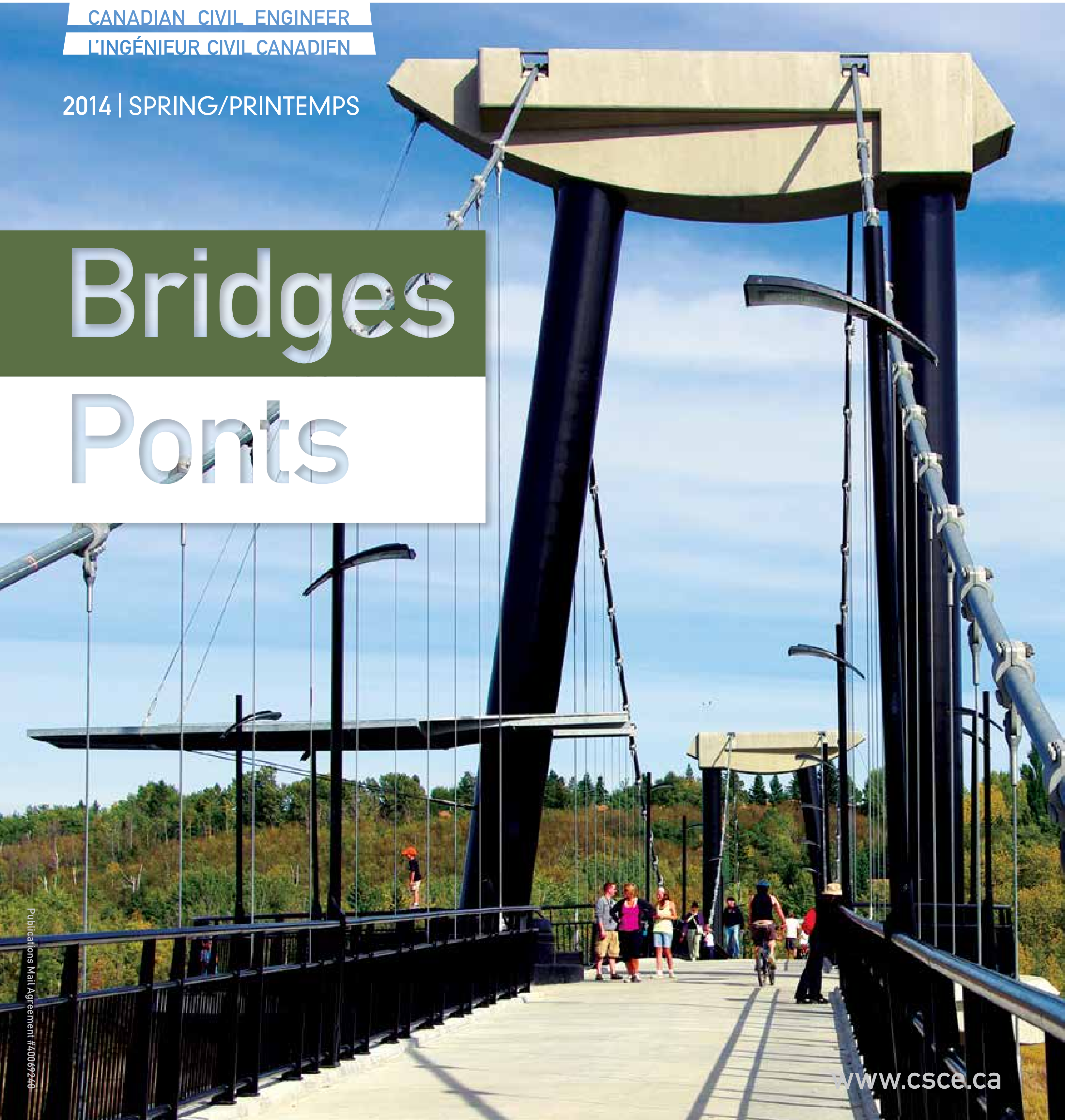
civil
CANADIAN CIVIL ENGINEER
L'INGÉNIEUR CIVIL CANADIEN

2014 | SPRING/PRINTEMPS

- Innovative short and medium span bridges
- Fort Edmonton Footbridge
- Restoring the Kinsol Trestle
- How to define sustainable infrastructure?



Bridges
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Cover photo: Fort Edmonton Footbridge. Photo courtesy CH2M HILL.

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L'INGÉNIEUR CIVIL CANADIEN

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Taking Stock of Civil Engineers' Role in Canadian Society

From need and opportunity came some of the greatest engineering achievements in defining Canadian society, in public health and safety, in economic development and in lifestyle.

Some of these achievements are appropriately characterized as nation building; perhaps none having as much impact as the construction of the Canadian Pacific Railway, given the time when it was done and its lasting role in the Canadian mosaic. In CP's own words "… [the] Canadian Pacific Railway was formed to physically unite Canada and Canadians from coast to coast. This incredible engineering feat was completed on Nov. 7, 1885 – six years ahead of schedule – when the last spike was driven at Craigellachie, B.C. Canada's confederation on July 1, 1867 brought four eastern provinces together to form a new country. As part of the deal, Nova Scotia and New Brunswick were promised a railway to link them with the two Central Canadian provinces – Quebec and Ontario."

After more than 125 years, this infrastructure is still having an effect on the life of Canadian citizens, including the economics and the politics of our country. Other transportation achievements with a similar impact include the Welland Canal system in Niagara, the Trans-Canada Highway, Lion's Gate Bridge in Vancouver, Champlain Bridge in Montreal, as well as more recent feats of engineering like the Confederation Bridge in P.E.I.

Civil engineering achievements have been equally impactful in the area of public health and safety. The development of water and sewer systems has evolved since the time of Confederation and continues to this day. These civil engineering infrastructure initiatives have been credited for saving more lives in Canadian history than the medical efforts and achievements of the health community, considering the cholera and dysentery epidemics of the 19th century. One of the early epidemics in Lower Canada and New England claimed more than 9,000 lives. Many thousands of lives were lost in subsequent years until the cause and spread of these diseases was determined and addressed with sanitation and water systems developed by the engineering community.

The needs of society in the early years of Canadian confederacy provided the opportunity for civil engineers to be leaders in responding to the social needs of the day. Driven by the obligations of their profession, civil engineers have persevered in the face of political, financial and technical challenges, finding ways to implement strategic solutions.

Engineers have done their job with little fanfare. The engineer's role does not seem to be understood by the general public. Rather than being recognized for its role, the engineering community has been pushed further and further away from the front line on these issues.

Headline disasters in recent years have resulted in infrastructure finding its way to the top of political agendas at all levels. These failures have alerted the public and the engineering community to the deterioration of our public infrastructure, leading to the concept of sustainability of these systems.

Sustainability, in the context of infrastructure, is the domain of civil engineers. And, lest we fool ourselves, it also involves other stakeholders – policy makers, financiers/accountants, contractors … the list goes on. Engineers, however, have the technical background and problem solving skills that equip them to be leaders in addressing core sustainable infrastructure issues. Civil engineers, in fact, have a duty to take a leadership role and, therefore, need to become more visible and vocal in this space. Link this need to CSCE's new vision and look for our "action plan" to engage every component of our organization, including individual members, to be more visible and vocal. Global sustainability and infrastructure is our current need and opportunity for our next great achievements! ■

An incredible engineering feat culminated on November 7, 1885, with the completion of Canada's first transcontinental railway./ Une incroyable réussite du génie a été réalisée le 7 novembre 1885 avec le parachèvement du premier chemin de fer transcontinental du Canada.

Bilan du rôle de l'ingénieur civil dans la société canadienne

Le besoin et les circonstances ont donné lieu à certaines des plus grandes réussites du génie civil pour la création de la société canadienne, pour la santé et la sécurité publique, et pour le développement économique et le mode de vie des citoyens. Certaines de ces réussites font partie, à juste titre, du processus de création d'un pays. Aucune de ces réussites n'a cependant eu autant de portée que la construction du chemin de fer du Canadien Pacifique, compte tenu de l'époque et de son rôle persistant dans la mosaïque canadienne. Selon les mots même du CP « …le chemin de fer du Canadien pacifique a été créé pour unir physiquement le Canada et les Canadiens d'un océan à l'autre. Cette incroyable réussite du génie a été parachevée le 7 novembre 1885, six années plus vite que prévu, lorsque le dernier clou a été enfoncé, à Craigellachie, C.B. Le 1er juillet 1867, la Confédération canadienne réunissait quatre provinces de l'Est pour créer un nouveau pays. En vertu de l'entente, on a promis à la Nouvelle-Écosse et au Nouveau-Brunswick un chemin de fer pour les relier aux deux provinces centrales, le Québec et l'Ontario ».

Après plus de 125 ans, cette infrastructure affecte toujours la vie des citoyens canadiens, notamment l'économie et la politique. Il y a eu d'autres réussites dans le domaine du transport, comme le canal Welland, dans la région de Niagara, l'autoroute transcanadienne, le pont Lion's Gate, à Vancouver, le pont Champlain, à Montréal, ainsi que d'autres ouvrages plus récents comme le pont de la Confédération, à l'Île du Prince Édouard.

