of the key observations and lessons learned, along with some of the changes that have taken place in civil engineering in India over the last 20 years.

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Background and introduction

In the early 1990s, India was in the process of transforming itself into a modern business economy. Nevertheless, telecommunication service was sporadic and unreliable, computer technology was just entering mainstream business, and on the streets traffic was heavy and chaotic (as it still is).

Even with the relatively short distances involved (12 to 15 km), two meetings a day in different locations was about all that could be achieved. Municipal bureaucracies – being extremely large, cumbersome and union controlled – remained one of the last segments of the Indian economy to be modernized; it was difficult to manage the implementation of municipal engineering projects under these conditions.

Core areas of Mumbai (Bombay) were served by conventional water distribution and sewerage networks. However, the bulk of the rapidly growing suburbs, like many other cities in India, were only partially served with piped systems. The slums were poorly served with tap-stands to meet their water needs, communal privies, and storm drain channels or nallahs serving as open sewers running through the neighbourhoods.

Local engineering capacity was available. Many senior municipal engineers had graduated from well respected Indian universities and many had received foreign training as well. The problems being experienced were a result of the need to keep up with the exceptional growth in demands for both sewer and water in these growth areas and the need to service the existing and also rapidly expanding slums.

R.V. Anderson Associates (RVA) became involved in Mumbai in 1994 in a World Bank-funded Operations and Maintenance Study of the sewerage pumping system, in association with a local firm PHE Consultants of Mumbai, based upon complementary skill sets and similar experience in the water sector. From this base, over the last 20 years, the firm has covered several projects in the States of Maharashtra, Gujarat, Delhi, Punjab and Karnataka, which have included not only the traditional water sector planning, design and project management work, but

also operations and maintenance audits and optimizations, solid waste assessments, asset management strategies and contract operation of water and wastewater plants.

The state of infrastructure

Engineering assignments in India, especially in the mega cities such as Mumbai, are, by virtue of the large population, of a scale that is magnitudes larger than anything experienced by engineers in Canada – for example, sewage pumping stations handling 10,000 litres per second and larger are common. The smaller water pressure zones and service areas contain as many as 2 million inhabitants, the size of an entire large city in Canada. Figure 1 shows the population density of regions in India based on information from the 2001 census.

Populations and flows

Design population and flow estimates represented a critical stumbling block to effective planning. In 2001 Mumbai had an official population of some 12 million, with projected estimates of an urban population at around 16.5 million persons during the life of the Master Plan. This represented about half the entire population of Canada at the time. About one-half of that population was concentrated in the slums and unserviced areas, both in the downtown core as well as in the rapidly expanding suburbs.

There were few reliable flow records available to undertake planning for the facilities and future flows, nor for planning the need for expansion and upgrading of infrastructure to meet huge future growth targets. The lack of basic data for planning required provision for extensive data collection efforts, including identifying any complementary data sources before any meaningful planning or design exercises could be carried out.

