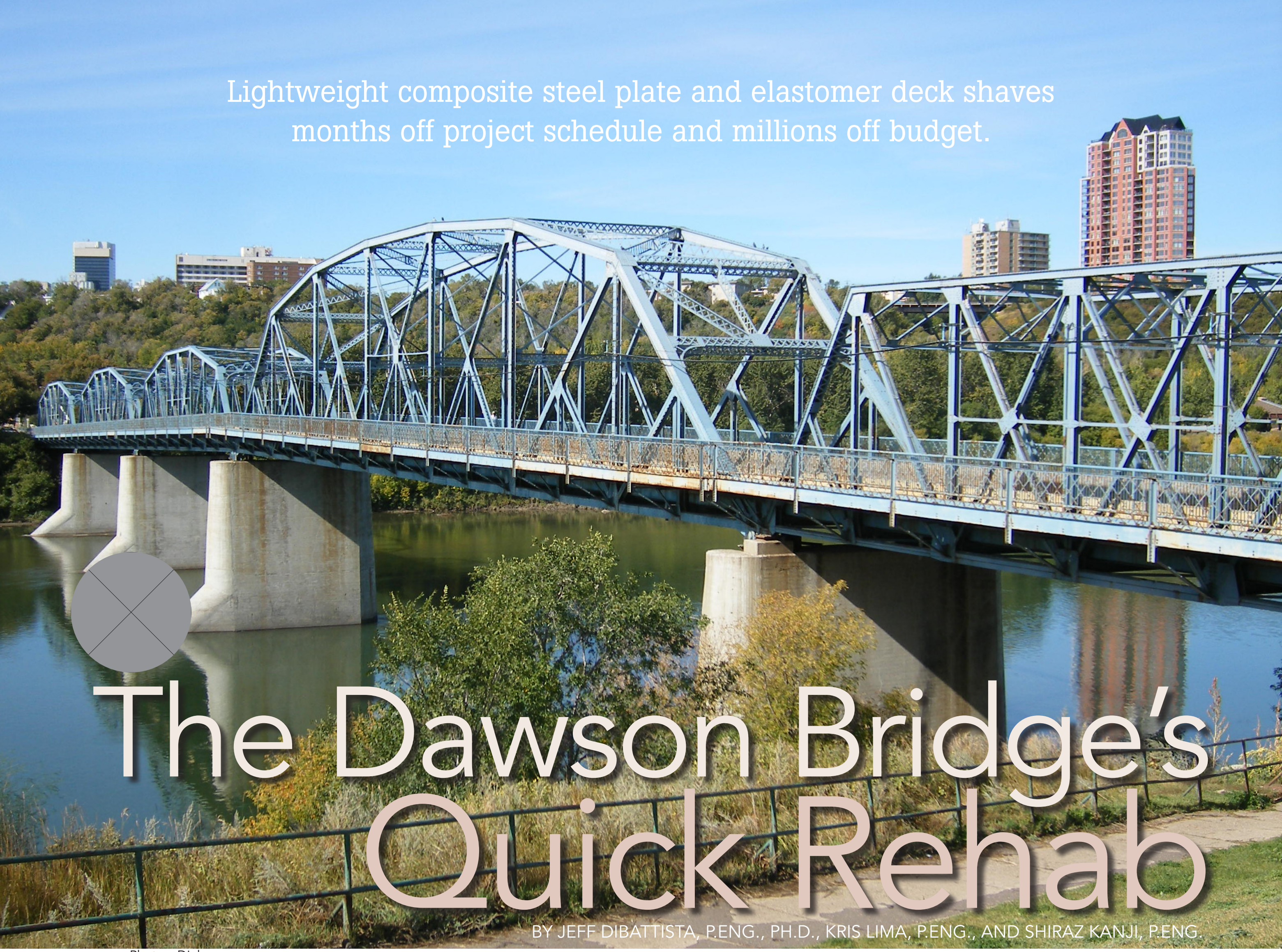
Lightweight composite steel plate and elastomer deck shaves months off project schedule and millions off budget.



The Dawson Bridge's Quick Rehab

BY JEFF DIBATTISTA, P.ENG., PH.D., KRIS LIMA, P.ENG., AND SHIRAZ KANJI, P.ENG.

Photos: Dialog

CITY OFFICIALS RECENTLY were able to both save a historic Edmonton bridge and avoid massive structural repairs and upgrades by opting for a lightweight steel deck system overlaid with asphalt instead of the traditional concrete replacement deck. The system uses composite panels consisting of steel plates with a solid elastomeric core. Although the material has been used in shipbuilding for years, its use in bridge construction is relatively new. In addition to providing an effective and economical solution, using this steel deck system also cut construction time significantly.

Bridge History

The North Saskatchewan River winds its way from the Rocky Mountains, across Alberta, and through the heart of Edmonton on its way toward Lake Winnipeg. Its shores have been populated at Edmonton by aboriginal peoples for millennia, with the first European influence appearing in the late 18th century. During World War II, Edmonton acted as a staging area for construction of the Alaska Highway, and today is the capital of Alberta with a regional population of over one million.