D'autres réussites du génie civil ont aussi eu un impact sur la santé et la sécurité publique. La création d'aqueducs et d'égouts a évolué depuis la Confédération et continue d'évoluer. Ces infrastructures auraient sauvé plus de vie au Canada que les efforts de la médecine et les réussites du secteur de la santé si on pense aux épidémies de choléra et de dysenterie du 19e siècle. L'une des plus anciennes épidémies au Bas-Canada et en Nouvelle-Angleterre avait fauché plus de 9 000 vies. Des milliers d'autres vies ont été perdues au cours des années qui ont suivi jusqu'à ce que l'on parvienne a déterminer la cause et la propagation de ces maladies et que le génie civil crée des aqueducs et des égouts appropriés.

Au début de la Confédération, les besoins de la société ont donné l'occasion aux ingénieurs civils d'agir comme leaders pour répondre aux nécessités sociales du pays. Poussés par les obligations de leur profession, les ingénieurs civils ont relevé les défis politiques, financiers et techniques pour inventer des façons de mettre en œuvre des solutions stratégiques.

Les ingénieurs ont fait leur travail sans tambours ni trompettes. Le rôle de l'ingénieur semble ne pas être bien compris dans le grand public. Plutôt que d'être reconnu pour son rôle, l'ingénieur civil semble avoir été de plus en plus éloigné des débats sur ces questions.

Les désastres qui ont fait la manchette au cours des dernières années ont fait en sorte que la question des infrastructures s'est retrouvée au sommet de l'agenda politique, à tous les niveaux. Ces échecs ont alerté le public et la profession quant à la détérioration de nos infrastructures, ce qui a mené à l'élaboration de la notion de durabilité pour ces ouvrages.

En matière d'infrastructures, la durabilité est l'affaire des ingénieurs civils. Sans nous tromper, on peut aussi affirmer qua la durabilité est aussi l'affaire d'autres intéressés : les décideurs politiques, les agents de financement, les comptables, les entrepreneurs, etc. Cependant, les ingénieurs ont les connaissances et les compétences techniques pour agir comme chefs de file dans le traitement des problèmes d'infrastructures durables. En fait, l'ingénieur a même le devoir de prendre le leadership, de se faire plus visible et de s'exprimer davantage dans ce domaine. Faites le lien avec la nouvelle conception de la SCGC et consultez notre plan d'action, destiné à mobiliser tous nos éléments, y compris certains membres précis, afin d'être plus présents et plus connus comme tel. La durabilité globale et dans les infrastructures constitue le besoin et l'occasion par excellence pour créer nos prochaines grandes réussites ! ■

Western Region: Connecting with the Community

D. Philip Alex, M.Sc., B'Arch (Hons),
PMP REGIONAL VICE-PRESIDENT, WESTERN REGION, CSCE

The Western Region core committee consists of the regional vice-president Dinu Philip Alex, the treasurer, Dr. Rishi Gupta, the regional coordinator (currently vacant) and the chairs of the four sections that comprise the region: Leslie Symon, Edmonton; Erin Dvorak, Calgary; Chelene Wong, Vancouver; and Kevin Baskin, Vancouver Island.

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.

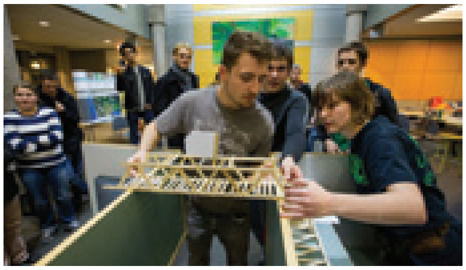
The sections are actively involved in the civil engineering community by providing services such as technical programs, technical tours to infrastructure projects, and student activities (poster contests, popsicle stick bridge contests, scholarship and bursary programs), and by connecting and partnering with other civil-related societies.

The Regional Lecture Tours (RLT) were initiated in 2012, spearheaded by Brad Smid, a former CSCE Western Region vice-president, with the sole intent of connecting the sections together. The RLT series for the spring of 2014 is the Glacier Discovery Walk in Jasper National Park and will be presented by Dr. Simon Brown from Read Jones Christoffersen, the key sponsor for the event.

One other key initiative within the region has been the enhancement of the Young Professionals initiative through industry nights, mentorship programs, involvement of technologists and the development of the student chapter at the University of Victoria under the guidance of Vancouver Island section chair Kevin Baskin, Dr. Rishi Gupta and Dr. Caterina Valeo.

Although there are significant challenges with respect to an aging workforce and succession planning within the sections, there is excitement within the Western Region as the Vancouver section works towards hosting the CSCE annual conference in 2017. ■

D. Philip Alex is director of strategic services, drainage services, financial services & utilities, City of Edmonton.



Activities such as bridge competitions help the Society connect with the community. / Des activités telles que des concours de pont aider la Société se connecter avec la communauté.

La région de l'Ouest : branchée sur la collectivité

D. Philip Alex, M.Sc., B'Arch (Hons),
PMP VICE-PRÉSIDENT RÉGIONAL, RÉGION DE L'OUEST, 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 : Leslie Symon, Edmonton ; Erin Dvorak, Calgary ; Chelene Wong, Vancouver ; et Kevin Baskin, Île de Vancouver.

Comme toute autre région, la région de l'Ouest travaille avec les sections pour construire et maintenir des initiatives conformes aux orientations stratégiques et aux conceptions de la direction de la SCGC.

Les sections participent à la vie de la profession en offrant des services comme les programmes techniques, les visites techniques des chantiers d'infrastructures et des activités étudiantes (concours d'affiches, concours de ponts en bâtons de « popsicles », bourses, et en s'associant en partenariat avec d'autres sociétés reliées au monde du génie civil.

La tournée régionale de conférences a été créée en 2012, sous la direction de Brad Smid, ancien vice-président régional pour l'Ouest, dans le seul but de relier les sections ensemble. Pour le printemps 2014, cette tournée portera sur la promenade sur le glacier dans le parc national de Jasper, avec le professeur Simon Brown, de « Read Jones Christoffersen », principal commanditaire de l'activité.

Autre activité importante dans la région : l'enrichissement du programme d'activités pour les jeunes professionnels, avec des soirées industrielles, des programmes de mentorat, la participation de technologues, et la création d'un chapitre étudiant à l'Université de Victoria, sous la direction du président de la section de l'île de Vancouver, Kevin Baskin, du professeur Rishi Gupta et du professeur Caterina Valeo.

Bien que nous devions faire face à de nombreux défis comme le vieillissement des travailleurs 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 de 2017. ■

D. Philip Alex est directeur des services stratégiques aux services de drainage de la ville d'Edmonton.

Lunch Networking Events Popular in Prairie Region

North Saskatchewan

The Saskatoon Section has recently hosted a number of events that target YPs. One of our goals this year is to maintain our student members as associate members following graduation, and we are working closely with our student chapter to help achieve this.

"Nooner" presentations have been held on a monthly basis and consist of a mini presentation on a local project followed by questions and answers. These presentations take place at a venue on campus and include lunch to encourage student attendance. The nooners are a hit with all members.

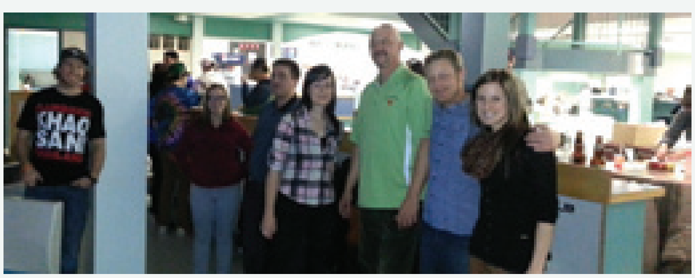
We have also hosted two networkers at a local venue. These informal events provide an opportunity for members to form connections within the civil engineering community. Although the networkers are open to both members and non-members of all ages, they have been attended primarily by YP and student members.
— Karleigh Pihowich, EIT, AMCSCE

South Saskatchewan

The South Saskatchewan Section hosted three "networker" events for its young professional members in Regina in 2013. The purpose of networkers is to provide young professionals an opportunity to meet and socialize with peers in an informal setting. Past events have included beverages and appetizers, pool, and glow bowling.

We have recently had the University of Regina added to the list of CSCE-recognized universities and we are working on creating the university's first student chapter.

We plan to host more networkers in 2014, which will be complemented with some technical lunch-and-learn events. Our goal is to maximize participation and member momentum leading up to the 2015 CSCE Annual Conference to be hosted in Regina.
— Katelyn Freçon, EIT, AMCSCE



December YP Networker, Nortown Bowling Lanes, Regina, SK. / Activité de réseautage en décembre chez les jeunes professionnels : soirée de quilles à Regina, SK. Photo : Ali Zaineddin

Les exposés-midi sont un succès dans la région des prairies

Saskatchewan Nord

La section de Saskatoon a récemment organisé des activités visant les jeunes professionnels. L'un de nos objectifs pour l'année est de conserver notre nombre de membres étudiants et de membres associés après leur diplomation, et nous collaborons étroitement notre section étudiante pour y parvenir.

Il y a eu des exposés-midi sur une base mensuelle, qui consistent en une mini-présentation sur un projet local, suivi d'une période questions et réponses. Ces présentations, qui comportaient un bon repas, ont eu lieu sur le campus afin de faciliter la participation étudiante. Les exposés-midi sont un succès auprès de tous les membres.