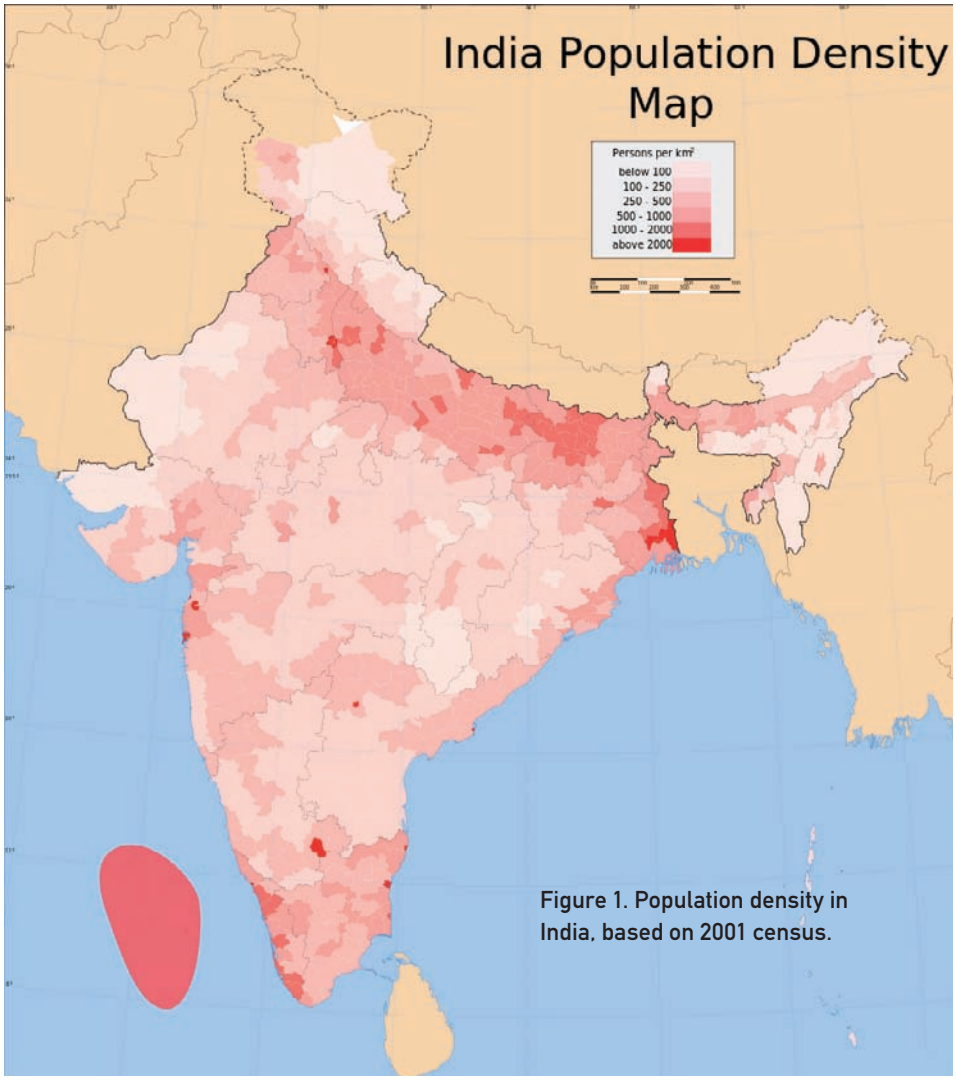

Photo: Wikimedia Commons, author Planemad

Figure 1. Population density in India, based on 2001 census.

Assets and condition

Mumbai, like most cities in India (and Canada as a matter of fact), had not generated revenues adequate to operate and maintain, let alone expand, its basic sewerage and water operations. The underground infrastructure suffered from a chronic lack of attention to the maintenance of core water mains, sewers and pumping stations, which were in extremely poor condition.

Water and sewer revenues were generated through a flat rate surcharge on the issuance of Mumbai's tax bills. Water users soon realized that there was little that the municipal agencies would do if these bills were not paid. After a number of years, the utilities have no options but to write off these significant outstanding water charges. While there should, in theory, be sufficient funds to meet current and future needs, as a result of the low rate of collection, the municipal agencies continue to depend on international financial institutions (IFI) and other internal and external borrowings to maintain their systems.

Leakage and infiltration

Systems that were poorly constructed and lacked of basic maintenance were subject to increasing demands for service. Furthermore, the amount of leakage, infiltration and flows from illegal connections was also huge.

Illegal water and power service connections were observed in many locations, known locally as "spaghetti junctions." There were substantial water losses experienced by many municipal corporations and, without serious attention and expenditure,

Table 1. Proposed treatment plants, 2002 Mumbai Sewerage Master Plan

Service Zone	Treatment Works	Average Dry Weather Flow (mld)	Pass Forward Flow (mld)	Effluent Quality BOD/ SS (mg/l)	Process
1	Colaba WwTW	31	85	20/30	ASP
2	Lovegrove WwTW	399	981	100/100	ASP
3	Bandra WwTW	241	591	100/100	CEPT
3	Dharavi WwTW	337	752	100/100	ASP
4	Versova WwTW	278	750	100/100	2SL
5	Malad WwTW	644	1726	100/100	2SL
5	Gorai WwTW	39	132	20/30	3SL
6	Bhandup WwTW	253	691	20/30	3SL
7	Ghatkopar WwTW	400	1048	20/30	3SL
	Total	**2622**	**6756**		

these losses would be very hard to eliminate. The poorly maintained systems coupled with an intermittent water supply result in a high level of contamination.

Sewage treatment

The level of sewage treatment provided in the urban areas was generally not meeting the discharge requirements and was of poor quality when compared to international standards. In cities such as Mumbai, the level of treatment was limited to primary screening and grit removal with disposal of the screened effluent through outfalls into the ocean. There was one small exception, where secondary treatment through a three-stage lagoon plant was being provided to less than 1% of the total flows.

Originally, the marine outfalls from the Mumbai system were established at a distance of 500 metres offshore. With this geometry, the beaches, which are heavily used by the population, were fouled with sewage during every incoming tide. Some outfalls have now been extended to 3 km offshore, with a resultant visible improvement of beaches and shorelines along the Arabian Sea.

Many inland lakes and rivers have been seriously degraded by the effluent from the population of upstream cities. Examples include the Yamuna River at Agra downstream from New Delhi, and Thane Creek and Ulhas River bordering Mumbai.

Operations and maintenance (O&M)

RVA's initial involvement in Mumbai concerned wastewater operations and maintenance, a World Bank-financed assessment of current operations, with recommendations designed to support the investments anticipated by the bank in the 1990s to refurbish the dilapidated infrastructure. Poorly implemented maintenance procedures in major pumping facilities, for example, resulted in large reductions in efficiency, up to 48% in some cases. This was not a surprise, as there was no consistent O&M philosophy being followed.

