

## Highlights

- **A RECORD SPAN CONSTRUCTED IN RECORD TIME FOR A RECORD LOW COST PSF**
- **UNEXPECTED INDUCED ADT ON ALEX FRAZER BRIDGE CREATES ALRT BRIDGE**

# SPANS



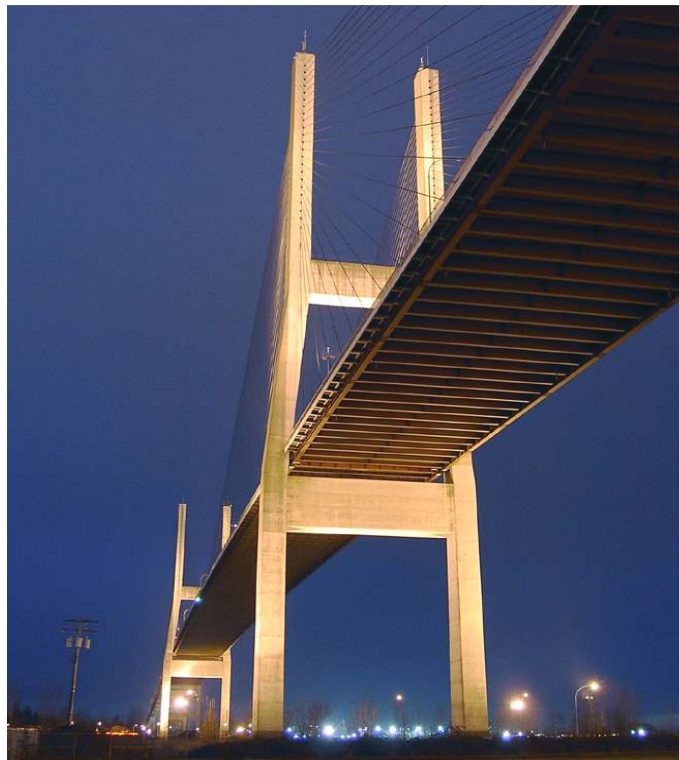
Public Works Department  
Bridge Team

*The Quarterly Newsletter of Inspired Bridge Technologies*

*July 2008, Volume 6*

## '86 WORLD RECORD SPAN IN 27 MONTHS

The Alex Frazer Bridge carries the Annacis Highway 91, in a north – south direction, from the community to the southeast, Delta, 200' high across the main channel of the Frazier River (Figure1) on a 5% grade to Annacis Island. The still elevated Route 91 continues across the island and the lesser, northern channel of the river and touches down on the north bank where it divides into the northwest connector to the City of Richmond with Highway 99 leading north to the urban center of Vancouver. Correspondingly, at this touchdown point, Highway 91 connects bridge traffic to the northeast and the cities of Burnaby and New Westminster on Highway 91A.



**FIGURE 1: Eight foot deep, cable-stayed, steel plate, edge-girders receive transverse steel floor beams in overhead view of superstructure.**

The Frazier River reaches north

850 miles from the bridge into the Rocky Mountains and its source at the continental divide. This river drains the mountain slopes of some of the richest timberland in the world. Harvesting this vast timber resource is vital to the economy of the Canadian northwest and getting this product to market is facilitated when the logs are transported down river in huge rafts that pass under