Nous avons aussi organisé deux activités locales de réseautage. Ces activités spontanées sont pour les membres une occasion de nouer des relations avec le monde du génie civil. Bien que ces activités soient ouvertes aux membres et aux non-membres de tout âge, il y avait surtout des membres étudiants et des jeunes professionnels.

— Karleigh Pihowich, EIT, MASCGC

Saskatchewan Sud

La section de Saskatchewan Sud a organisé trois activités de réseautage pour ses jeunes professionnels, à Regina, en 2013. Ces activités ont pour but de donner aux jeunes professionnels l'occasion de rencontrer d'autres jeunes professionnels dans un cadre de détente.

L'Université de Regina a récemment été ajoutée à la liste des universités reconnues par la SCGC, et nous nous employons à y mettre sur pied le premier chapitre étudiant.

Nous prévoyons organiser plus d'activités de réseautage en 2014, en y ajoutant des activités plus techniques de style « Lunch and Learn ». Notre but est de maximiser la participation et le recrutement d'ici au congrès annuel de 2015 de la SCGC, qui aura lieu à Regina.

— Katelyn Freçon, EIT, MASCGC

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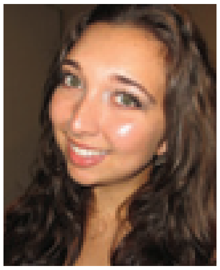


Jayme-Lee Berton
PRESIDENT, CSCE STUDENT CHAPTER, UNIVERSITY OF OTTAWA

The University of Ottawa's CSCE student chapter is creating an environment for civil engineering students that will help stimulate an early professional consciousness right from our campus. We have decided to welcome at least one renowned guest speaker each semester for a guest speaker night series. Since we have internationally respected faculty members, we decided to start by inviting our own professors in the various civil engineering specialties. We have offered two guest speaker nights on the four major disciplines of civil engineering offered at U. of Ottawa, namely, structural, geotechnical, hydraulics and environmental. This has been an excellent tool for student chapter members and other civil engineering students to be well informed about the civil engineering profession and to make an informed decision concerning their future in this profession. There is also an added bonus, in that we have the chance to closely interact with professors that we do not usually meet.

Student attendance and turnout at the guest speaker nights has increased significantly from one session to the next. There have been excellent testimonies about the event and its impact on students. Our professors who offered to share their knowledge with us have also expressed their pleasure at being a part of the event.

The CSCE student chapter at University of Ottawa plans to continue holding these events with the hope of bringing more students out each time. Our plans for future events will be to bring in professionals from the industry with various levels of expertise and experience. The focus will be on providing our students with insight on what young civil engineering professionals can expect once they graduate and how they can choose and develop their own career paths. ■

Exploiter les ressources locales pour trouver des conférenciers

Jayme-Lee Berton,
PRÉSIDENTE DU CHAPITRE ÉTUDIANT DE L'UNIVERSITÉ D'OTTAWA

Le chapitre étudiant de la SCGC de l'Université d'Ottawa crée à l'intention des étudiants en génie civil un environnement susceptible de favoriser une prise de conscience professionnelle dès le campus. Nous avons décidé d'accueillir au moins un conférencier de renom à chaque semestre, dans le cadre de nos soirées-conférences. Comme nous avons ici des professeurs de réputation internationale, nous avons décidé de commencer par inviter nos propres professeurs dans les divers secteurs du génie civil. Nous avons offert deux soirées-conférences à quatre spécialités importantes du génie civil offertes à l'Université d'Ottawa : les charpentes, la géotechnique, l'hydraulique et l'environnement. Cette formule s'est avérée un excellent outil pour permettre aux membres du chapitre et aux autres étudiants en génie civil d'être bien renseignés sur la profession et de prendre des décisions éclairées sur leur avenir dans cette profession. Avantage additionnel : nous avons la chance d'être en interaction étroite avec des professeurs que nous ne rencontrons pas souvent.

The student chapter at University of Ottawa invited university professors to discuss careers in civil engineering. / Le chapitre étudiant de l'Université d'Ottawa invite des professeurs d'université pour débattre des carrières en génie civil.

La participation étudiante à ces soirées-conférences augmente de façon importante d'une soirée à l'autre. Les témoignages relatifs à ce sujet et à l'effet bénéfique sur les étudiants sont positifs. Nos professeurs qui ont accepté de partager leur expérience avec nous se sont également dits heureux de participer à ces soirées.

Le chapitre étudiant de la SCGC à l'Université d'Ottawa entend poursuivre ces activités dans l'espoir d'augmenter constamment la participation étudiante. Nos plans pour l'avenir consistent à attirer des professionnels de l'industrie possédant divers degrés de compétence et de connaissances. Notre but est d'offrir à nos étudiants une idée de ce à quoi les jeunes ingénieurs civils peuvent s'attendre après avoir obtenu leur diplôme et des choix qu'ils auront à faire pour assurer le développement de leur carrière. ■

Restoring the Kinsol Trestle

This restoration project on Vancouver Island in B.C. retained 60 per cent of the trestle's historic timber and met the current bridge code.

Re-opening ceremony.

Photo: ISL Engineering and Land Services

By Robin Zirnhelt, P.Eng. and Reid Costley, P.Eng.
ISL ENGINEERING AND LAND SERVICES

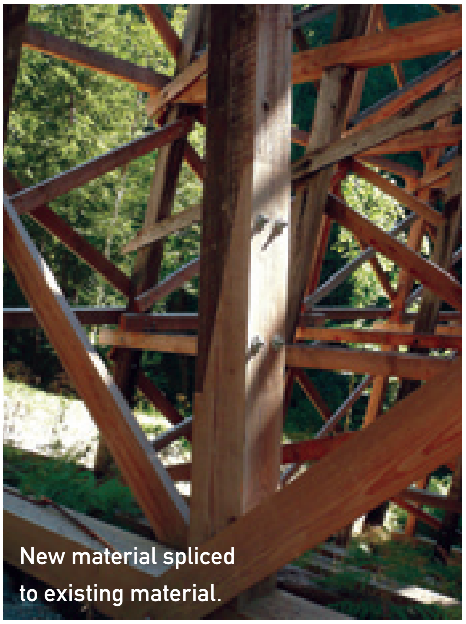
The Kinsol Trestle soars 145 feet over the Koksilah River on Vancouver Island, B.C.; it is Canada's tallest timber trestle. Built in 1920 for CN Rail, this historic railway bridge had fallen into disrepair and was slated for demolition. In 2007, however, the Cowichan Valley Regional District requested an assessment to determine the viability of its restoration as a pedestrian bridge connecting the last leg of the Trans-Canada Trail on south Vancouver Island. ISL Engineering and Land Services (then Cascade Engineering Group) executed a complex timber and steel solution, which simultaneously reused 60% of the original timber and met the Canadian Highway Bridge Code.

To achieve this outcome, the consultant team needed to address the apparently conflicting requirements of BC's Ministry of Transportation and Infrastructure (MOTI) and the Standards and Guidelines for the Conservation of Historic Places in Canada. The former required that all load-bearing timbers had to be new, not reclaimed timber. The latter required the retention and repair of as much of the existing structure as possible, using existing materials where possible.

Rehabilitation strategy

In response, the design-build team developed an innovative rehabilitation strategy that divided the structure into "inactive" and "active" portions. The "inactive" components were non-load bearing structures that used as much of the original timber as possible, enabling the project to meet the conservation standards. The "active" portions were re-constructed components that would support the planned new pedestrian walkway above so that the bridge complied with MOTI requirements. This strategy brought together cost certainty, compliance with current bridge building codes, and adherence to good conservation practice.

First, the team needed a detailed understanding of the structure and how the pieces fit together. The prime contractor, Macdonald & Lawrence Timber Framing (M&L), developed a comprehensive data sheet on each of the 6,000 timbers that make up the trestle and obtained a complete set of documents (working drawings, correspondence, and engineers' assessments) from the former owner, CN Rail. M&L then carried out a detailed wood condition assessment, combining the new technology of a 3D survey of existing conditions with resistograph testing. This approach enabled the creation of a detailed digital model of the existing structure, complete with the physical properties of the surveyed geometry. After M&L's assessment, ISL's timber engineers carried out further modeling and analysis of the key structural elements to determine what could be saved and what had to be replaced.



New material spliced to existing material.

The Howe trusses, spanning 95 feet over the river, were an integral part of determining the viability of the restoration. In the overall structural system these trusses are engaged only to carry the dead load of the inactive bents above. The condition assessment and analysis concluded that new timber was required only to reinforce a few critical connections and reinstate some bracing.

ISL proceeded to design the structural elements for both the new bents (which incorporate some original timbers in sound condition as non-loading bearing elements) and repairs to the non-load bearing bents.

Blending old and new

The resulting restoration process included replacing unsound timbers and reinforcing the structure to ensure that the historic characteristics — including the span, height and timber aesthetic qualities of the original structure — were preserved. Under-slung steel trusses were built to "bridge" the active bents (two-dimensional braced frames), thereby leaving 29 of the 46 original bents in place as non-load bearing. The last 17 bents incorporated new timber to support the new pedestrian walkway above. In this manner, the restoration blended new construction with heritage aspects so that the rehabilitated bridge looks the same as the original structure from the underside of the pedestrian bridge down. Design of the steel superstructure for the new 618-ft. walkway atop the trestle was undertaken by Stantec, and the ISL-Stantec design team collaborated on the design solution to ensure that the two structural components worked together. MMM Group provided leadership to the project as the coordinating registered professional.

