January 2020 ABC-UTC Webinar Featured Presentation: Use of ABC Techniques for the Samuel De Champlain Bridge		
#	**Questions**	**Responses**
	Design	
1	Can you comment on the 125-year design life information (how, etc.)?	**Why 125:** Targeted Long Life (lesson learned from performance of Old Bridge, Importance of the New Bridge, North American & World-wide tendency, Sustainable Development, eg. Confederation Bridge in Canada, Other Bridges of Importance, FHWA Guidelines for Tunnels looks at 100-125 yrs. with a trend towards 125 to 150 years. Initial prefeasibility studies looked at both Tunnel and Bridges options. **How**: Requirement for Durability Plans, Time to Corrosion Modelling, general principles of Fib Bulletin 34 Model Code for Service life design applied, integrated use of HPC (low w/cm), stainless steel reinforcement, increase in standard Truck load, fatigue evaluated over extended life, OMR (Operation-Maintenance Rehabilitation) addressed in a holistic approach (Design-Construction-Maintenance), minimization and sealing of cracks.
2	How did you determine the estimated life of this new bridge?	**Concrete**: Time to corrosion modelling (probabilistic), measurement of concrete transport properties, accelerated testing (ex. scaling resistance for example), avoidance strategy (use of high quality aggregates,etc.). **Steel:** Fatigue stress evaluated over the extended design life including fatigue in rebar, increase in standard truck model, attention to energy absorption properties of steel at low temperatures (i.e., appropriate notch toughness), etc. **General:** Specific exposure conditions examined for each component, integration of durability plan, durability expert, industry guidelines, best practices, adopted approach subjected to independent review/audit.
3	Service life is always a topic of discussions or controversy. How do you justify/ provide evidence of the 125-year life?	Please refer to the two questions above which are of a very similar nature.

4	What special specification was used to give an extended life for the bridge?	**Prescriptive requirements**: Stainless steel rebar, multi-layer defense (water-proofing membrane, HPC (low w/cm), low chloride ion-penetration value imposed (700 coulomb), good concrete cover, increase in standard truck model, requirement for structural health monitoring system, special attention assigned to concrete abrasion in splash zone, small crack widths and sealing of cracks required.
5	How was the 125-yr service life calculated? What structural elements are included in that value?	**How:** Time to corrosion modelling for chloride ion penetration (probabilistic approach), carbonation, fatigue analysis, estimation of cover loss due to ice abrasion, avoidance of deterioration (low or non-reactive aggregate). **Components:** As noted in the presentation, non-replaceable components (substructure, superstructure, deck slab) and also piles.
6	Construction / design were highly governed by the Request for Proposal restrictions. Being a design-build project, would you eliminate all these requirements next time?	From the engineering's design perspective, Definition Drawings were primarily driven by aesthetics and not by technical engineering. More flexibility might have been considered to achieve similar aesthetic objectives while simplifying the works. With that said, a bridge is more than just a structure, it is a gateway statement that the community wanted. From the Owner's Perspective: What-you-see-is-what-you-get. There was a commitment made to the community to deliver a bridge that the community wanted. The Owner is satisfied with the level of prescription. Some would argue we were too prescriptive and others not enough - a balance was thrived for.
7	What type of hydraulic modeling was used for this structure, and were there any concerns with scour potential around the piers?	3-dimensional hydraulic modeling of the river basin was performed. The St. Lawrence river is fast running. The presence of weathered rock was a concern for scour; however, an engineering design decision was made to bring the footing depths to competent rock (which was a few feet deeper), such that scour does not become a concern.
8	What were some difficulties that were encountered in the construction of the foundation, and how were they addressed or overcome?	Some challenges encountered during the foundation construction and their solutions include a) river current, it required deflectors to protect divers and offer a better tolerance for placement of footings; b) working in winter conditions with ice sheets, it required breaking the ice and protecting workers, c) environmental mitigation in particular turbidity in the water, which required turbidity curtains during the excavation of the rock bed.