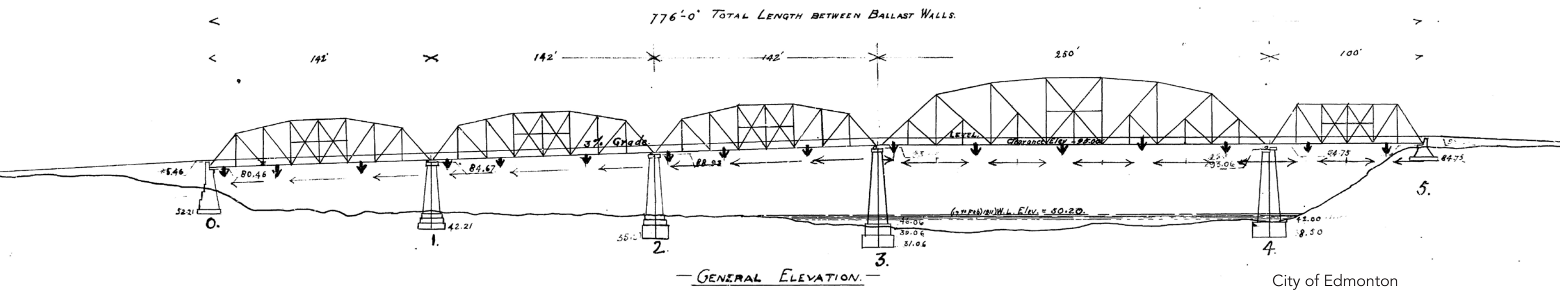
Historic Dawson Bridge has been a vital link for the people of Edmonton for generations, entering its 100th year of service in 2011. Originally known as the East End Bridge, it is a five-span riveted steel through-truss with a clear width of 26 ft, 8 in. and a total length of 776 ft: three spans of 142 ft, a navigation span of 250 ft, and an east approach span of 100 ft.

Originally constructed to carry horse-drawn wagons and electric trains to the Dawson Coal Company mine located on the east bank, the bridge opened on October 8, 1912 with a construction cost of $145,000. Only the second bridge to cross the North Saskatchewan River at Edmonton, Dawson Bridge quickly became a vital link for the city's growth, allowing coal to be transported quickly into the heart of the city for industry and home heating.

After closure of the Dawson Mine in 1944, the bridge was converted to carry only highway vehicles. Today, the bridge has one lane of traffic in each direction and accommodates about 17,000 vehicles each weekday. As a link to Edmonton's extensive multi-use river valley trail system, the two sidewalks on Dawson Bridge serve many pedestrians and cyclists.

Condition Assessment

In 2007 the city of Edmonton commissioned Dialog to conduct a condition assessment for Dawson Bridge. Field inspection revealed the nearly 100-year-old superstructure in need of significant repair, including total replacement of the bridge deck and complete recoating of all steelwork. Structural analysis also identified numerous truss members requiring strengthening or



City of Edmonton

General plan from 1913 of the East End Bridge, now known as the Dawson Bridge, in Edmonton, Alberta, Canada.

With an overall length of 776 ft, the Dawson Bridge consists of five simply supported trusses that cross the North Saskatchewan River on the east side of Edmonton.

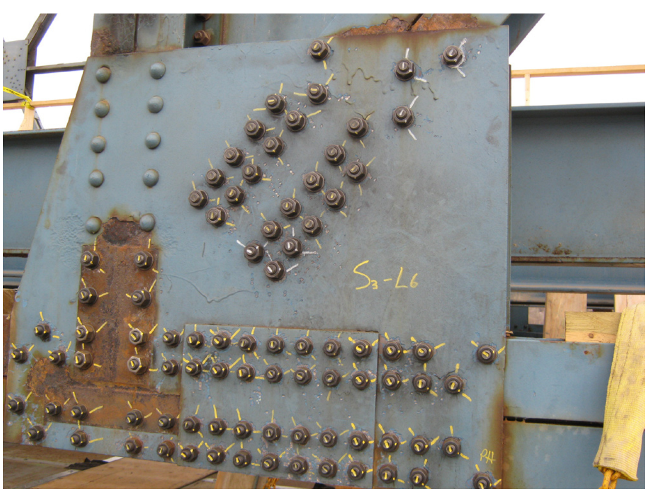
replacement in order to increase the service life of the bridge and meet the target reliability indices of the *Canadian Highway Bridge Design Code 2006*. In addition, the original narrow sidewalks—only 5 ft wide—caused safety problems due to mixed use by pedestrians and cyclists.

Especially problematic was the existing 6½-in. steel-fiber reinforced semi-lightweight concrete deck, cast in 1986 on top of old timber subdecking from the 1940s. Though its relative light weight was beneficial for limiting dead loads, the thin concrete deck was too flexible to resist cracking. In particular, the city had continual maintenance problems with the methyl methacrylate membrane wearing surface at details where the concrete deck passed over the transverse floor beams. The concrete deck section was reduced to only 2½ in. thick to clear the top flange of the floor beams, making it nearly impossible to control cracking.

As part of the assessment, a load rating of Dawson Bridge was conducted using a 4-axle, 63.5 ton Alberta CS3 rating vehicle, the largest vehicle that might practically access the bridge considering its vertical clearance restrictions and location. That assessment concluded that numerous truss members required strengthening or replacement to meet the required level of safety and to extend the life of the bridge.

As options for rehabilitation were developed, it became clear that the bridge could be rehabilitated economically only if a lightweight deck replaced the existing deteriorated deck. A traditional concrete deck would require costly replacement or strengthening of many truss members along with difficult

The Dawson Bridge rehabilitation included upgrading critical connections by replacing the original rivets with high-strength bolts.



A hydraulic jacking system was used to relieve the load on truss members in need of strengthening or replacement as the work was performed.

Jeff DiBattista, P.Eng., Ph.D., is a principal and Kris Lima, P.Eng., is an associate with Dialog, an integrated design firm specializing in engineering and architecture. Shiraz Kanji, P.Eng., is chief bridge engineer for the City of Edmonton.



▲ The old, deteriorated concrete deck was sawcut and removed in March 2010.

◄ **Top left and inset:** All members were blast cleaned in preparation for applying a three-part zinc/epoxy/urethane coating system, providing protection well into the bridge's next century of service.