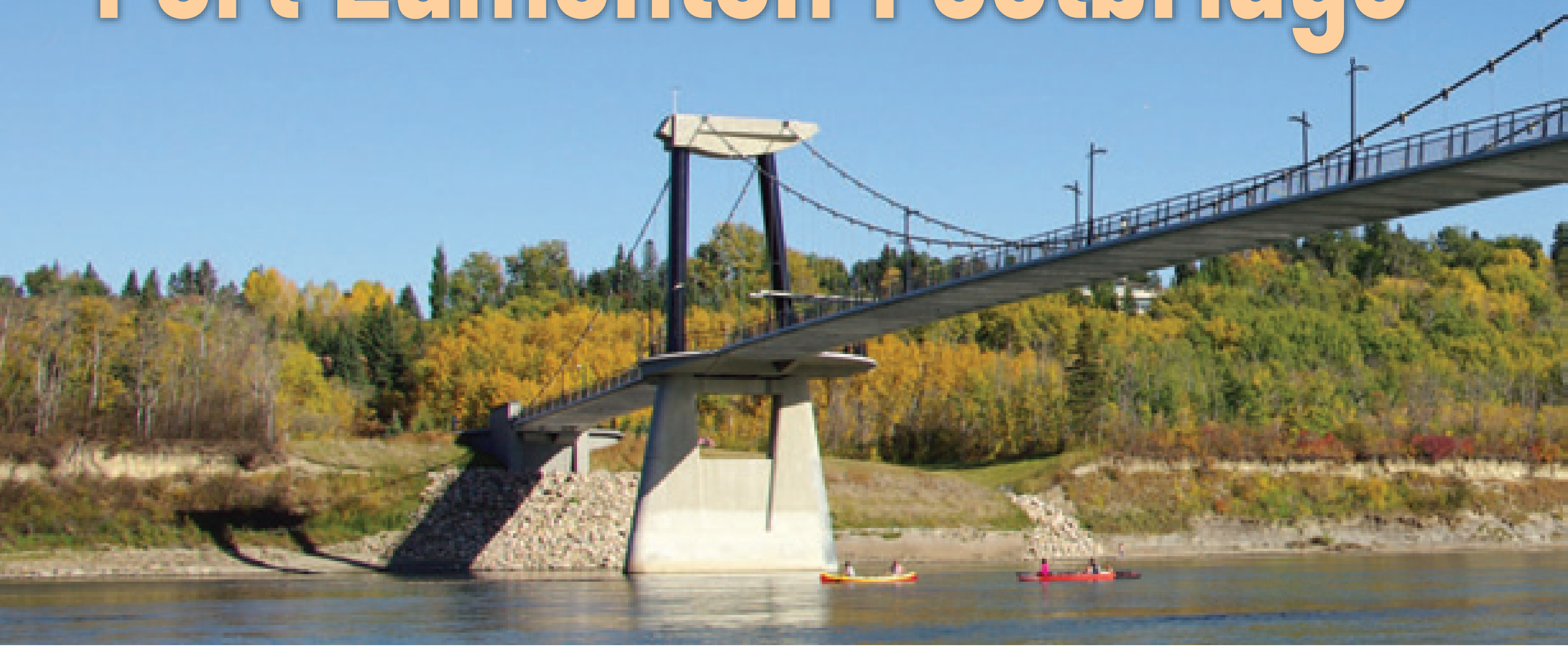
New "active" bents being lowered into position.

Photos: Macdonald & Lawrence Timber Framing

Re-opened in July 2011, the Kinsol Trestle provides pedestrians, cyclists and equestrians with passage over the Koksilah River, removing a difficult 8.5-km detour. The bridge also brings recreational and economic opportunities to communities in south Vancouver Island by connecting the last leg of the Trans-Canada Trail between Shawnigan Lake and the Town of Lake Cowichan. Today, this historic landmark draws in visitors from near and far as a spectacular showcase of Canadian heritage, engineering and construction skills. Its restoration has been recognized with several awards for sustainability. ■

OWNER-CLIENT: Cowichan Valley Regional District
COORDINATING REGISTERED PROFESSIONAL: MMM Group
HEAVY TIMBER SUBSTRUCTURE ENGINEERING: ISL Engineering and Land Services (Robin Zirnhelt, P.Eng., Reid Costley, P.Eng.)
PRIME CONTRACTOR: Macdonald & Lawrence Timber Framing
OTHER KEY PLAYERS: Jonathan Yardley Architect, Stantec Consulting (superstructure), C.N. Ryzuk & Associates (geotechnical), Knappett Projects (contractor)

Fort Edmonton Footbridge



Photos: CH2M HILL

A new suspension bridge over the North Saskatchewan River in an Edmonton park provides a signature landmark in the city's river valley.

By Gary Kriviak, P.Eng. and Stephanie Robertson
CH2M HILL

The Fort Edmonton Footbridge and Trails project comprises several kilometres of new pathways and a major pedestrian crossing of the North Saskatchewan River. Fort Edmonton Park has been developed to pay homage to the City of Edmonton's history and is a "living heritage museum" located in the city's picturesque river valley. The footbridge site, just upstream from the park, is a remote and heavily treed section of the river valley.

Major objectives of the project were to provide a functional trail crossing over the river, create a resting place on the river, and construct a signature landmark in the city's river valley. Completed in 2010, the footbridge is the city park's first suspension bridge and its first new river crossing built in the last 15 years. The classic bridge form suits the natural site character and its towers serve as beacons to trail users in its vicinity.

Engineering firm CH2M HILL, as prime consultant, led and coordinated specialists who worked to achieve the city's vision for the project. Due to the sensitive ecosystem in which the project is situated, significant attention was given to environmental factors. The CH2M HILL team brought together specialists with extensive experience who were well suited to the challenges.

Clean and slender form

This technically complex project relied on the judicious use of several technologies to address the challenges of achieving the functional, strength, aesthetic, and durability requirements of the selected bridge form. Cast-in-place concrete, precast concrete, and composite steel-concrete, each with a combination of normal reinforcement and post tensioning, were all used on the project. These along with the main catenary cable system were key in creating a "long span" footbridge with a light and organic profile that respects the natural character of the site, compared to other bridge types. The primary structural elements i.e. the pier shafts, the towers caps, the anchor block / entry plazas, and the tower belvedere seating / gathering areas, are each detailed to a high architectural standard with clean, sculpted shapes.

There is a long history of steel stiffening truss use in suspension bridge superstructures. However, the Fort Edmonton Footbridge relies on concrete deck elements to achieve its clean, slender and pleasing form. Given the relatively flexible superstructure that results, the consideration of dynamic behaviour due to wind and pedestrian

The suspension bridge in the picturesque river valley park in Edmonton is the first new river crossing built in the last 15 years. Its long span and light and organic profile respect the natural character of the site.

The consideration of dynamic behaviour due to wind and pedestrian loading was an important aspect of the design.

loading was an important aspect of the design. In-service full-scale dynamic monitoring occurred after construction to further assess the structure's dynamic response, and the effectiveness of the dynamic control provisions incorporated in the bridge was confirmed.

The geometrically complex suspension bridge form, its relative flexibility, and the shallow deck structure were a few elements of design complexity that flowed through into the construction phase. Careful consideration of the post tensioning details, vigilant attention to the layout of the bridge geometrics, and the use of high-quality finishes on the entirely exposed structure were some of the key items completed to high standards, as reflected in the quality of the finished structure.

Minimizing the environmental footprint

Due to the sensitive ecosystem in which the project is situated, significant consideration was given to environmental factors. For example, one of the primary reasons the three-span suspension bridge was selected was because the permanent footprint of the bridge, with only two instream piers in the river channel, was minimal compared to other options that were studied.

An environmental impact assessment of the project was prepared to understand the potential impacts and to guide project decisions affecting the river valley ecosystem. Approvals from all levels of government were required prior to moving ahead with the project.

In order to compensate for the construction phase impacts (temporary in-river construction berms) and the permanent footprint of the bridge where it affects the bed and banks of the river (piers, bank armouring), side-bank rock groins were constructed downstream of the bridge on the west bank of the channel. These features are designed to provide fisheries habitat, particularly during periods of the year when the river flows are above normal. The groins create slower velocity pools for resting and foraging by fish and other aquatic life in this reach of the river. ■

OWNER-CLIENT: City of Edmonton
PRIME CONSULTANT, PROJECT MANAGER, BRIDGE DESIGN, ENVIRONMENTAL LEAD: CH2M HILL (Gary Kriviak, P.Eng.)
OTHER KEY PLAYERS: Boundary Layer Wind Tunnel Laboratory (dynamics), Thurber Engineering (geotechnical), AMEC (environmental support), Northwest Hydraulic Consultants (hydrotechnical), Jiri Strasky (bridge type consultant), HFKS Architects (architect), EDA Collaborative (landscape), Gray Scott Consulting (public communications)
GENERAL CONTRACTOR: Alberco Construction

How Does the CSCE Define Sustainable Infrastructure?

Nick Larson, MEPP, P.Eng., Chair,
INFRASTRUCTURE RENEWAL COMMITTEE, CSCE,
Sarah Young, P.Eng., LEED AP BD+C

Over the past year this column has shared ideas from across Canada to articulate how civil engineers interpret the phrase "sustainable infrastructure." This discussion has helped to support CSCE's Vision 2020 Strategic Direction to demonstrate leadership in sustainable infrastructure.