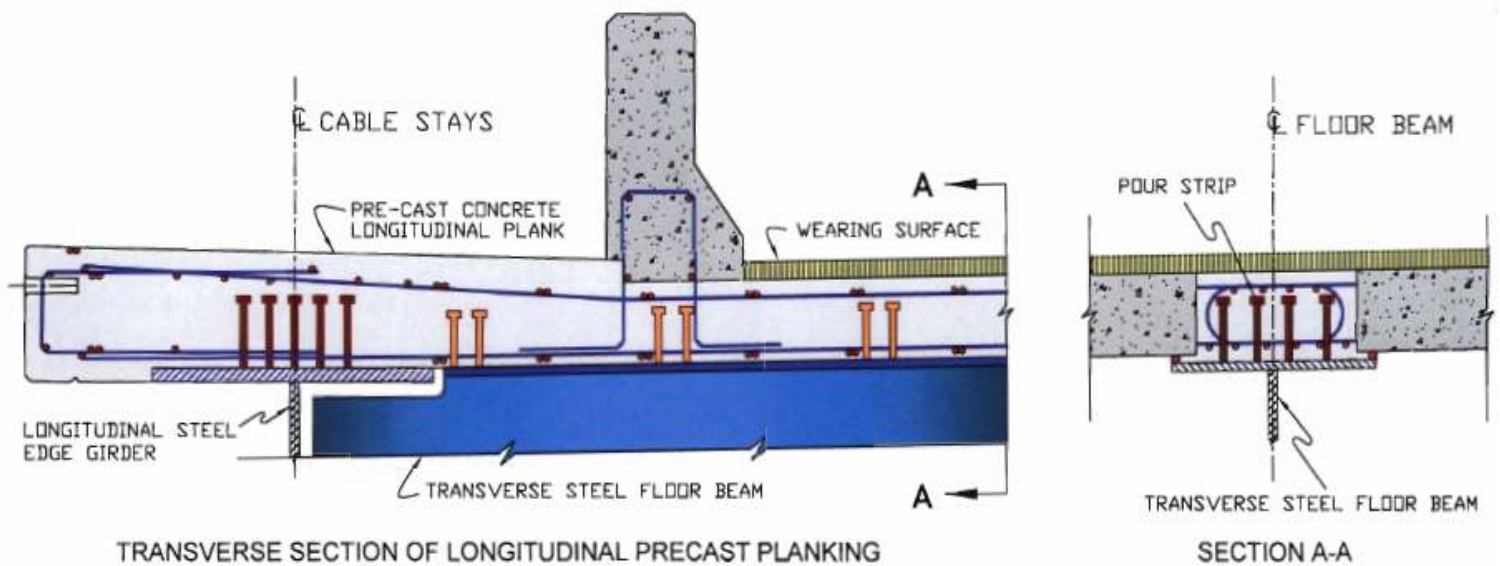
the bridge's main span for processing and distribution in the river's delta country. Additionally, the bridge is a vital link in the Annacis Highway 91 connection to Interstate 5, just south east of the river.

Immediately upstream of Annacis Island the Frazier River splits in two forming the North Arm of the Frazier River which radiates into the river delta. The stream

velocity is consequently reduced causing the release of waterborne, particulate mater. The accumulation of this sediment on the river bottom over thousands of years causes the formation of features such as what we today call Annacis Island. All six of the mainspan piers are founded on steel, pipe piles which are driven into these dense, sedimentary materials. This material is found near the ground surface on the south bank but, on the island, the piles had to be driven to depths of 275' to reach the dense material.

The Canadian Provincial Government of British Columbia (BC), Ministry of Transportation and Highways, selected Canadian engineering groups; CBA-Buckland and Taylor to design a steel alternate and Bush

Bolman and Partners to design the concrete alternate for this 3,052', major bridge segment of the Annacis Highway Project. Coincidentally, the long standing river name comes from the 18<sup>th</sup> century explorer Simon Frazer who helped open the area to development. The bridge's namesake, Alex Frazer, served as the B.C. Minister of Transportation for eleven years until his untimely death in 1989.



**FIGURE 2: Transverse Section: Longitudinal, composite, pre-cast concrete deck-plank bears on floor beams. Section A-A: Pour-strip on top of transverse floor beams render pre-cast plank composite and continuous.**

The New York City engineering firm of DRC Consultants Inc. was hired by Larry Bush, of Bush Bolman, as a cable stayed bridge design consultant. The ensuing designs evolved and were advertised with the Ministry receiving bids on January 18, 1984. The joint-venture of Dillingham-Jones was the only concrete bid (Figure 5) received at \$60,109,976 (Canadian), \$45,082,482 (US) and the winning bid was by the joint-venture of PCL-Pashen-Pike at \$45,754,806 (Canadian), \$34,316,104 (US). The 6,050 tons of weathering steel used to fabricate the plate girders that provided the framing for the composite deck girder superstructure were imported from Japan. All of the deck steel was fabricated in Delta, British Columbia by Canron.

The 105'-0" wide, cable-stayed deck covers five spans with the then world record main span for cable stayed bridges of 1,526'-0" centered between two side spans of 600' and with the most outboard spans of 163' for a total deck length of 3,052'. The two 505' tall, twin legged towers splay 192 steel cable stays in two vertical planes radiating in a fan pattern from the north and south tower faces of the four upturned legs. Twenty four stays from each tower face are attached with equal spacing to the 8'-0" deep, steel plate, edge-girders which support the transverse steel floor beams (Figure 1).