9	Can you give some background about the lateral loading requirements for the piers and pylons and associated design challenges?	Lateral loadings include seismic, wind, ship collision, current loads, ice loading, as well as thermal loading due to temperature differential. In terms of governing loads, ship collision and thermal loading governed the marine foundations; while wind governed the remaining foundations.
10	Can we make a steel cable-stayed bridge (pure steel)?	Yes. But probably more expensive. It would likely require an orthotropic deck and stiffened steel box sections. Since the 80s, the use of jump form technology have made tall concrete towers more competitive compared to steel towers.
11	What software programs were used for design?	RM for design; Larsa for design of approaches; SOFiSTiK for independent design checks; CSI Bridge for approaches independent check and local finite element analyzes; ADINA for seismic time history analysis.
12	Was there any staged post-tensioning on the stayed cables during and after construction?	Yes. During construction the stays in both main span and the back span were stressed in multiple stages to avoid unbalanced load on the pylon. Toward the time of bridge closure, the stays were fine-tuned mostly prior to closure; while the remaining fine-tuning occurred after closure so that this activity is not on the critical path.
13	Was the bridge modelled to be tested in a wind tunnel?	Yes. Wind tunnel testing was performed extensively (state-of-the-art) and to industry best practices - which included critical construction stages and final stage. Bridge was tested to be stable against vortex shedding, fluttering & buffeting. 10,000 year-return-period wind was used for aerodynamic stability. Wind tunnel testing was also performed with and without the original Champlain Bridge due to its close proximity to the new Bridge.
14	What were the seismic design criteria considered during the design of the main bridge?	Bridge prescribed by Owner to be a lifeline bridge. Performance-Based Design Imposed. Required Non-Linear Time History. Designer adopted an essentially elastic design approach (bridge required to be repairable following a 2% probability of exceedance in 50 yr. event. Design requirements in line with most recent version of Canadian Highway Bridge Design Code. Best-practices used. Seismic Design subject to Independent review by seismic specialist.
15	When designing pylons and if logistically feasible, would 1000-ton precast segments add value to the overall build?	Yes; however, erecting 1000 tons at higher elevations becomes problematic and would require erecting a significant temporary tower.

16	Can you comment on the different types of ABC techniques used or considered for this bridge?	The ABC methods used were discussed in the webinar. In sum, it is the maximum use of precasting and prefabrication which allowed activities to be performed in parallel in multiple shops; while minimizing field construction as there were many restrictions on navigational channel and winter closures.
17	Please comment on challenges in coordinating the structural analysis, constructability, and architecture / aesthetics during the design processes.	With respect to architecture, Definition Drawings prescribed by the Owner avoided subjective debates on the final outcome of the bridge aesthetics. The prescribed architectural features necessitated the meticulous coordination between the design and construction teams on constructability and erection means and methods, and the bridge was engineered to achieve them.
	Construction	
18	Could you describe some knowledge learned during construction that would have changed the initial design?	The initial design for the W-pier cap was in precast concrete - later it was realized that it was too heavy for practical forming and erection and would occupy valuable and limited laydown area at the site. We worked with the contractor to switch from concrete to steel. Another example was the back-span design - originally the back-span was to be built in large, long segments on the temporary jetty and then lifted into place; later on, the backspan was built in smaller segments using temporary supporting towers.
19	To what extent was the contractor involved in the design phase?	It is a Design-Build contract so the constructor is heavily involved in both the bid and design phase - Fabricators as well are involved during the construction phase (close collaboration between designers and fabricator allowed for the high optimization of connection details, particularly along approaches). This is a major advantage of DB - Designers, constructors and fabricators work together.
20	Can you elaborate on postponed delivery, schedule challenges, delays related to not meeting the design standards during construction, and extra costs?	Schedule was important due to the condition of the original bridge. We knew the schedule was challenging going in. Important liquidated damages were tied to delivery ($100 k per day first week, $400 k per day afterwards). One construction milestone payment, remaining payment tied to reaching substantial completion with certification by the independent Engineer. Payment made for acceleration measures following agreement to account for labor pressures, new heavy load restrictions on existing bridge and network wide transportation issues for special permits.
21	Please discuss the construction process with form travelers at the cable-stayed bridge.	No form travelers used. Steel structure. Heavy lift for main span using dynamic lifting frame. Erection of back span on temporary towers.