The city of Quebec is a past winner of the CSCE Award for Governmental Leadership in Sustainable Infrastructure, for its clean-up of the St. Charles River.

Civil engineers are stewards of Canadian infrastructure. We are largely responsible for all aspects of infrastructure projects, including planning, designing, constructing and maintenance. This responsibility provides civil engineers with a unique opportunity to impact the future of Canadian infrastructure and to steer our society onto a sustainable pathway. This article provides an overview of how the CSCE is beginning to formally define sustainable infrastructure.

Sustainable infrastructure considers the economic, social and environmental factors that are influenced by the project or program along its entire life cycle. To encourage the development of sustainable infrastructure, the CSCE will award the third annual Award for Governmental Leadership in Sustainable Infrastructure at this year's conference in Halifax. This award is open to all levels of government, and is given to provide recognition to a Canadian public sector orga-

Sustainable Infrastructure Best Practices – Round 1

Planning, Decision Making and Leadership

- Consideration of all options for addressing the relevant issues, such as non-infrastructure solutions, demand management, rehabilitation of the infrastructure, etc.
- Clear justification for the need for the infrastructure project/program.
- Leadership to advance the sustainable performance of the project/program.
- Inclusion and collaboration with all stakeholders to work together toward optimizing sustainable performance.
- Cooperation or sharing of information to benefit other communities.
- Demonstration of how the project/program has contributed to a change in the corporate culture of the organization.

Financial and Risk Management

- Integration with asset management processes to demonstrate the benefit of the project/program to reducing long-term costs, reducing risk exposure of the organization, or increasing social/environmental service levels.
- Consideration for the impact of the project/program on the affordability of infrastructure systems in the community.
- Demonstrate the anticipation for future changes during the design process, such as the risks associated with climate change or the potential for changing modes of transportation.
- Demonstrate the economic contribution of the project/program to the local/regional/national economy.

Society

- Community engagement and approval of the project/program.
- Improve or enhance public health and safety (pollution reduction, improved accessibility, improved ability to use alternative transportation, etc.).
- Preserve/add to the community culture.
- Preserve/add to the access to the natural environment.

Resources

- Reduce the impact of waste by using recycled materials during construction or diverting waste from landfills.
- Reduce the energy consumption during construction by using regional materials, using processes to recycle/reduce wasted energy, or using renewable resources for energy.
- Reduce the use of water during the project life cycle.
- Use a monitoring program to track the reduction in resources (water, energy, gas, etc.) used during construction and in normal operation/maintenance of the project over its life cycle.

Environment

- Protect and enhance all aspects of the natural environment.
- Implement low impact development measures to manage storm water runoff.
- Reduce greenhouse gas emissions.
- Reduce the impacts of urbanization (i.e. heat island effect).

nization that has shown true innovation and leadership to advance the practice of sustainable infrastructure.

Over the course of the past year, the CSCE's Infrastructure Renewal Committee has developed a formalized set of best practices that will be used to guide organizations that are submitting nominations for the Award for Governmental Leadership in Sustainable Infrastructure (see sidebar opposite). The best practices can also be applied to advance the sustainable contribution of any infrastructure project or program.

We recognize that there are a number of systems available for guiding and evaluating the sustainable contribution of infrastructure projects. One of these is the Envision system that has been adopted by our American counterparts in the ASCE. While the CSCE has yet to endorse any one sustainable infrastructure rating system, the best practices summarized in the sidebar should be viewed as foundational elements that are essential to a formal rating system.

It should be emphasized that articulating and defining sustainable infrastructure is an ongoing challenge being faced by civil engineers and the CSCE. The best practices listed should be considered as a starting point for bringing the topic to the forefront. They will evolve over time as our industry's view of sustainable infrastructure matures and infrastructure owners will begin to specifically ask for these types of best practices to be applied to their projects.

Applying the best practices for sustainable infrastructure will be the key to ensuring that the projects we start today will provide the services we expect without compromising our ability to provide these services to future generations.

For more information, eligibility requirements and submission guidelines for the CSCE's Award for Governmental Leadership in Sustainable Infrastructure, please visit www.csce.ca. ■

Innovative Short and Medium Span Bridges

SMSB-IX Conference in Calgary: a worldwide forum dedicated to this prevalent category of bridges.

Mamdouh El-Badry, Ph.D., P.Eng., FCSCE
PROFESSOR OF CIVIL ENGINEERING, / PROFESSEUR DE GÉNIE CIVIL, UNIVERSITY OF CALGARY

Bridge structures are a major component of the transportation infrastructure of any country. Engineers are continually seeking innovative ways to design and build bridges that are aesthetically pleasing and sustainable, with a reduced maintenance cost and longer service life.

Short and medium span bridges constitute 90 to 95 per cent of bridge infrastructure in any country. Since 1982 the International Conference on Short and Medium Span Bridges (SMSB) has been held in Canada, under the auspices of the Canadian Society for Civil Engineering, to provide the only worldwide forum dedicated to this category of bridges. Bridge engineers, researchers, contractors, and owners from around the world will meet this year in Calgary at SMSB-IX to again enjoy a unique opportunity to discuss recent practices and new research and development. Over 250 papers from 25 countries will be presented covering a wide range of themes.

The technical articles that follow are short versions of two papers that will be presented at the conference. The article by Strasky, Zich, and Novotny presents a technique for construction of prestressed concrete bridges with a wide deck, ranging from 25 to 31 m, supported on a narrow (6.5 m) box-girder spine. The design allows for a significant reduction in self-weight to facilitate construction and reduce costs.

Sakai introduces prestressed concrete bridge design and construction for a new expressway in Japan. His innovative examples include a hybrid concrete and steel tube truss bridge, a box-girder bridge with steel corrugated web, a box girder with ribbed slab and strut, precast segmental construction, and incremental launching of concrete box-girder bridges.

The SMSB-IX Conference is organized in partnership with the University of Calgary, the City of Calgary, and Alberta Transportation, and will be held July 15-18, 2014, at the Hyatt Regency Hotel in Calgary. We look forward to seeing you there. ■

Ponts de courte et moyenne portée novateurs

La Conférence SMSB-IX de Calgary : un forum mondial dédié à cette catégorie dominante de ponts

Les ponts constituent une partie importante des infrastructures de transport de tout pays. Les ingénieurs sont constamment à la recherche de façons novatrices de concevoir et de construire des ponts esthétiquement agréables et durables, avec un coût de maintenance réduit et une longue durée de vie.

Les ponts de courte et moyenne portée constituent 90 à 95 pourcent des infrastructures de ponts dans n'importe quel pays. Depuis 1982, la Conférence internationale sur les ponts de courte et moyenne portée (SMSB) a lieu au Canada sous les auspices de la Société canadienne de génie civile afin de fournir le seul forum mondial dédié à cette catégorie de ponts. Des ingénieurs des ponts, des chercheurs, des entrepreneurs et des propriétaires du monde entier se rencontreront cette année à Calgary à la SMSB-IX afin de profiter d'une occasion unique pour discuter les pratiques récentes et les nouveautés en recherche et développement. Plus de 250 communications de 25 pays seront présentées sur un large éventail de thèmes.

Les articles techniques qui suivent sont des versions abrégées de deux communications qui seront présentées à la conférence. L'article de Strasky, Zich et Novotny décrit une technique de construction de ponts en béton précontraint avec un large tablier de 25 à 31 m, porté par une colonne de poutre-caisson étroite (6,5 m). Cette conception permet une réduction significative du poids qui facilite la construction et réduit les coûts.

Sakai présente la conception et la construction de pont en béton précontraint sur une voie rapide au Japon. Ses exemples innovants comprennent un pont hybride en béton précontraint et treillis en tube en acier, un pont à poutre-caisson avec âme en acier ondulé, une poutre-caisson avec dalle et entretoise nervurées, la construction segmentaire préfabriquée et le lancement de ponts à poutre-caisson.

Organisée en partenariat par l'Université de Calgary, la ville de Calgary et le ministère des transports de l'Alberta, la SMSB-IX se déroulera du 15 au 18 juillet 2014 à l'hôtel Hyatt Regency à Calgary. Nous espérons avoir le plaisir de vous y rencontrer. ■

Bridges with Progressively Erected Decks

Jiri Strasky
STRASKY, HUSTY AND PARTNERS, BRNO, CZECH REPUBLIC & GREENBRAE, CA, USA

Milos Zich
BRNO UNIVERSITY OF TECHNOLOGY, CZECH REPUBLIC

Petr Novotny
STRASKY, HUSTY AND PARTNERS, BRNO, CZECH REPUBLIC

Several long prestressed concrete viaducts are currently being built in Slovakia (Figure 1). The bridges have spans varying from 42 to 69 m and widths ranging from 25 to 31 m. The bridge decks consist of a single-cell box girder spine that is additionally widened by precast struts and cast-in-place overhangs (Figure 2). Construction of the bridge decks is carried out in stages. The spine girder is cast span-by-span in a formwork suspended on a special overhead gantry (Figure 1(b))with a so-called 'organic' prestressing system. This prestressing progressively eliminates deformation of the gantry during casting. The spine girder is very narrow in width (6.50 m) in order to reduce its self-weight as much as possible. Therefore the transverse projection of the overhangs extends up to 11.00 m (Figure 3). Casting of the spine girder is followed by the erection of precast slab struts on each side of the girder. The struts are not mutually connected. The overhangs are then cast-in-place on simple formwork supported by the struts. This progressive technique is similar to that implemented about 30 years ago in the construction of several cable-stayed bridges, including one across the River Elbe and the Vrsovice bridge built in Prague (Strasky, 1993). It is evident that this solution requires not only careful analysis and detailing, but also experienced contractors. Also the construction and service of these bridges have to be carefully checked and monitored.