► Fabrication of the SPS components, which consist of two ⅜-in. steel plates connected with perimeter bars and continuous fillet welds then filled with a liquid elastomer that quickly solidifies.

upgrading of existing connections. Additionally, it might overload the piers, abutments, and foundations. The design team concluded that replacing the existing semi-lightweight concrete deck with a lightweight steel deck would allow the dead load savings to be applied to carrying additional live load and widening the sidewalks. Only steel offered viable lightweight deck options: grating, orthotropic deck, or an innovative composite steel plate and elastomer system called the Sandwich Plate System (SPS) developed by Intelligent Engineering (Canada) Ltd.

Grating was quickly eliminated as an option for the deck because increased road noise would be detrimental to the nearby Riverdale community. Orthotropic steel deck was judged a suitable option, but detailing would be challenging where the deck had to clear the tops of the floor beams without raising the grade line. There also were concerns about its susceptibility to fatigue cracking. After considerable research, the design team recommended the patented SPS solution, judging that SPS technology offered the best combination of light weight, thin profile, and ease of erection for the Dawson Bridge Rehabilitation project.

Innovation and Risk Control

The SPS composite steel plate and elastomer system was originally developed by UK-based firm Intelligent Engineering Ltd. for ship hulls and decks in the marine industry. Application of this technology in the bridge industry began about a decade ago. After its use on several bridges around the world, SPS technology is gradually gaining acceptance by bridge engineers.

SPS makes use of two relatively thin steel face plates connected by an injected thermosetting elastomer core. The final product is a composite panel with high stiffness and strength, but relatively low weight.

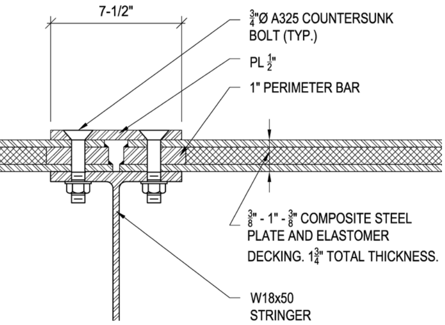
Deck panels are fabricated in the shop using conventional steel fabrication techniques. First, solid "perimeter bars" are welded along each edge of the bottom plate using a continuous fillet weld. The top plate is then lowered onto the perimeter bars and fillet welded all around forming a panel with a sealed void. The liquid elastomer, which cures into solid form within an hour, is injected through a port to form the core. For Dawson Bridge, the ⅜-in. steel face plates sandwich a 1-in. elastomer core, forming a composite deck panel with a total thickness of only 1¾ in. These prefabricated panels are typically 6 ft, 1 in. wide and 28 ft long.

Risk is inherent in the application of all new technologies in all industries. Perceived risk and its associated liability often dissuade engineers from trying innovations that might advance the state of the art in their area of practice. Potential liability places a constriction on the pace of innovation that, in the long run, is most often a disservice to society. Striking the right balance between innovation and risk control is the key to success. Thus, when Dialog recommended SPS—a relatively new technology—to the City of Edmonton, that recommendation came with the proviso that an intensive risk control program must be implemented, especially because Dawson Bridge is an important and expensive asset. As a progressive bridge owner, the city welcomed that innovation and directed the design team to proceed with SPS as the basis of design for the deck.

The risk control plan developed for the deck comprised six key elements:

- Extensive background research in the available literature;
- Site visits by the design team to other bridges with SPS decks, and interviews with the bridge authority managing those structures;
- Development of improved connection details in consultation with Intelligent Engineering;
- Fatigue testing of full-scale sample connections in the laboratory;
- Enhanced quality control and quality assurance programs during deck fabrication and erection; and,
- Monitoring of deck performance over the lifetime of the bridge as part of the Edmonton's bridge maintenance program.

Dialog judged the most important aspect of the risk control



Deck connection detail, showing A325 bolts countersunk into the top connection plate while the beam flange serves as the lower connection plate.

Laboratory sample of a typical steel plate and elastomer connection detail for the Sandwich Plate System.

SPS deck construction sequence: A) Steel deck in place; B) The surface is grit blasted; C) The steel is covered with a waterproof membrane; D) The asphalt wearing course is placed.

Placement of one of the SPS 6 ft by 28 ft deck pieces on the Dawson Bridge in August 2010.

plan to be the development of new connection details between adjacent SPS deck panels. Of the handful of bridges around the world built using SPS technology, all have involved significant field welding—a method that is costly and makes quality control difficult. Risks associated with field welding include fit-up out-of-tolerance, the potential for excessive heat input that might debond the elastomer from the steel, and undesirable weld flaws that might inadvertently result in premature fatigue cracking.

Taking to heart the golden rule "shop weld and field bolt," the Dialog design team developed unique bolted details for connecting the SPS deck panels that completely eliminate the need for field welding. Bolted connections drastically increase speed of erection, significantly reduce cost, and improve fatigue performance from Detail Category D (depending on the specifics of the weld geometry) to Detail Category B when using slip-critical connections.

To connect adjacent SPS deck panels, a top splice plate is fastened by a single row of countersunk pretensioned ¾-in. ASTM A325 bolts. Countersunk bolts provide a flat surface for the finished deck, except for the thickness of the splice plate itself. This surface, once grit blasted, is prepared to receive a waterproof membrane and asphalt.