22	What were the specifications for precast concrete, including any fabricator/supplier qualifications to ensure quality precast products?	Standards Council of Canada, Precast concrete - materials and construction, CSA A23.4 imposed. Components were to be fabricated by a certified precaster. Temporary precast plants on site also needed to be certified.
23	Was UHPC used in the deck joints? Was an overlay installed on the deck?	UHPC was not used in deck joints. Conventional HPC with properties similar to parent concrete was used by the contractor. Stainless steel rebars were used; loop bars were used for development length. Yes, an asphalt overlay was used along with a waterproofing membrane. The overlay was thicker than typical to allow for adjustment to achieve final desired elevation and to meet IRI (International Roughness Index) target values for smooth ride.
24	Why are different colors of polystyrene used on the bridge?	Minor deficiency: Not what the Designer or Owner expected. No structural purpose (not related to stiffness of bedding material).
	Maintenance	
25	Could you introduce the structural health monitoring system for this bridge?	Significant: Over 400 instruments, including strain gauges, corrosion sensors, displacement sensors, stress sensors for all stays, triaxial accelerometers, GPS, tilt meters, temperature sensors, solar radiation sensors, stray current monitoring, weather stations, weight-in-motion, etc.
26	How has the stay cable de-icing system performed to date?	Too early to tell at this time. We are watching closely. Not aware of problems to date, including during construction phase. The operator appears satisfied to date with the system.
27	What considerations were taken for the inspection and maintenance of this bridge?	RFP was very prescriptive in this respect. Includes elevators in tower, shuttle in box girders, under bridge inspection gantry (traveler), cable gantry and unmanned cable robot for stays, staircases and ladders in piers, electrical lighting system in components.
	Cost	
28	Please address the cost of the project.	The information that we are able to provide is given in Slide no. 3. As noted during the presentation, the main bridge (component B1) accounts for approximately 63% of the project costs, with the Nuns' Island Bridge 9%.
29	Please discuss potential claims emanating from ABC. Settlement vs. benefit.	This question is commercial and hypothetical in nature; the panelists are not in a position to respond.

30	What was the estimated time savings achieved by using precast elements? What were the economic benefits of utilizing ABC?	The estimated time saving is difficult to quantify. To put things in perspective, the bridge took only 48 months from design to opening to traffic; it would not have been achievable without the use of ABC.
31	What would you do differently now that the bridge has been opened to traffic? What would be the main lesson learned from the project?	Slide 53 of the presentation summarized a few key takeaways. Please refer to the recorded webinar.
	Questions during Webinar	
32	What was the longitudinal steel reinforcement ratio in the towers?	For the reinforced concrete upper tower segments, the reinforcement ratio is in the order of 2%. For the prestressed concrete lower tower segments, the steel ratio is about 150 lb./ CY.
33	What was the moment magnification factor for the top portion of tower legs?	The effect of axial load on moment was accounted for in the PM (axial-moment interaction) calculations used for the design of the tower legs.
34	How was the bid value for T.Y. Lin compared to COWI's team?	This is commercially confidential information. We are not in a position to divulge cost comparison.
35	Is there uplift at the W01 bearings?	There is no uplift at the service condition; there was counterweight in the backspan to avoid uplift on W01 under service condition.
36	What was the reasoning behind the asymmetric cable-stayed span / configuration?	The asymmetric cable-stayed span configuration was driven by the architectural vision. The architect felt that by having an asymmetrical span, focus would be on the longer main span, whereas with a symmetrical structure, focus would be on the main span tower.
37	What type of steel was used for the pier caps? What coating was applied?	**Steel:** 350 WT notch tough weldable steel was used for the pier caps with good energy absorption properties at low temperatures (toughness). Steel fabrication and welding for pier caps had to meet fracture critical requirements. **Paint:** A three-coat paint system is used for the exterior surfaces (inorganic zinc, epoxy, polyurethane) with a high brilliance. The interior is a two-coat system (zinc and epoxy) since UV is not an issue for interior surfaces.
38	MS09 was actually erected in less than 15 days!	Mr. Guitard was responsible on site for the construction of the Cable Stayed Bridge section and greatly contributed to the success of the project.