Architectural and structural design

The span arrangement, section dimensions, and construction sequence of the bridges were developed on the basis of detailed static and dynamic analyses. The first structure of this kind is a 975-m long viaduct built across the Hostovsky Creek on Expressway R1 near the city of Nitra's R1 205 (Figure 1). The bridge deck is 25.66 m wide and extends over 17 spans of length varying from 33.0 to 69.0 m. The girder depth varies from 4.00 to 2.60 m. The bridge was opened to traffic in September 2011 (Novotny et al., 2013).

Two bridges of similar arrangement are being built on the section Fričovce – Svinia

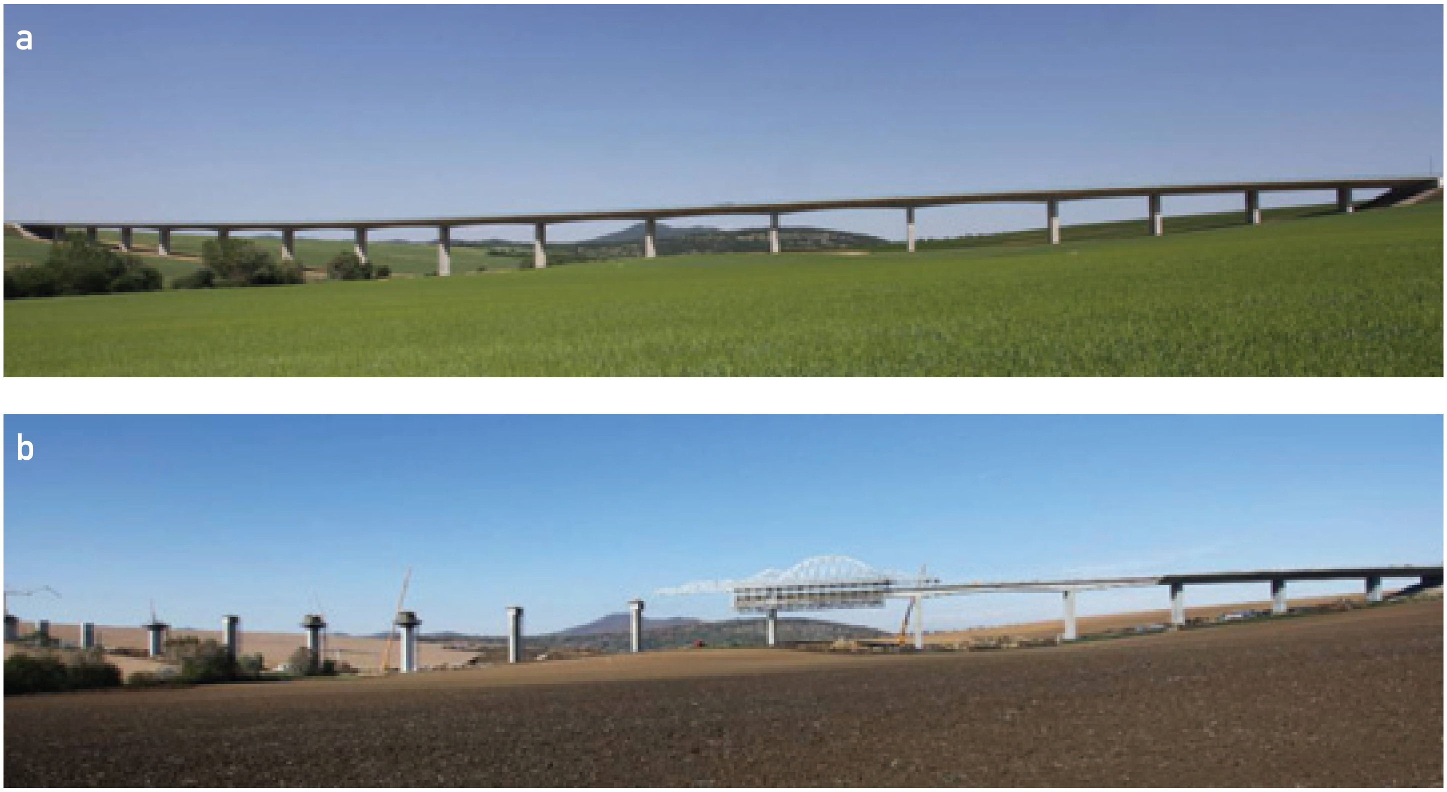


Figure. 1 – Bridge across the Hostovsky Creek Valley: (a) completed bridge, (b) span-by-span erection

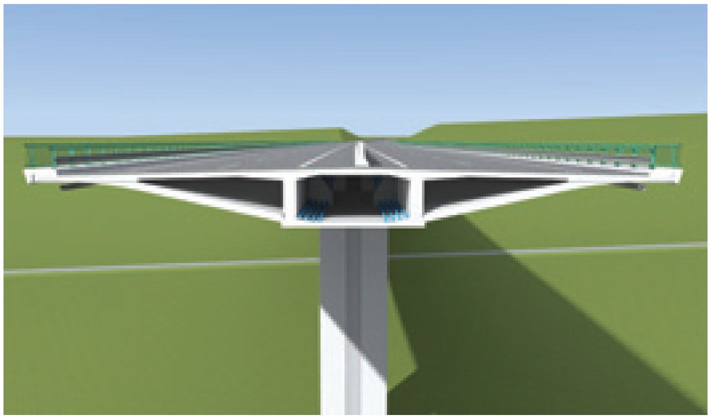


Figure 2 – Typical cross section

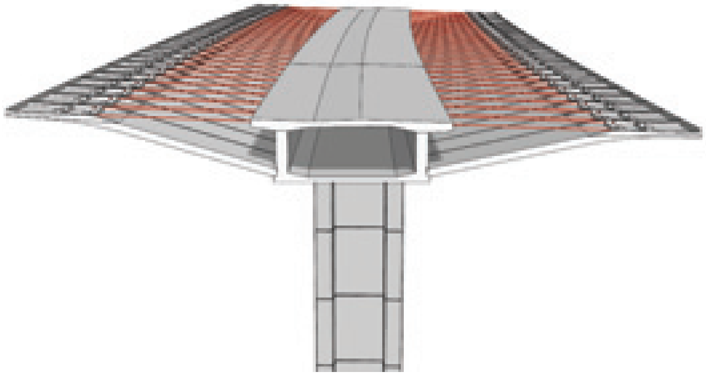


Figure 3 – Progressive erection of the deck

near the city of Presov on Motorway D1. The bridges that are being built across the Lazny and Stefanovsky Creek have total lengths of 269 m and 182 m; typical span length is 45 m. Both motorway directions are carried by one bridge of a total width of 29.5 m. The girder has a constant depth of 2.60 m. The bridge decks are rigidly connected to H shaped piers and form semi-integral structural systems.

Another two bridges of similar arrangement are also being built on the Janovce–Jablonov intersection near the city of Levoca on Motorway D1. The bridges across the Lodina and Doliansky Creek Valley have total lengths of 367 m and 414 m; typical span length is 65 m. Both motorway directions are carried by one bridge of a total width of 28.70 m. The girder depth varies from 4.00 to 2.60 m. The bridge decks are hinge connected to twin piers and form semi-integral structural systems.

The spine girder of all the bridges is progressively cast span–by-span in the formwork suspended on the overhead gantries (Figure 4). The girders are cast with an overhanging cantilever. The gantry's front support is situated on the pier table and the rear support is on the overhanging cantilever. The decks of all the bridges are longitudinally prestressed by internal bonded tendons situated within the basic cross section, and by external non-bonded tendons situated inside the central box. The bonded tendons are coupled at each construction joint. The external tendons are anchored at the pier diaphragms and are deviated at pier and span deviators.

In the transverse direction the deck slab is prestressed by tendons consisting of 4 strands placed in flat ducts situated at a distance of 1.50 m. During erection the struts are suspended on two prestressing bars anchored at the outer cantilevers of the basic cross section (Figure 3). The struts of a nominal width of 3.00 or 2.50 m are supported by short bottom corbels of the box girder (Figures 3 and 5).

The deck slab is cast-in-place in the formwork supported by the already erected precast struts (Figure 6). Following prestressing of the deck slab with transverse tendons, the longitudinal external tendons are post-tensioned.

The quality of the workmanship and performance of the bridges are verified by detailed static and dynamic loading tests. During construction, strain gauges are placed in the critical sections and the structures are carefully monitored both during construction and in service.

Static analysis

The structural solution was developed on the basis of very detailed static and dynamic analyses. The structures were analyzed by a MIDAS program system. The bridges were modeled as 3D structures assembled by beam, shell, and solid elements. A detailed time-dependent analysis of the progressively erected structure was also performed. Strut and tie models were also used for checking important details.