The O&M investigation focused on health and safety concerns, performance-limiting factors and housekeeping issues within the Sewerage Department, with its very large number of staff workers. Recommendations from this study included facility upgrades, the establishment of a new Utility Management Centre, organizational de-layering, implementation of standard operating procedures and new customer service standards. The main recommendations of this six-year project were related to the need for upgrading the design standards, establishing O&M systems and improving staff skills through focused training.

The O&M experience also provided an opportunity for R.V. Anderson to undertake similar services in related assignments in smaller cities: contract operation of industrial waste treatment and potable water treatment facilities. Similar poor operating conditions were found to exist in these plants. The waste treatment was an even greater problem in remote and rural areas, often resulting in serious degradation of the local receiving water quality.

Planning and management

Having established recommended actions for improvements for Mumbai, the next phase of the RVA involvement was the preparation of a Wastewater Master Plan. The original 1979 Master Plan required updating, not only to establish a strategy for the management of current and future sewage flows, but to recognize the updating of national and international effluent standards.

The resulting 25-year Mumbai Master Plan, developed by RVA as part of an international consortium, included a review of the need for sewerage system upgrades, major new pumping stations and transfer schemes (tunnels and cross town trunks), and the establishment and upgrading of sewage treatment works and ocean outfalls. The recommended scheme was valued at approximately CAD$1.1 billion at 2002 prices. A major component of the recommended program for implementation was a slum sanitation program. This program was to build on the work already undertaken by the municipal corporation, and recommended close coordination with local community-based organizations for successful implementation. The treatment plants proposed in the seven sewerage zones in Mumbai under the 2002 Mumbai Sewerage Master Plan are shown in Table 1.

Based on this experience, similar planning work was subsequently carried out at smaller scales for Delhi and Sangli, for industrial waste

management in Punjab, and for an asset management plan for Bangalore. The main objective for RVA in these exercises was to present cost-effective, sustainable infrastructure solutions.

Currently, RVA, as part of an international consortium, is involved in the design and implementation of the "Stage II Priority Works" indentified in the 2002 Master Plan. The Design-Build-Operate approach is being experimented with for the treatment elements as an alternative to traditional design and construction using bank or International Monetary Fund (IMF) financing.

Conclusion

Based upon the experience gained, a number of observations and "lessons learned" can be made, reflecting changes in engineering in India over the last 20 years.

▶ **Scale and complexity** – Due to the size and complexity of the working environment in Indian cities such as Mumbai, the economies of scale and relative cost structures are therefore quite different than Canada's. Working closely with local Indian engineering professionals was, and remains, very important.

▶ **Operations and maintenance** – Efficient O&M of existing infrastructure remains the cornerstone of sustainable development. The benefit-cost ratio of O&M improvements is very high, as much as 3:1. Streamlined O&M and preventative maintenance programs are now being implemented in Mumbai and other Indian cities.

▶ **Slum sanitation** – This continues to be a difficult issue to integrate with larger infrastructure upgrade projects, in part because of the difficulty of engaging communities and incorporating acceptable decentralized facilities, such as communal toilets, that will be used and maintained properly.

▶ **Municipal efficiency** – Efficiency has been increasing, in part due to the pressures of a rapidly growing economy and also because of the extensive adoption of information technology and significant improvement in communication systems.

▶ **Client approvals** – Decision making in the local municipal environment continues to occur collectively through a review committee. Providing regular presentations to the committee and documenting agreements during the various stages of the planning process proved to be an expedient approach to receiving timely client approvals and minimizing the otherwise usual project delays.

▶ **Data availability** – : Lack of available data makes planning a significantly more complex process requiring extensive consultation with all stakeholders, and places importance on the ability to make decisions under considerable uncertainty, as little detail about existing physical assets, performance data, accurate maps or plans may be available.

▶ **Local Indian engineering expertise** – Indian engineering expertise is capable and easily available. Foreign expertise is generally required for planning and design support, as well as to bring an international perspective that was difficult for local municipal agencies to obtain. The ratio of foreign "expats" to local staff has fallen from 1:4 to 1:15 over the years, as a result of the growing skills and experience of local Indian engineers.

▶ **Complementary project assistance** – Canadian government support through Canadian International Development Agency (CIDA) and the Department of Foreign Affairs and International Trade (DFAIT) programs for planning and operations in India has been beneficial to the municipal agencies involved as a resource to provide additional training and guidance to their operations staff. ■

Promoting Sustainable and Earthquake Safe Building Construction Practices in India

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The purpose of this article is to describe an initiative to introduce earthquake-safe confined masonry construction technology in India, a country where masonry construction constitutes approximately 90% of the building stock. Significant human and economic losses in past Indian earthquakes were due to inadequately designed and constructed masonry and concrete buildings. Confined masonry was identified as an alternative to current building construction practices due to its good performance in past earthquakes in Latin America and other regions. Its first large-scale application in India occurred recently at the new campus of the Indian Institute of Technology Gandhinagar (IITGN). The project provided an opportunity for promoting this technology among students, faculty members and practicing engineers through several educational activities, including a short course for practicing engineers and a graduate course for IITGN students.