Longitudinal deck splices are designed to align with floor stringers below. This arrangement enables the top flange of the stringers to act as the bottom splice plate for the connection, saving both weight and complexity. The new stringers chosen—W18×50—are larger than required for flexural strength but offer a flange wide enough to accept a row of bolts on each side of the web. At transverse deck joints, located away from floor beams to avoid clashes, bolted splice plates are used both top and bottom. In all cases enough bolts are used so that sealing requirements are met and negative moments in the deck can be transferred across the supporting stringers. This very simple approach to connections makes the deck very easy to fabricate and simple to erect. Using similar bolting details, the traffic barriers along the length of the bridge are also bolted down through the deck to the edge stringer.

Also as part of the risk control plan, three small 1:1-scale samples of the longitudinal bolted deck connection detail were built and tested under fatigue loading at the University of Alberta with the assistance of professor Gilbert Grondin, P.Eng., Ph.D. Those tests demonstrated that the new connection detail can withstand fatigue loads nearly double in magnitude to those expected in actual in-service conditions.

Reaping the Benefits of Innovation

Because the composite steel deck panels could be fabricated entirely in the shop and bolted quickly into position on the bridge, erection of the deck was completed in only six weeks during July and August 2010. This speed allowed the $17 million rehabilitation to be finished in only 12 months: the bridge closed to traffic on January 4, 2010, and reopened on December 20, 2010. A traditional concrete deck would have extended the project schedule to at least 18 months, added millions of dollars of extra truss strengthening work, and caused numerous other technical issues.

The Dawson Bridge project has successfully advanced the state of the art in bridge technology and has achieved cost savings for the City of Edmonton, while allowing the rehabilitation work to be completed within a single construction season. Today, Dawson Bridge is fully rehabilitated with the world's largest SPS deck—the only installation built entirely without field welding—and it stands prepared to serve Edmontonians for many generations to come. MSC

Owner
City of Edmonton, Alberta, Canada

Structural Engineer
Dialog, Edmonton, Alberta, Canada

Steel Detailing
Empire Iron Works Ltd., Edmonton, Alberta, Canada (NISD Member)

General Contractor
ConCreate USL Ltd., Crossfield, Alberta, Canada

DAWSON BRIDGE REHABILITATION

EDMONTON, ALBERTA

DAWSON BRIDGE REHABILITATION, EDMONTON, ALBERTA

PROJECT OVERVIEW: NEW LIFE FOR A 100-YEAR-OLD STEEL TRUSS BRIDGE

In its 100th year of service, Dawson Bridge is now one of Edmonton's most modern bridges thanks to the innovative use of new technology. During its 2010 rehabilitation, its deteriorated concrete-on-timber deck was replaced with an SPS™ composite steel plate and elastomer lightweight deck system. Dawson is the largest bridge in the world with this innovative steel deck system, and the first designed with unique bolting details that entirely eliminate field welding.

The shop-fabricated lightweight steel deck drastically reduced the need for costly and difficult truss strengthening. Bolted quickly into position, the speed of deck installation allowed the entire rehabilitation project—truss strengthening, painting, deck replacement, and sidewalk widening—to be completed in one year, months faster and millions less expensive than a traditional concrete deck.

BRIDGE HISTORY

A five-span riveted steel through-truss, Dawson Bridge was originally constructed to carry electric trains to a coal mine located on the east bank of the North Saskatchewan River. With five simply supported spans of 43.3 m, 43.3 m, 43.3 m, 76.2 m, and 30.5 m from west to east, its overall length between abutment walls is 236.5 m. Today the bridge carries one lane of vehicular traffic in each direction—about 16,000 vehicles per day—along with many pedestrians and cyclists on its two sidewalks as part of the River Valley trail system.

The City of Edmonton commissioned a condition assessment for Dawson Bridge in 2007. That study revealed the superstructure was in need of significant repair, including total bridge deck replacement and truss repainting. Field inspection and structural analysis also identified numerous truss members that required strengthening or replacement in order to increase the level of safety to modern standards and to extend the service life of the bridge. The original narrow sidewalks were also identified as a detraction and potential safety hazard for pedestrians and cyclists.

Dawson Bridge is listed on the register of historic resources in The City of Edmonton and is one of very few structures in the city—of any kind—to reach its centenary. The project team was given the mandate to respect the historical appearance of the existing structure and make certain that the rehabilitation measures would not be apparent to the public once construction was complete.

INNOVATIVE REHABILITATION

During the design phase, a load rating of Dawson Bridge was conducted using an Alberta CS3 rating vehicle, the heaviest vehicle that might practically access the bridge considering its vertical clearance restrictions and location. That assessment concluded that numerous truss members must be strengthened or replaced in order to increase the level of safety and to extend the lifespan of the bridge.

The analysis work also showed that the scope of strengthening work could be reduced significantly by choosing a deck replacement option that lightens dead load on the bridge. By replacing the existing, deteriorated 165 mm semi-lightweight concrete deck with a lightweight steel deck, those weight savings could be applied to carrying additional live load and widening the sidewalks.

Two lightweight deck options were considered for the project: orthotropic steel deck and an innovative composite steel plate and elastomer decking system. Ultimately, the deck design best suited to the project was determined to be a composite steel plate and elastomer decking system patented by Intelligent Engineering (Canada) Ltd. of Ottawa. Called the Sandwich Plate System (SPS™), the system was originally developed for use in the marine industry for ship hulls and decks. Application of this new technology has recently begun in the bridge industry.

SPS makes use of two relatively thin steel face plates—10mm thick, in the case of Dawson Bridge—connected by an injected elastomer core. The final product is a composite panel with high stiffness and strength, but relatively low weight. The deck plates are fabricated in the shop using conventional steel fabrication techniques, and the liquid elastomer, which cures into solid form within an hour, is injected to form the core. For Dawson Bridge, the 10mm 350AT steel face plates sandwich a 25mm elastomer core, forming a composite deck panel only 45mm in total thickness.