Design of the first structure – the Viaduct across the Hostovsky Creek Valley – was performed according to the Slovakia's standards (STN) in effect at the time of design. All other viaducts were designed according to Eurocode. All aspects of the analysis are presented in (Novotny et al., 2012).

The detailed analysis has confirmed that although the struts are not mutually connected, they contribute to resistance of the structure both in bending and torsion. Since the performance of the bridge depends on a perfect connection of the struts to the corbels of the box girder, which in turn depends on the quality of workmanship, the following conservative approach was accepted. The spine girder was designed without contribution of the struts in both bending and torsion. On the other hand, the precast struts were designed for the stresses that originate based on condition of a perfect connection of the struts to the box girders' corbels. This approach ensures that the struts will not be damaged during the service of the bridge.

Bridge monitoring during construction and service

The first structure, the Viaduct across the Hostovsky Creek Valley (R1 205), has been carefully monitored during construction, detailed loading tests, and during service. For the monitoring of concrete stresses, strain gauges were placed in four sections. Two sections were placed in span 6 and two sections

Figure 4 – Progressive erection of the bridge

Figure 5 – Erection of precast struts

Figure 6 – Formwork of the overhangs

were in span 7. Span 6 represents a typical span supported by movable bearings on pier 6 and by a concrete hinge on pier 7. Span 7 is a special span supported on a hinge at pier 7 and rigidly connected with pier 8. In both spans one section is situated at midspan and one section situated at distance 0.5 from the pier table. Ten strain gauges were placed in each section.

Since longitudinal strains were measured, the gauges were placed longitudinally at mid depth of individual slabs. The gauges were connected to Data Taker situated inside the box girder. Measurements by individual strain gauges as well as their temperature were recorded at selected intervals. Also temperature and humidity inside the bridge box were monitored.

Strain measurements were recorded right after casting of the structural members instrumented by the strain gauges. Measurements were recorded also just before and just after post-tensioning of the bonded tendons, stripping of the formwork, erection of the struts, casting of the overhangs and post-tensioning of the external cables, applying the additional dead load, the loading test, and bridge opening. During service, the strain measurement is recorded twice a year. Figure 7 presents calculated and measured values from which a good agreement of results is evident.

The strain measurement was also recorded during tests under three static loading stages. Spans 5 and 7 were loaded by 16 trucks of average weight of 32.05 tons situated symmetrically to the bridge axis. This loading produced maximum positive bending moments in the two spans. Span 6 was loaded by 8 trucks situated only on one side of the bridge, which created maximum torsion. The measured and calculated values were in a good agreement.

Conclusions

The design and construction techniques described above proved to be efficient. The viaduct across the Hostovsky Creek was built without any significant issues and monitoring of the bridge so far has confirmed excellent structural performance. Also, construction of the new bridges is progressing without any major issues.

The architectural and structural solutions as well as the final design of the above bridges were done by Strasky, Husty and Partners (SHP), Brno, Czech Republic. The bridge monitoring is being done by SHP

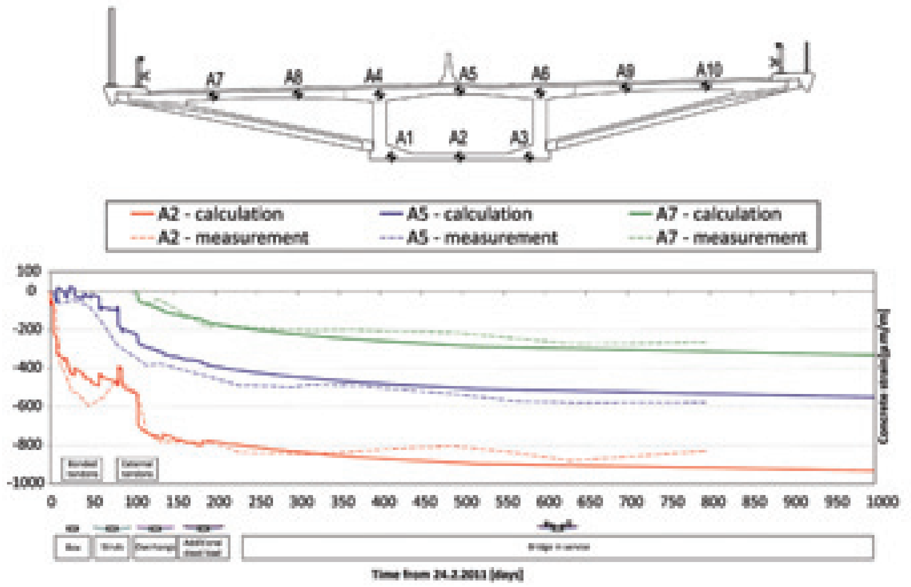


Figure 7 – Long term measurement

testing laboratory. The bridge decks are being built by EUROVIA CS, a. s. zavod Mosty a konstrukce. ■

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LIFELONG LEARNING | FORMATION CONTINUE

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HEC-RAS Modeling Including Advanced Applications

Ottawa – March 25, 2014
Toronto – March 26, 2014
Regina – March 27, 2014

The course covers the basic theoretical background of one-dimensional hydraulic modeling, model calibration, bridges and weirs, flood flow simulation and inundation mapping, flow separation, and simulation of unsteady flow. It is based on exercises that cover each topic.

The course is presented by Wolf Ploeger, Dr.-Ing., Project Manager, Golder Associates

Cette formation est présentée en anglais.

CAN/CSA-S6-06 Design of Aluminum Bridges and Footbridges

Fredericton – April 22, 2014

Denis Beaulieu presents the contents of Section 17 – Aluminum Structures of CAN/CSA-S6-06, Canadian Highway Bridge Design Code in force since October 2011 to engineers, professionals, technicians, teachers and students. Additional material and application examples are also provided.

Denis Beaulieu is a former professor of structural engineering and research chair at Université Laval. He has carried out numerous research projects on steel and aluminum structures and authored several books used by practitioners as well as teaching staff.

Cette formation est présentée en anglais

Please visit www.csce.ca for details of these courses.

Innovative Design and Construction for New Expressway Bridges in Japan

By Hideaki Sakai
CENTRAL NIPPON EXPRESSWAY CO., JAPAN
Mikio Nishioka
CENTRAL NIPPON EXPRESSWAY
TECHNICAL MARKETING CO., JAPAN

About 50 years have passed since Japan's first expressway was built between Tokyo and Kobe over a route covering about 540 kilometres. Since then, increased traffic volumes have led to congestion. Also there is a need for action to prevent problems as the road structures age.

To address these issues, a new expressway is currently being built for the same section. Most of the route for the new expressway passes through mountainous areas or along the coastline to avoid level areas where urbanization is already advanced. Therefore, the route has many bridges and tunnels. Building the new expressway required accelerated construction and a significant reduction in construction and maintenance costs.

To meet these requirements, NEXCO-CENTRAL has utilized innovative structures, materials, and construction methods for the expressway bridges, including hybrid structures combining prestressed concrete and steel structures, cross-sections that enable lighter superstructures, advanced materials, and precast segmental and incremental launching construction methods. Examples of these innovative bridge technologies are described below.

Hybrid prestressed concrete and steel tube truss

A box-girder bridge with a hybrid of prestressed concrete and steel tube truss is a structure where the concrete web of a box girder is replaced by steel truss members. In addition to permitting a lighter superstructure, the steel truss allows light to pass, reducing oppressiveness and making the bridge a more attractive part of the scenery. The Saruta River Bridge (7-span continuous rigid frame bridge, total length 625 m, longest span 110 m, Photo 1, Figure 1, is built with this hybrid system. It is the world's first rigid frame structure of this type.

Box-girder bridge with steel corrugated web

Prestressed concrete box-girder bridges with steel corrugated webs are structures where the webs of conventional concrete box-girder bridges are replaced with steel corrugated webs, and internal or external tendons are used to apply prestressing. With the aim of reducing self-weight in order to reduce the construction time and cost of an expressway bridge, the Hontani Bridge on the Tokai-Hokuriku Expressway (3-span continuous rigid frame box-girder bridge, total length 198.3 m, longest span 97.2 m) was constructed using cantilever erection, and utilizing a prestressed concrete box-girder design with steel corrugated web. This was the first application of a corrugated steel web in an expressway bridge. The bridge was completed in 1999, and the design has since been widely adopted for bridges on the new expressway.

The New Akabuchi River Bridge (5 + 6 span continuous box-girder bridge, total length 885 m, longest span 115 m, Photo 2) is a prestressed concrete box-girder bridge using a steel corrugated web. Figure 2 shows a cross-section of the girder. To further reduce the construction time the design employed precast ribs and precast prestressed concrete panels, in addition to the use of steel corrugated webs.