Indian seismic and construction scenario

A major part of Indian territory, particularly in the northern region close to the Himalayan mountain range, is located in areas of high seismic risk. India is divided into four seismic zones, namely, Zones II through V, that are associated with increasing intensity of ground shaking (BIS 2007). Approximately 60% of the land area of the country falls in Zone III or above. A few Indian mega-cities, including Delhi, Mumbai, and Calcutta, are located in regions of moderate to high seismic risk.

Significant population growth in India has resulted in ongoing strong demand for safe and affordable housing throughout the country. Unfortunately, Indian construction practice is largely populated by unskilled workers, and most buildings are non-engineered (constructed without input provided by qualified engineers and architects). Furthermore, the enforcement of building codes is not mandatory and there is no licensure process for engineers at a level similar to Canada. As a result, human and economic losses in past earthquakes have been unacceptably high.

In January 2001, the magnitude 7.7 Bhuj earthquake struck the Kutch area of Gujarat and caused huge human and economic losses: the death toll was 13,805, and more than 167,000 people were injured, while the estimated economic loss was approximately US$5 billion. Both older non-engineered masonry dwellings and modern reinforced concrete (RC) apartment buildings were affected by the earthquake. The city of Ahmedabad (population 5.5 million), located at about 220 km away from the epicentre, experienced shaking intensity VII on the MSK scale, which was consistent with Ahmedabad's location in seismic Zone III. Despite that, 130 RC frame buildings in Ahmedabad collapsed leading to a death toll of 805. All these buildings were "engineered," that is, technical professionals such as architects and structural engineers were involved in their design and construction. Unfortunately, the quality of construction and understanding of the seismic design philosophy might be questionable even though the buildings were constructed in the formal sector. There are significant challenges related to RC construction practices in India, and many new RC buildings are seismically vulnerable due to inadequate design and/or construction practices. After the 2001 Bhuj earthquake, the Indian earthquake-engineering community recognized the need for inherently robust building technologies that ensure good seismic performance and reduce the death toll, even when adequate engineering input may not be available (Jain 2005).

Confined masonry provides a viable and seismically safer alternative to poorly built RC buildings and seismically vulnerable

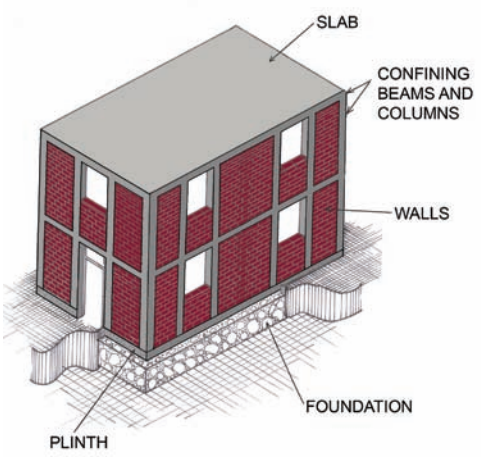


Figure 1. Key components of a confined masonry building (Brzev, 2008).

unreinforced masonry buildings which are widespread in India. This construction technology has evolved over the last 100 years through an informal process based on its satisfactory performance in past earthquakes. This technology has been practiced in countries and regions of high seismic risk, including Latin America, Mediterranean Europe, the Middle East, and South Asia. It has been used for both engineered and non-engineered construction, and its applications range from one- or two-storey single-family dwellings to six-storey apartment buildings. Provisions for confined masonry buildings are included in building codes of several countries, including Mexico, Peru, Chile, Eurocode in Europe, etc.

Canadian civil engineers may not be familiar with confined masonry, since this technology is not practiced in Canada. Key structural components of a confined masonry building are (see Figure 1): (a) masonry walls – transfer both lateral and gravity loads from the floor and roof slabs down to the foundations; (b) horizontal and vertical RC confining elements (tie-beams and tie-columns) – provide confinement to masonry walls and protect them from collapse, even during major earthquakes; (c) RC floor and roof slabs – distribute gravity and lateral load to the walls; (d) RC plinth band – transfers the loads from walls to the foundation system and reduces differential settlement; and (e) foundation – transfers the load to the underlying soil. In a confined masonry panel, the masonry wall is constructed first, and vertical RC tie-columns are then cast. The entire masonry panel height is usually constructed in two 1.2-m to 1.5-m lifts. Once the wall construction is completed up to the full storey soffit level, RC tie-beams are constructed atop the walls and the concrete is cast monolithically with the floor slab (see Figure 2).

Figure 2. Confined masonry walls under construction at the IITGN Palaj campus.