DAWSON BRIDGE REHABILITATION, EDMONTON, ALBERTA

The design team recommended to the City of Edmonton an intensive risk control program for the application of a new technology, especially considering that Dawson Bridge is a large and expensive asset for the City. Only a handful of bridges around the world have been built using SPS technology, and all have involved significant field welding that is both costly and difficult to maintain consistent quality.

As the first and most important step of the risk control program, the design team set out to develop new details for connection of the SPS deck panels in order to eliminate entirely the need for field welding. The new details, developed by the design team and detailed by Intelligent Engineering, involve using splice plates to connect adjacent deck panels with countersunk ASTM A325 bolts. To save weight and complexity, the top flange of the new floor stringers act as the bottom splice plate. Also as part of the risk control plan, full three-scale samples of the new connection detail were built and tested under fatigue loading at the structural engineering laboratory at the University of Alberta. Those tests demonstrated that the new connection detail can withstand fatigue loads nearly double in magnitude to those expected in actual in-service conditions.

Because the composite steel deck panels could be fabricated entirely in the shop and bolted quickly into position on the bridge, erection of the deck was completely in only six weeks. This speed allowed construction to be completed in 12 months, with the bridge closed on January 4, 2010 and reopened on December 20, 2010. If a traditional concrete deck had been used, the difficultly and expense of strengthening truss members would have been far greater and the construction schedule would have taken at least 18 months.

CONCLUSION

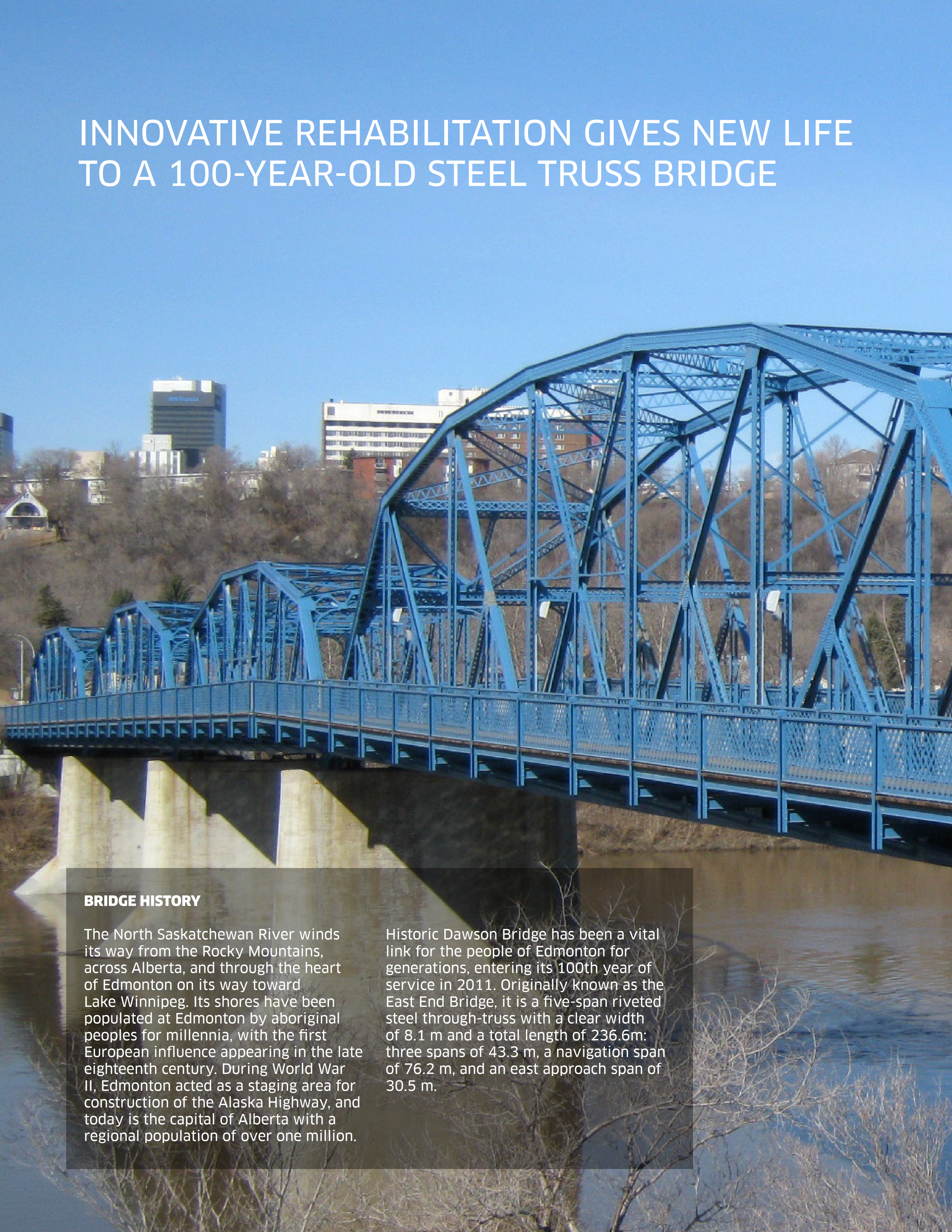
The rehabilitation project involved removing the existing deteriorated concrete deck, erecting new floor stringers, installing 1850 m^2 of innovative composite steel plate and elastomer decking, removing 17,500 rivets, tightening 37,500 new bolts, and blast cleaning and recoating of the entire structure with high-performance zinc/epoxy/urethane paint. New sidewalks 2.65m wide were also installed. Under budget at $17 million, Dawson Bridge reopened to traffic almost exactly on schedule on December 20, 2010.