Prestressed concrete box-girder with ribbed slab and strut

For box-girder bridges carrying three lanes in each direction, a design using single-cell box

Photo 1 – Saruta River Bridge

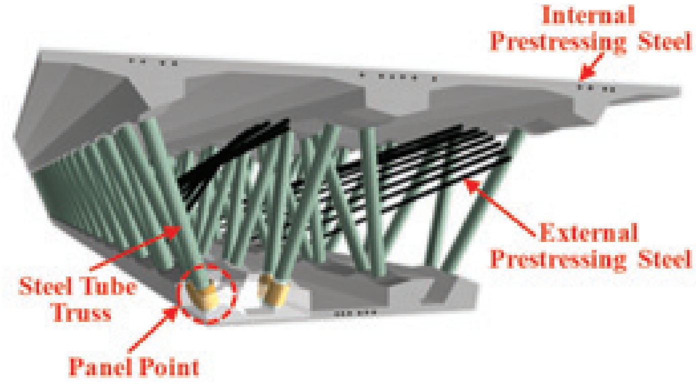

Figure 1 – Cross section of a girder

Photo 2 – New Akabuchi River Bridge

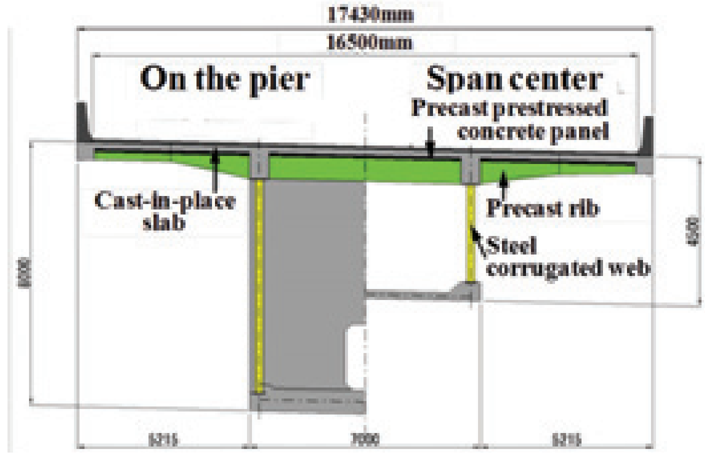

Figure 2 – Cross section of girder

girders results in large spacing between the slab supports. Thus, with conventional construction methods, the use of two-cell girders proved to be more effective. The Katsurajima Viaduct (4-span continuous box-girder bridge, total length 216 m, longest span 54 m, Photo 3) utilizes ribs and struts to reduce the weight and construction cost. The bridge also has steel corrugated webs. This type of construction has enabled a reduction of self-weight to 70% of a conventional design (Figure. 3).

Tendon system using epoxy-coated ultra-high strength strands

Many concrete bridges in Japan use uncoated stress relieved steel strands for internal and external prestressing cables in compliance with JIS G 3536. Ultra-high strength strands have been developed in Japan with a tensile strength about 20% greater than conventional steel strands. These have been used in some bridges. When ultra-high strength strands are used in external cables, the material cost per unit weight of steel is higher, but less steel needs to be used, allowing for an overall reduction of construction cost.

For a reduction of the expressway construction cost, epoxy-coated ultra-high strength strands were used for the external cables of the Matoba Viaduct (9-span continuous box-girder bridge, total length 403.5 m, longest span 60 m). Quality assurance for the epoxy coating was based on ASTM A882.

Precast segmental construction of box-girder bridges

For expressway construction a segment casting yard can be set up near the erection site in order to reduce the construction time and cost. This approach has been used for bridges such as the Yatomi Viaduct (prestressed concrete continuous box-girder bridge, total length 1,519 m, longest span 87.5 m, largest segment 80 tons) and the Kiso River Bridge (prestressed concrete-steel composite 5-span continuous extradosed bridge, total length 1,145 m, longest span 275 m, largest segment 400 tons). Figure 4 depicts the Yatomi Viaduct segment cross-section. Photo 4 shows erection of a segment.

For urban projects in Japan, it is often difficult to secure sufficient space for a casting yard near the bridge construction site. In such cases, shop fabrication is used, casting the segments at a permanent PC precasting plant. This method was used for construction of bridges such as the Furukawa Viaduct and Kamikazue Viaduct. The need to transport segments along ordinary roads means

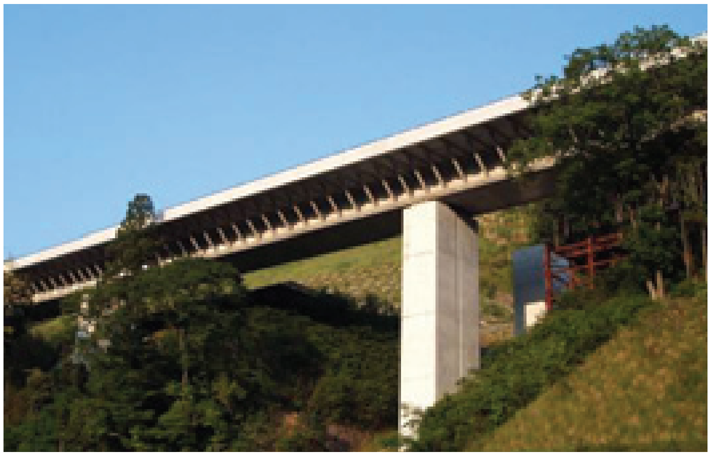

Photo 3 – Katsurajima Viaduct

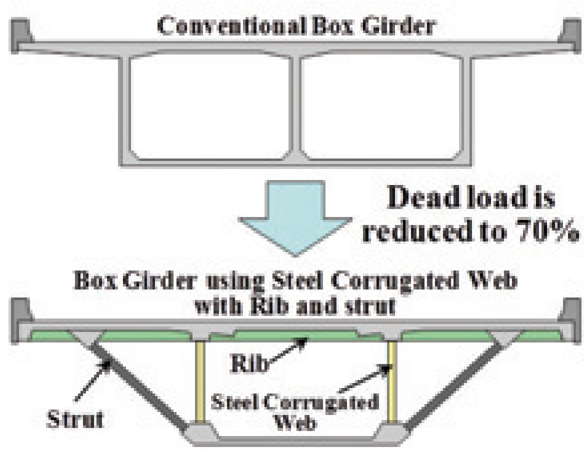

Figure 3 – Comparison of cross section

Photo 4 – Erection of the Yatomi Viaduct

Photo 5 – Furukawa Viaduct

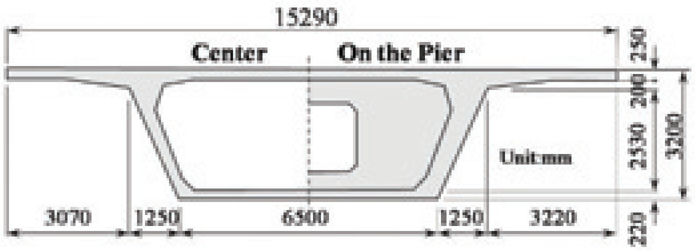

Figure 4 – Cross section of precast segment

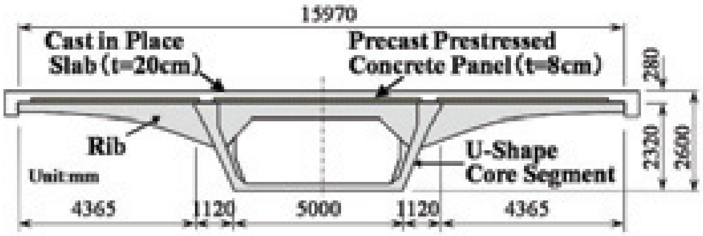

Figure 5 – Cross section of precast segment

that with shop fabrication, the largest segment that can be transported in Japan is limited to about 30 tons. For this reason we developed approaches such as using a cast-in-place system for the upper slab (Furukawa Viaduct) or joining two main box girders together with a double loop rebar joint (Kamikazue Viaduct). Figure 5 depicts the Furukawa Viaduct segment cross-section. Photo 5 shows the completed bridge.

Incremental launching of concrete-box girder bridges

Incremental launching enables concentration on the fabrication of the bridge girders in a casting yard before erection. This can improve the quality and reduce the impact on the environment. However, it is necessary to reduce the weight to facilitate erection and reduce the construction cost. Incremental launching was used for the Katsurajima Viaduct described above. As shown in Figure. 3, the use of steel corrugated webs, ribs, and struts enabled a significant weight reduction, but in order to further reduce the launching weight, a core segment (box section excluding cantilevered slabs) was launched first (Figure 6 and Photo 6).

Conclusion

New expressway construction in Japan has led to innovations that reduce the cost and time required for bridge construction. These innovations include hybrid structures that combine concrete and steel structures, cross-section designs that reduce dead load, and more efficient erection methods. Part of the new expressway is already completed and in service. The innovations are performing in line with expectations. It is still necessary to continue reviewing these initiatives to achieve additional efficiencies and further reductions in construction costs. However, we believe that initiatives like these in Japan provide useful ideas for bridge construction elsewhere. ■

Photo 6 – Incremental launching erection of Katsurajima Viaduct

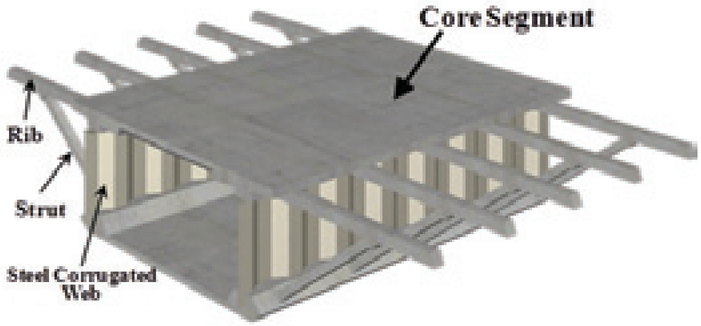

Figure 6 – Core segment

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