Confined masonry is deemed suitable for applications in India because it uses concrete, masonry, and steel, which are widely available construction materials. In addition, it performs very well in earthquakes, provided that nominal care is ensured during design and construction. A few initiatives related to promoting the use of confined masonry in India have been undertaken since 2005. The National Information Centre of Earthquake Engineering (NICEE; www.nicee.org) was established in 1999 at the Indian Institute of Technology Kanpur (IITK) with the mandate to empower stakeholders in the building industry in seismic safety towards ensuring an earthquake-resistant built environment. It has taken on several initiatives to promote the application of confined masonry in India (Rai and Jain 2010). NICEE hosted the inaugural meeting of the global Confined Masonry Network in January 2008 (www.confinedmasonry.org), and sponsored development of publications on confined masonry for Indian engineers and architects (Brzev 2008). A comprehensive research program related to seismic response of confined masonry structures was undertaken at IITK over the last few years (Singhal and Rai 2014). Building on these initiatives, IITGN pursued an opportunity to make the first large-scale application of confined masonry in India, as discussed next.

IIT Gandhinagar and the Palaj campus construction project

The Indian Institute of Technology (IIT) is the most prestigious university system for technical education at the national level and is internationally known for the academic excellence of its graduates. It was established in the 1950s and currently consists of 16 universities, including IITGN (www.iitgn.ac.in), which was established in 2008. As of December 2014, IITGN has about 950 students in total, 88 faculty and 100 staff members. The student body includes undergraduate students enrolled in B.Tech. programs, and graduate (M.Tech. and Ph.D.) students. One of the unusual aspects of IITGN's undergraduate curriculum is its five-week foundation program for freshmen that aims to foster creativity, leadership, societal awareness, ethics, engagement in sports, and physical activities. This program is critical for students as an immersion into the unique IITGN culture, characterized by a focus on societal issues, with students being inculcated values wherein they feel responsible to

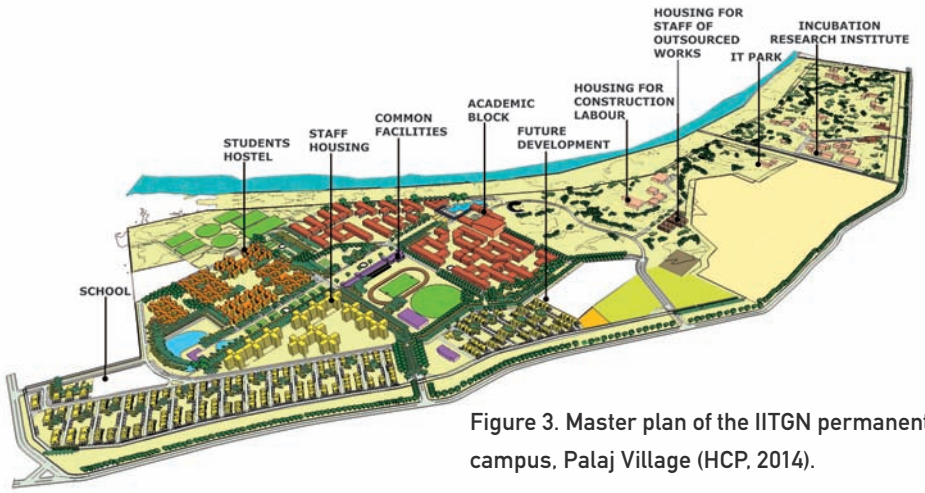


Figure 3. Master plan of the IITGN permanent campus, Palaj Village (HCP, 2014).

Figure 4. Student hostels nearing completion (October 2014).

help remove misery from lives of the poor. Another unique feature for a technology-based educational institute is the tremendous emphasis on humanities and social sciences (HSS), both in the curriculum and in other facets of academic life. This is in line with the belief that any technology development must be for the wellbeing of the society. IITGN undergraduate students have compulsory courses such as Biology and World Civilizations, along with eight HSS courses. There is a great emphasis on project-based learning. An example is a compulsory course on Design and Innovation offered early in the program (third semester), and several courses that have included open-ended projects. IITGN is a student-focused educational institution with significant emphasis on continuously enhancing student experience. For example, there is a comprehensive "Viva Voce" for all students, where each student meets with three faculty members once in a semester and talks about his/her life at the institute, academics, and career.

IITGN's innovative undergraduate curriculum was recognized through the World Education Award 2014 at the World Education Summit for Global Collaborative Learning. IITGN was recognized for globalizing its curriculum, offering study-abroad opportunities to nearly one third of its undergraduate students, engaging a large number of international faculty, and offering collaborative courses and projects with leading international institutes. Several features of IITGN's undergraduate engineering curriculum, especially the foundation program, the focus on project-based learning, and student-focused education, could be implemented at Canadian universities and would benefit the students' educational experience and graduate competencies.

Since its inception in 2008, IITGN has been housed in the premises of Vishwakarma Government Engineering College in Chandkheda, Ahmedabad. In July 2012, the Government of Gujarat provided a piece of land (approximate area: 163 hectares) on the banks of Sabarmati River at Palaj village, Gandhinagar District, for setting up IITGN's permanent campus. The campus development plan envisages the fully-residential campus housing 2,400 students and the associated faculty and staff in Phase 1 (see Fig. 3). It is eventually expected to host about 6,000 students. Phase 1A of the campus development (to be completed in mid-2015) comprises the construction of academic buildings, student hostels for 1,200 students, faculty and staff residences, and the related infrastructure. The academic area includes about 45,200 m^2 of built-up area comprising classrooms, laboratories and offices. There are six four-storey student hostels, with a total built-up area of 36,000 m^2 (see Fig. 4), and 30 three-storey buildings, with 270 apartments in total, housing the faculty and staff (total built-up area of about 49,300 m^2).