Pre-cast concrete deck panels are oriented north and south and span between the transverse, steel floor beams (Figure 2, Transverse Section) and are locked together with looping reinforcing steel dowels across a pour-strip on top of the floor beams (Figure 2, Section A-A). This pour-strip has shear connectors which make the pre-cast decks composite with the structural steel deck framing once the pour-strip is filled

with concrete and cured.

Mr. Peter Sanderson, then with PCL, was a hard driving construction manager who met with a post-tensioning material supplier in Vancouver and subsequently they went directly to New York City to resolve certain construction issues to expedite the work on his job. The Director of



**FIGURE 3: All eight "work stations" are evident at the tower-heads coupled with the four derricks at the leading edges of the balanced deck erection.**



**FIGURE 4: Mid-span derricks assemble steel deck framing.**

Project Development for DRC Consultants, Inc discovered that they were staying at the New York Hilton but did not know the precise time of arrival. He sat in the lobby looking for his friend, who accompanied Mr. Sanderson, for four hours until they showed up to register. Consequently, in an expedient move, DRC got the contract from PCL to analyze the construction stages and provide the camber curves for this record setting span.

Once the 50 story reinforced concrete towers were in place, the steel edge girders were hoisted, positioned and attached, piece by piece (stick fashion) by deck mounted, stiff legged derricks located at all four leading edges of the progressing, cable-stayed, composite deck superstructure (Figure 4). Sequentially, the transverse floor beams were installed and the stays were attached. The precast concrete deck planks were hoisted and placed onto the steel floor beams in a way to maintain the balancing sequence about each tower (Figure 3). Lifting from the grade at the tower bases was effected by crawler cranes which could put materials on the deck for distribution out to the four advancing deck edges as needed.

Somerset Engineering supplied construction engineering services which included the supervision of their erection scheme and they designed enclosed, self climbing “work stations” on the tower legs to facilitate all weather installation of the stay anchors to the tower heads, reaching up to 50 stories above

the river. Furthermore, they devised a track system to anchor and advance the four, stiff legged derricks (Figure 4) at the leading edges of the cantilevered, steel and composite, pre-cast plank deck system. To further stabilize the cable stayed deck, while it was being assembled, they devised a temporary set of “bob-stays” which were added to the bottom of the edge girders and drawn back to be anchored down at the tower bases. The entire superstructure was installed in only 10-1/2 months using single shift labor.

The Annacis Highway 91 was opened to traffic in 1987. The 3,052’ of bridge was completed ahead of schedule in 1986, in a remarkable 27 months. This construction feat is a testament to the contractor’s selection of knowledgeable technical support, his choice in ordering and scheduling of materials, his selection of prideful, dedicated, local subcontractors and his strong, dynamic management and administration of these diverse capabilities. Additionally, the design for this cable-stayed bridge set the record for the longest span of this type of structure in the world in 1986.

The Average Daly traffic (ADT) for

the Annacis Highway 91, when opened to traffic, was 41,900 vehicles. The bridge was striped for four lanes of vehicular traffic and two lanes for pedestrians and bicycles but, in just one year, it became apparent that the anticipated growth in traffic was grossly underestimated so, the decks were repainted for six lanes of vehicular traffic. The pedestrian and bicycle traffic was then; consequently, relocated to the outside of the two plains of cable-stays.

Nevertheless, in only another 5 years the ADT had jumped to more than 100,000 and the realization sank in that the modest expectation of growth in thru traffic was far exceeded by the unexpected growth in induced development to the area by the Annacis Island Vehicular Bridge. This realization led BC Transit to wisely and quickly expand their operations into these new suburbs south of the river so they built the ALRT Skytrain, cable-stayed bridge to carry two commuter train tracks into the area a short distance upstream from the Alex Frazer Bridge.