The Dawson Bridge project has successfully advanced the state of the art in bridge engineering and has achieved millions in cost savings for the City of Edmonton, while allowing the rehabilitation work to be completed within a single construction season. Today, Dawson Bridge is fully rehabilitated with the world's largest SPS deck--and the only installation built entirely without field welding--standing prepared to serve generations of Edmontonians.

PROJECT AWARDS

CISC Alberta Steel Design Award of Excellence - Sustainability, March 2011

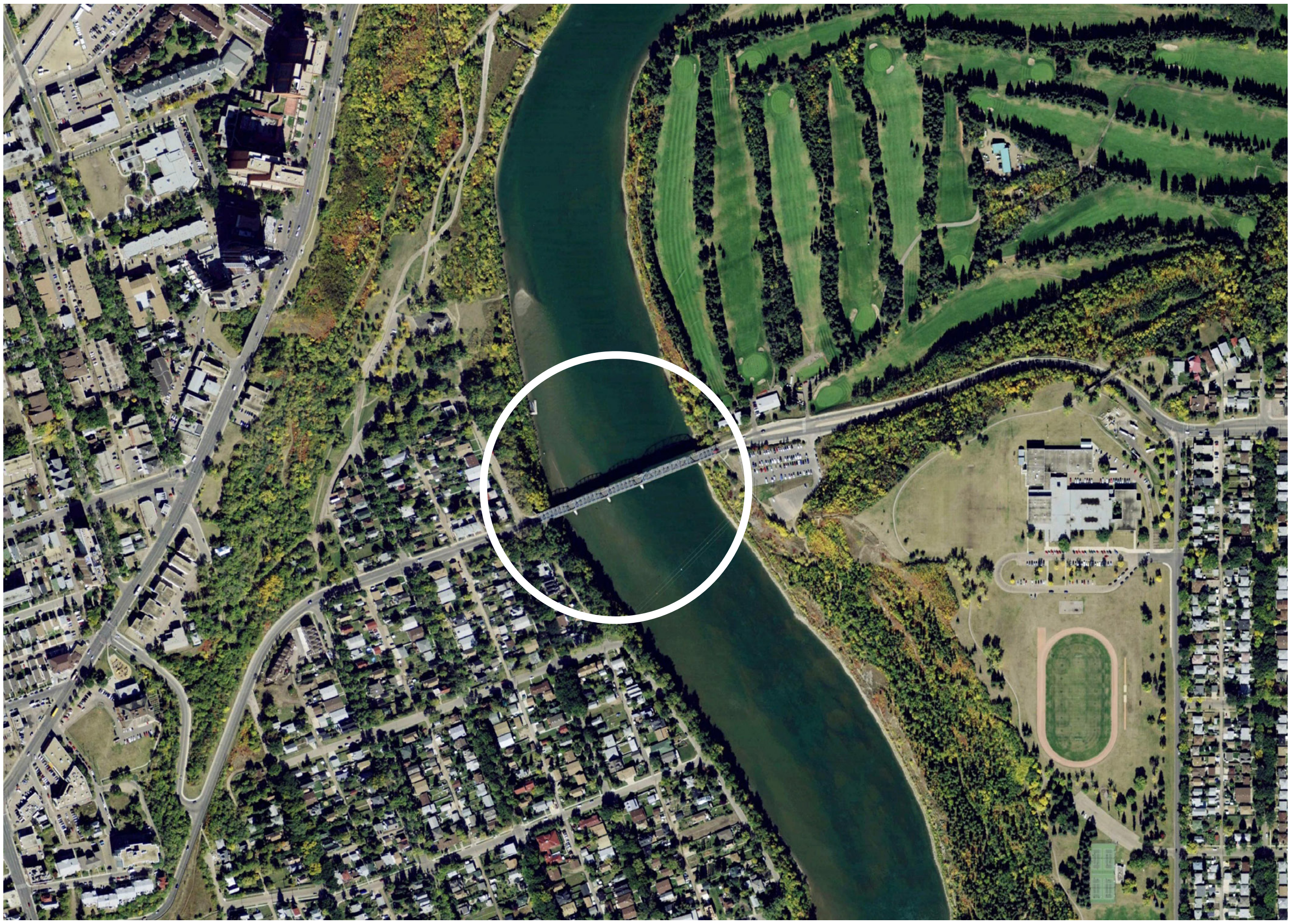
INNOVATIVE REHABILITATION GIVES NEW LIFE TO A 100-YEAR-OLD STEEL TRUSS BRIDGE

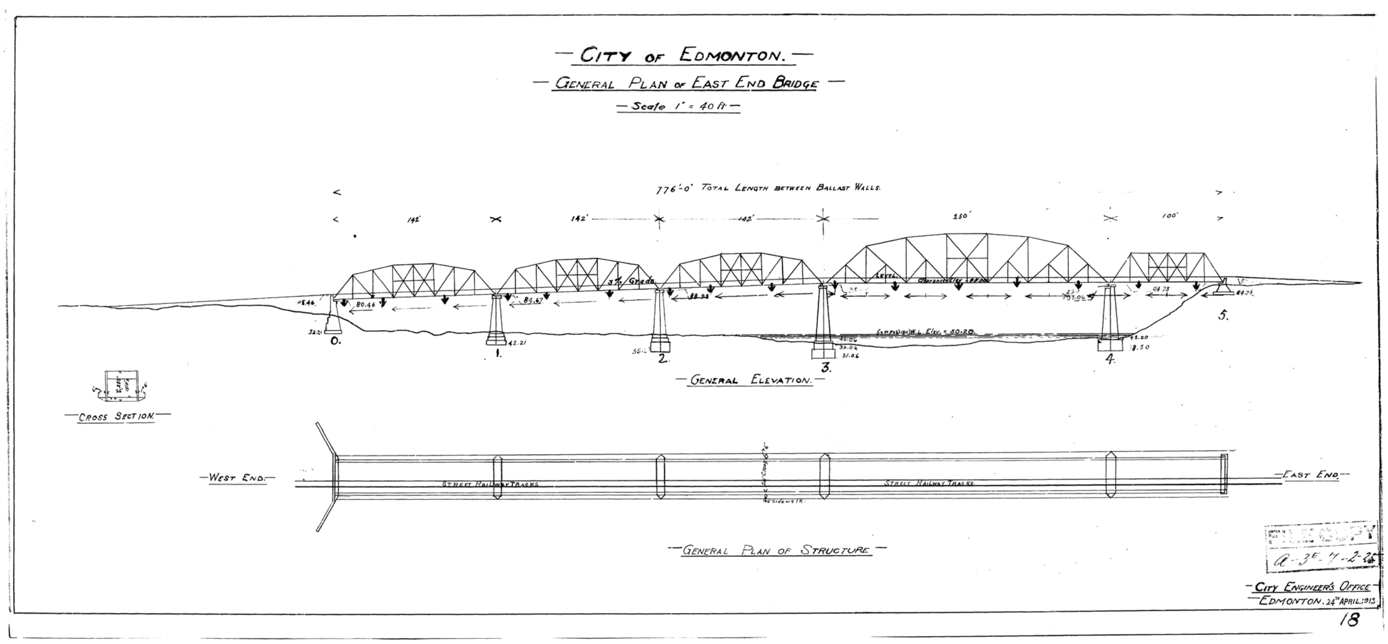


BRIDGE HISTORY

The North Saskatchewan River winds its way from the Rocky Mountains, across Alberta, and through the heart of Edmonton on its way toward Lake Winnipeg. Its shores have been populated at Edmonton by aboriginal peoples for millennia, with the first European influence appearing in the late eighteenth century. During World War II, Edmonton acted as a staging area for construction of the Alaska Highway, and today is the capital of Alberta with a regional population of over one million.

Historic Dawson Bridge has been a vital link for the people of Edmonton for generations, entering its 100th year of service in 2011. Originally known as the East End Bridge, it is a five-span riveted steel through-truss with a clear width of 8.1 m and a total length of 236.6m: three spans of 43.3 m, a navigation span of 76.2 m, and an east approach span of 30.5 m.





CITY OF EDMONTON.
GENERAL PLAN OF EAST END BRIDGE
Scale 1" = 40 ft
776'-0" TOTAL LENGTH BETWEEN BALLAST WALLS.
142'
142'
142'
250'
100'
3% Grade
LEVEL
GENERAL ELEVATION.
CROSS SECTION.
WEST END.
STREET RAILWAY TRACKS
STREET RAILWAY TRACKS
EAST END.
GENERAL PLAN OF STRUCTURE
CITY ENGINEER'S OFFICE
EDMONTON. 24TH APRIL 1913
18

Originally constructed to carry horse-drawn wagons and electric trains to the Dawson Coal Company mine located on the east bank, the bridge opened on October 8, 1912 with a construction cost of $145,000. Only the second bridge to cross the North Saskatchewan River at Edmonton, Dawson Bridge quickly became a vital link for the city's growth, allowing coal to be transported quickly into the heart of the city for industry and home heating.