The student hostels and faculty and staff housing were ideal candidates for the adoption of confined masonry technology, in terms of building height, small room size, and a significant amount of walls relative to floor area (wall density ratio). An additional project feature was the use of fly ash lime gypsum (FALG) bricks for masonry construction. FALG bricks utilized fly ash available from nearby thermal plants and were chosen as an environmentally sustainable and structurally sound alternative to traditional burnt clay bricks. To supplement the significant brick demand, a manufacturing plant for FALG bricks (capacity 65,000 bricks/day) was set up at the construction site. Since this was the first large-scale field application of confined masonry in India, the project team was faced with several challenges which were successfully resolved during construction. For a detailed overview of the confined masonry construction process at the IITGN campus, refer to Jain et al. (2014 and 2015).

During the campus construction, IITGN established a Construction Workers' Welfare Programme to ensure dignified and sanitary housing conditions for construction workers, which won the 2014 National HUDCO Award for Best Practices to Improve the Living Environment. It was mandatory for contractors to construct clean, hygienic and well ventilated workers' housing with adequate water supply, electrical, and sanitation facilities. The contractors were also required to implement safety measures, which is not a common practice at construction sites in India.

Educational initiatives

Although masonry construction constitutes approximately 90% of the building stock in India, design of masonry buildings is not included in the curriculum at the majority of engineering colleges and universities

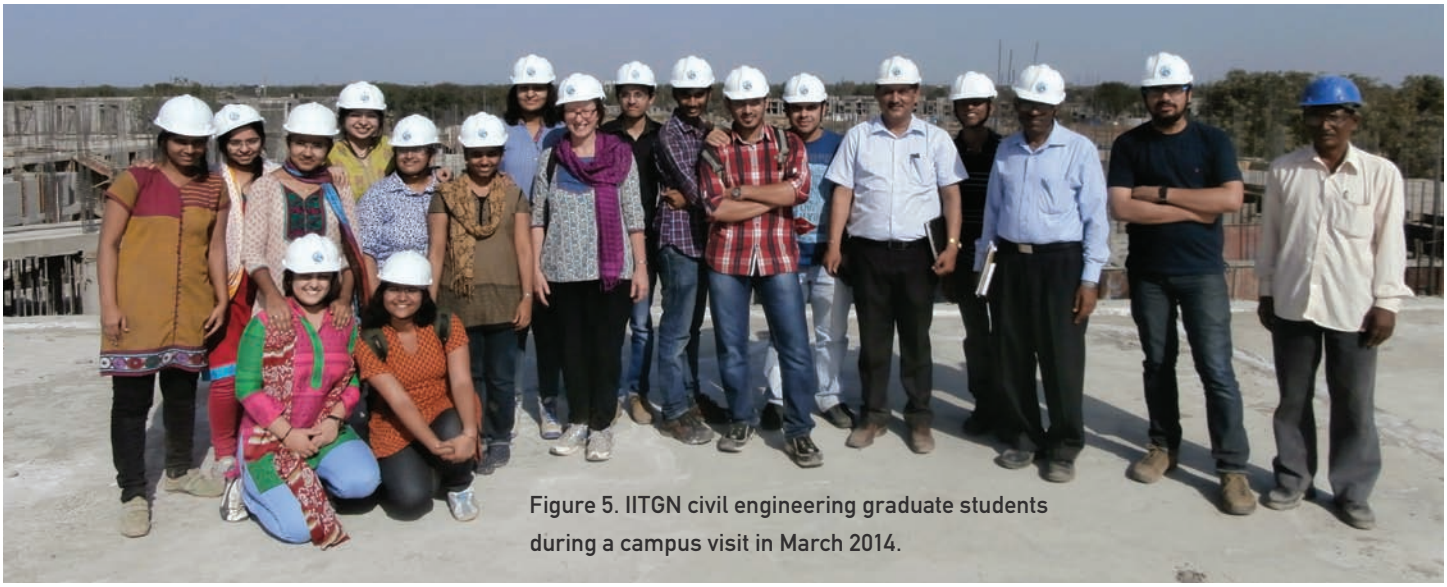


Figure 5. IITGN civil engineering graduate students during a campus visit in March 2014.

in the country. IITGN's academic program includes design of masonry buildings in the curriculum of its undergraduate civil engineering program. Furthermore, in January 2014, a full-semester graduate course in Analysis and Design of Masonry Buildings was delivered by the co-author of this article (Visiting Professor Svetlana Brzev). The course covered the key concepts of structural and seismic analysis and design of reinforced and confined masonry buildings. The students were also exposed to a real-world design project of a confined masonry building at the IITGN campus, and had an opportunity to visit the construction site, observe the construction process, and interact with the site engineers and contractors (see Fig. 5). As a result of the exposure to confined masonry design and construction through coursework and site visits, five IITGN civil engineering graduate students chose masonry-related research topics for their M.Tech. theses. In February 2014, a five-day Short Course on Seismic Design of Reinforced and Confined Masonry Buildings was organized for practicing engineers, academics, and students from various parts of India. A team of masonry experts from India, Mexico, and Canada is currently developing code provisions and companion guidelines for the seismic design of engineered confined masonry buildings in India, which are expected to facilitate its broader application in the country.