**FIGURE 5: The iconic, concrete alternate by Bush-Bolman only remains with this artistic rendering.**

# Guest Commentary

By:  
**SIMON HAGEDOORN**

## The I-4, Multi-Use, Trail Overpass

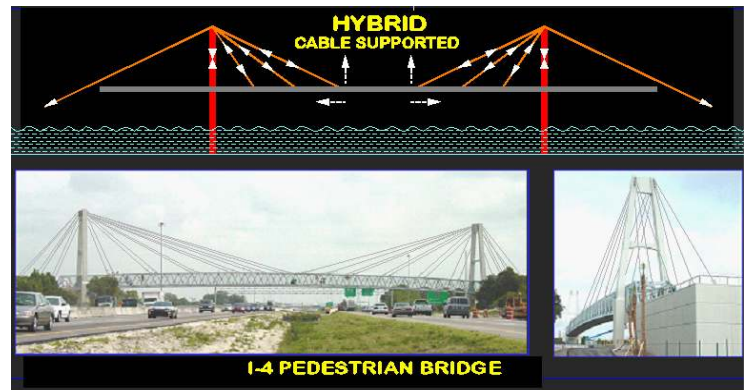
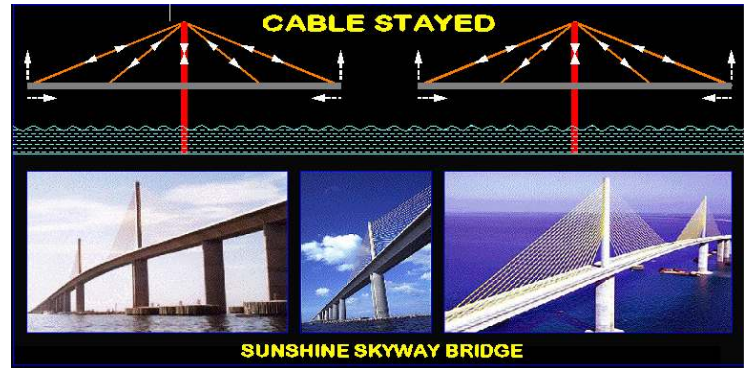
In 1998, the Public Works Department of Seminole County determined that it would be beneficial to provide a link between the Cross Seminole Trail and the Rinehart Road Trail in Lake Mary, Florida. These existing multi-use trails were separated by I-4 which created a barrier between the two trail systems. In providing a connection between each trail, the County would be able to create a continuous trail system that linked the entire County.

The County concluded that an I-4 overpass could be constructed, within an existing utility corridor that connected both of the trails. In order to provide flexibility for future widening of the Interstate, it was determined that it would be desirable to span the entire Interstate Right-of-Way with no intermediate foundations. This resulted in a span requirement in excess of 350 feet for the proposed crossing.

Based on the sizable span length, several feasible bridge systems were considered including a through style arch, a through truss, a suspension style bridge (similar to the Golden Gate Bridge), a traditional cable stayed bridge (similar to the Sunshine Skyway Bridge), and a hybrid cable stayed bridge. Simply supported truss alternatives were considered for the original concept; however, they were not structurally feasible if they were to be proportioned at a depth between truss cords based on the clear unobstructed height of 10 feet required for the trail.

Based on the 350 foot dimension, a simply supported truss span would have required a minimum depth between the top and bottom cords of the truss of approximately 40 feet. Structural systems including simply supported steel and concrete girders were deemed to be not feasible based on the span length requirement. After careful consideration of the site constraints, aesthetics, constructability and construction economy it was decided that a hybrid cable stayed bridge would be the optimum alternative for the crossing.

The proposed, hybrid, cable supported bridge would combine elements of a traditional suspension bridge with those of a balanced cantilever, cable stayed bridge. The proposed system was similar to a suspension bridge in the use of a fixed anchorages used to hold down the back-span stays at each abutment of the bridge. The system was similar to a traditional cable stayed bridge in the use of inclined stay cables that were supported by each pylon to provide an upward lifting force component in the main-span. The combination of the suspension system and the traditional cable stayed system resulted in a notably different resolution of forces throughout the bridge that were well suited for the site and constructability concerns over the heavily traveled I-4 roadway.



Optimization of the hybrid cable supported system resulted in the main-span pylons having an overall height of 95 feet, a main-span length between pylons of 373 feet, stay spacing varying between 24 to 36 feet and anchorage weights of 2,400,000 pounds. A Warren Style Truss matching the clear height required for the trail with a cast-in-place concrete deck was used to resist lateral forces generated by wind. The final configuration was evaluated with nodal analysis to ensure there would be no problems associated with pedestrian induced vibration or wind initiated aeroelastic instability. The bridge was constructed in 15 months for a cost of \$3,400,000 including the elevated approaches and connecting trail construction. The bridge was opened to trail traffic in June of 1993.

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