After closure of the Dawson Mine in 1944, the bridge was converted to carry only highway vehicles. Today, the bridge has one lane of traffic in each direction and accommodates about 17,000 vehicles each weekday. As a link to Edmonton's extensive multi-use river valley trail system, the two sidewalks on Dawson Bridge serve many pedestrians and cyclists.

CONDITION ASSESSMENT

In 2007 The City of Edmonton commissioned DIALOG™ to conduct a condition assessment for Dawson Bridge. Field inspection revealed the superstructure in need of significant repair, including total replacement of the bridge deck and complete repainting of all steelwork. Structural analysis also identified numerous truss members requiring strengthening or replacement in order to increase the service life of the bridge and meet the safety requirements of the Canadian Highway Bridge Design Code 2006. In addition, the original narrow sidewalks—only 1.5 m wide—caused safety concerns due to mixed use by pedestrians and cyclists.

Especially problematic was the existing 165 mm steel-fibre-reinforced semi-lightweight concrete deck, cast in 1986 on top of old timber subdecking from the 1940's. Though its relatively light weight was beneficial for limiting dead loads, the thin concrete deck was too flexible to resist cracking. In particular, The City of Edmonton was experiencing continual maintenance problems with the methyl methacrylate thin membrane wearing surface at details where the concrete deck passed over the transverse floor beams. The concrete deck section was reduced to only 65 mm thick to clear the top flange of the floor beams, making it nearly impossible to control cracking.

As part of the assessment, a load rating of Dawson Bridge was conducted using a 4-axle, 63.5 tonne Alberta CS3 rating vehicle, the largest vehicle that might practically access the bridge considering its vertical clearance restrictions and location. That assessment concluded that numerous truss members must be strengthened or replaced in order to meet the required level of safety and to extend the lifespan of the bridge.