The ultimate goal of the initiative described in this article is to develop the technical expertise required for the design of safe and durable masonry buildings in India through educational activities and field applications. Although opportunities for constructing full-scale buildings to demonstrate a novel construction technology may be limited, it may be possible for civil engineering students at Canadian universities to construct scaled models or perform hands-on building exercises to enhance their learning experience related to structural design courses. For example, during annual hands-on masonry construction sessions sponsored by Masonry Institute of B.C., civil engineering students at BCIT build a portion of masonry wall and gain first-hand exposure to practical aspects of masonry construction. ■

References

BIS (2007). Indian Standard - Criteria for Earthquake-Resistant Design of Structures - Part 1, IS 1893 (Part 1):2002, Fifth Revision, Bureau of Indian Standards, New Delhi, India.

Brzev, S. (2008). Earthquake-Resistant Confined Masonry Construction, National Information Centre of Earthquake Engineering, Indian Institute of Technology Kanpur, India (www.nicee.org).

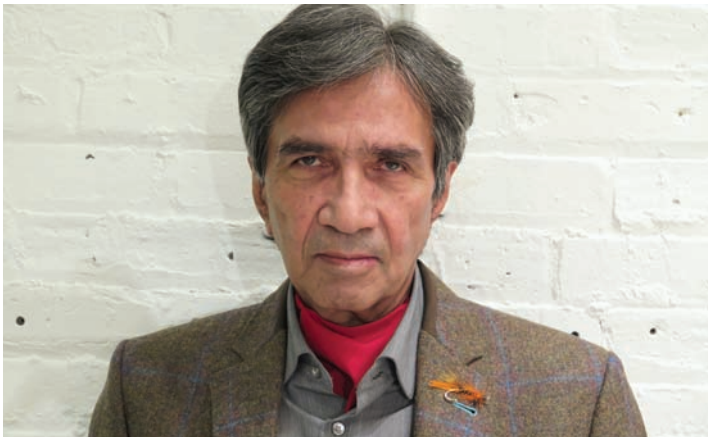
Jain, S.K. (2005). "The Indian Earthquake Problem," *Current Science*, 89(9):1464-1466.

Jain, S.K., Basu, D., Ghosh, I., Rai, D.C., Brzev, S., and Bhargava, L.K. (2014). "Application of Confined Masonry in a Major Project in India," Proceedings of the 10th National Conference on Earthquake Engineering, Earthquake Engineering Research Institute, Anchorage, AK, USA.

Jain, S.K., Brzev, S., Bhargava, L.K., Basu, D., Ghosh, I., and Ghaisas, K.V. (2015). First Large-Scale Application of Confined Masonry Construction in India, Indian Institute of Technology Gandhinagar, India.

Rai, D.C. and Jain, S.K. (2010). "NICEE's Role in Promoting Confined Masonry as an Appropriate Technology for Building Construction in India," Proceedings of the Ninth U.S. National and Tenth Canadian Conference on Earthquake Engineering, Paper No. 1689, Toronto, ON, Canada.

Singhal, V., and Rai, D.C. (2014). "Role of Toothing on In-Plane and Out-Of-Plane Behavior of Confined Masonry Walls," *Journal of Structural Engineering,* American Society of Civil Engineering, 140(9): 850-865.



Baidar Bakht, Fellow of CSCE, Appointed Member of the Order of Canada

Baidar Bakht of Toronto became a Member of the Order of Canada recently, honored for his contributions and improvements to bridge design, and for his translations of Urdu poetry which made these works accessible to the Canadian public.

"I'm absolutely thrilled. It is out of this world to be honoured this way," Bakht told the *Toronto Sun* newspaper. Bakht has been involved in bridge research for 40 years. "I suggest new ways of improving bridges with new materials so they can last forever. The efforts of my team have changed the way bridges have been designed," Bakht said. "We have invented a new slab deck that will never corrode because [the deck] is the first thing to corrode on a bridge."

In the *Sun* article, Bakht said he has inspected 300 bridges across Canada and that nine out of 10 times he recommends that a bridge can be saved. "The Gardiner [expressway in Toronto] is another story. That bridge has to go," he said.

Bakht is also recognized for translating poetry from Urdu, a language of many Indian states.