39	What software did you use for analysis of the cable supported portion?	Refer to Question 11 above.
40	Was the bow tie section of the tower cast in place?	The bow-tie was precast on ground in three pieces and lifted in place at its final location on the tower.
41	Was it not necessary to use cross ties between the towers above the bow tie?	It was not necessary to have a cross-tie because the actual configuration was designed for. The need for cross ties was looked at carefully, especially for wind loading; it was designed to 1 in 10,000 year wind to ensure that there is no vibration issue.
42	What material(s) was used to fill the gap between precast concrete deck panels?	Refer to Question 23 above.
43	Were fiber-reinforced polymer (FRP) reinforcing bars considered as an option prior to stainless steel (SS) bars being selected?	In light of the 125-yr design requirement and the critical nature of this bridge, including the need for threat mitigation, the Authority specifically specified stainless reinforcement in strategic locations. The Authority, however, did not prevent the use of FRP in other replaceable components of the bridge. For example, some GFRP (glass-fibre reinforced polymer) was used in combination with the stainless steel reinforcement in the barriers of the Nuns` Island Bridge. The Canadian Highway Bridge Design Code permits the use of FRP, but this code is calibrated to a 75-yr design life.
44	For durability, has FRP reinforcement been considered?	As noted above, in light of the 125-yr design requirement and the critical nature of this bridge including the need for threat mitigation, the Authority specified stainless reinforcement in critical locations. The Authority, however, did not prevent the use of FRP in other replaceable components of the bridge. For example, some GFRP (glass-fibre reinforced polymer) was used in combination with the stainless steel reinforcement in the barriers of the Nuns` Island Bridge.
45	Has access for regular inspection and maintenance been considered and accommodated?	The RFP was very prescriptive in this respect. It includes requirements for elevators in the tower, shuttle in box girders, under-bridge inspection gantry (traveler), cable gantry and unmanned cable robot for stays, tower inspection cradles, staircases and ladders in piers, designated walkways in box girders, electrical lighting systems inside bridge components. Stainless steel anchors are also required to facilitate inspection by rope climbing techniques. The Private Partner was also required to develop a bridge access and maintenance plan.

46	There were many mentions of efforts to keep various items off the critical path. What items were on the critical path?	Foundations, steel pier caps, then the approaches, the superstructure deck panels, and the cable-stayed bridge erections were happening on paralleled paths; later it was the cable-stayed bridge and, therefore, there was a mitigation measure performed to accelerate the bridge closure.
47	Would designing the entire structure straight, instead of the curve, save a significant amount of money?	The cable-stayed bridge is on a tangent (straight); the approaches have very large radius, gentle curve. The "kink" is taken in fabrication. Therefore, there is no significant impact or difference in cost.
48	Why didn't you use a precast section for the top portion of the tower?	Each upper tower segment contains the "cable link beam" which serves as anchorages for the stays. While the upper shafts are cast-in-place (CIP) segments, each segment is preassembled with the link beam, the reinforcements, and the bracing frames in place on the ground. Each preassembled segment is lifted and placed on top of the preceding segment by stacking the bracing frames. Finally, concrete is poured in place within the self-climbing jumpform in a controlled environment. Thus, although CIP, modular construction was used - each one of the 15 jumps at each north and south tower shaft advanced every two weeks - accelerated the upper tower construction and took it off the critical path.
49	Did you really need to have the W01 pier?	Yes. W01 pier is needed for the support of the cable-stayed bridge. The span would have been too long for the superstructure depth (which is required to be constant) to accommodate the configuration without W01 pier.
50	With the cable stay arrangement, did you allow for lateral forces in the pylon?	The asymmetrical stay cable arrangement was driven by aesthetics. The stay stressing sequence was designed and implemented to minimize the temporary unbalanced lateral forces in the pylon. The backspan has counterweights to balance the loads on the pylon.
51	Drainage was a major problem in the old bridge. How will the new bridge take care of this?	The new bridge has good cross-falls, a waterproofing membrane, an extra thickness of asphalt and an elaborate drainage system. All water is channeled through a piping system that runs inside the box girders (where easy access is provided to carrier pipes) and then inside the tower legs. Water is discharged very closely to water level or ground level, avoiding spillage onto the infrastructure to the extent possible. Also, the number of expansion joints have been limited to 8 (including the two at the abutments) compared to some 57 expansion joints on the existing bridge. Exposed drainage pipes are made of stainless steel, whereas those protected inside the structure are made of suitable thermoplastics.

	Additional Question	
52	What are the federal bridge inspection requirements for the new bridge?	Bridge inspections will generally follow the Quebec Ministry of Transport (MTQ) inspection requirements with special adaptations defined in the Project Agreement which take into account the size of the bridge, its importance and the expected conditions at handback (30-year PPP concession). This consists of annual inspections (visual examination of the main elements of the structure each year), general inspections (material evaluation and structural performance evaluation of components) which systematically examines all elements of the structure (hands-on inspections on a four-year interval or alternatively 25% of the bridge each year), underwater inspections (on a 10-year interval, or following flood or detection of scour), scour inspections (annually for the first five years and then every five years) and special inspections to clarify any structural deficiency or following an extreme or exceptional event such as an earthquake or vessel collision. Special inspections are also required by a Handback Independent Engineer, including physical examination of stays and evaluation of remnant life of components.