"I'm involved in engineering and poetry," he told the *Sun*. "It may seem a strange new combination, but painters have also been inventors of machines." ■

Baidar Bakht, Fellow de la SCGC est nommé membre de l'Ordre du Canada!

Baidar Bakht de Scarborough a été nommé membre de l'Ordre du Canada pour ses contributions et les améliorations qu'il a apportées à la conception des ponts ainsi que pour avoir rendu la poésie ourdou accessible au public canadien.

« Je suis absolument ravi. Il est hors de ce monde d'être honoré de cette façon » a déclaré Baidar Bakht qui a été impliqué dans la recherche sur les ponts depuis 40 ans. « Je suggère de nouvelles façons d'améliorer les ponts avec de nouveaux matériaux afin qu'ils puissent durer pour toujours. Les efforts de mon équipe ont changé la manière dont les ponts ont été conçus » a dit Bakht. « Nous avons inventé une nouvelle dalle de pont qui ne se corrode jamais car c'est la première chose à se corroder dans un pont. »

Bakht a indiqué qu'il a inspecté 300 ponts au Canada et que neuf fois sur 10 il recommande qu'un pont peut être sauvé. « Le pont Gardiner est une autre histoire. Ce pont doit partir », a-t-il déclaré.

Il est également reconnu pour ses traductions de la poésie de l'ourdou, la langue de nombreux états indiens. « Je suis impliqué dans l'ingénierie et la poésie. Cela peut paraître une nouvelle combinaison étrange, mais les peintres ont également inventé des machines », a déclaré Bakht. ■

CSA-S-06 Canadian Highway Bridge Design Code: New Edition

CSCE will be offering a one-day course on the new edition of the Canadian Highway Bridge Design Code. Authors of the code will present and explain the major changes made to four main sections of the code: Section 4: Seismic Design; Section 5: Methods of Analysis; Section 6: Foundations and Geotechnical Systems; and Section 12: Barriers and Highway Accessory.

The course will be presented throughout Canada starting in the spring of 2015.

The 11th edition of CSA-S-06 Canadian Highway Bridge Design Code applies to the design, evaluation and structural rehabilitation design of fixed and movable highway bridges. ■

CSA-S-06 Code canadien sur le calcul des ponts routiers: Nouvelle édition

La SCGC présentera une formation d'une journée sur la nouvelle édition du Code canadien sur le calcul des ponts routiers. Les auteurs du code présenteront les modifications importantes apportées à quatre principaux chapitres du code : Chapitre 4 : Conception parasismique; Chapitre 5 : Méthodes d'analyse; Chapitre 6 : Fondations et systèmes géotechniques et Chapitre 12 : Dispositifs de retenue et supports d'équipements routiers. La formation sera offerte dans tout le Canada à compter du printemps 2015.

La 11e édition du CSA-S-06 Code canadien sur le calcul des ponts routiers couvre la conception, l'évaluation et la conception de réhabilitation de la structure des ponts routiers fixes et mobiles. ■

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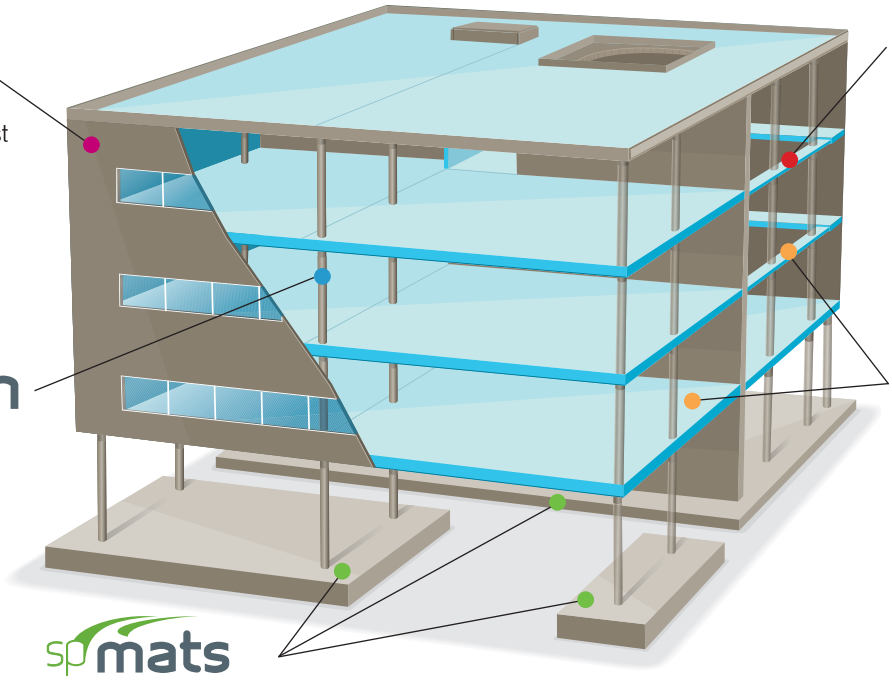

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