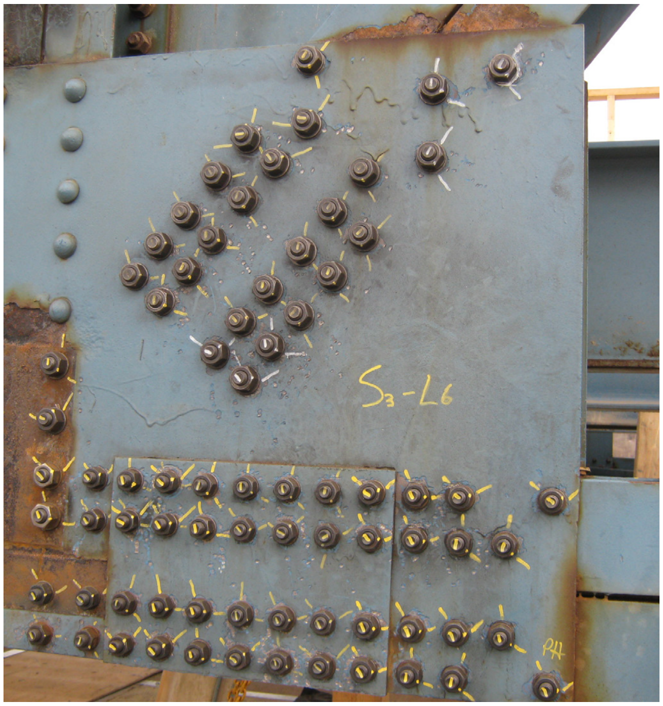
Dawson Bridge is listed on the register of historic resources in The City of Edmonton and is one of very few structures in the city—of any kind—to reach its centenary. The project team was given the mandate to respect the historical appearance of the existing structure and make certain that the rehabilitation measures would not be apparent to the public once construction was complete.

TRUSS REHABILITATION

The original truss members of Dawson Bridge are built-up rivetted members with an I-shaped cross-section, with steel angles forming the flanges and lattice plates crossing back and forth between the flanges to form the web. All members were originally connected by 19 mm or 22 mm rivets.

The load rating results showed that it was necessary to strengthen or replace several of the existing truss members. For the replacement members, the new members are constructed to the same dimensions as the original, but they have solid plates welded together to form the flanges and the webs. The original lattice pattern of the web is duplicated by plasma-cut holes in the new web plate, an economical modern construction technique that maintains the historical appearance of the members.

An analysis of estimated remaining fatigue life showed that the fatigue life of many of the riveted connections on the bridge has theoretically been consumed. Fortunately, the steel inspection carried out as part of this assessment did not reveal any fatigue cracking. In response, a simple fatigue strengthening strategy was implemented by to reduce the risk of structural problems over the remaining service life of the Dawson Bridge replacing all rivets at critical connection locations with high strength pre-tensioned bolts.



After completion of all truss strengthening and rivet replacement work, the entire superstructure was blast cleaned and recoated with a three-part organic zinc/epoxy/polyurethane system. This system is anticipated to last 25 years before overcoating is required.

One change from the original appearance is that the new sidewalks are nearly twice as wide as the original sidewalks. However, steelwork detailing for the new sidewalk brackets was done using geometry that matches the historical nature of the bridge. The new, wider sidewalk dramatically improves the experience for pedestrians and cyclists using this bridge as part of the River Valley trail system.

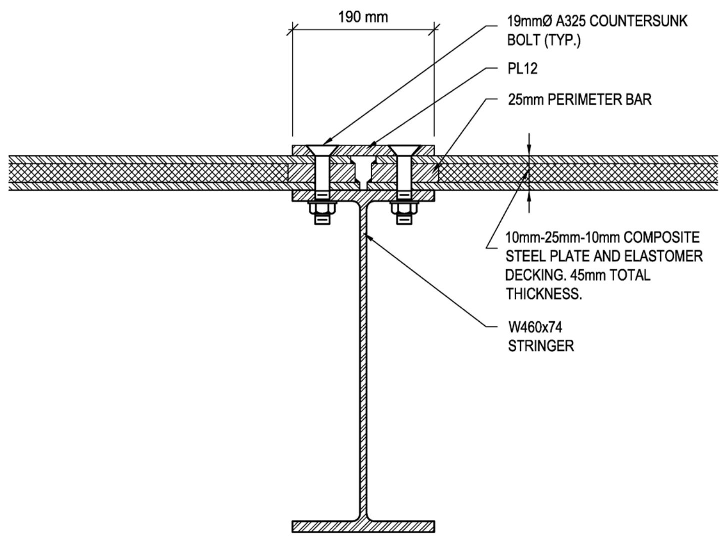
LIGHTWEIGHT DECK: INNOVATION AND RISK CONTROL

As options for rehabilitation were developed, it became clear that the bridge could be rehabilitated economically only if a lightweight deck replaced the existing deteriorated concrete deck. A traditional concrete deck would require costly replacement or strengthening of many truss members along with difficult upgrading of existing connections. Additionally, it might cause overload for the piers, abutments, and foundations. By replacing the existing semi-lightweight concrete deck with a lightweight steel deck, the design team concluded that the dead load savings could be applied to carrying additional live load and widening the sidewalks. Only steel offered viable lightweight deck options: grating, orthotropic deck, or an innovative composite steel plate and elastomer system called the Sandwich Plate System (SPS™) patented by Intelligent Engineering (Canada) Ltd.

Grating was quickly eliminated as an option for the deck because increased road noise would be detrimental to the nearby Riverdale community. Orthotropic steel deck was judged a suitable option, but detailing would be challenging where the deck had to clear the tops of the floor beams without raising the grade line, and orthotropic deck may be susceptible to fatigue cracking. After considerable research, the design team recommended SPS to The City of Edmonton, judging that SPS technology offered the best combination of light weight, thin profile, and ease of erection for the Dawson Bridge Rehabilitation project.

The SPS composite steel plate and elastomer system was originally developed by Intelligent Engineering Ltd. for ship hulls and decks in the marine industry. Application of this technology began about a decade ago in the bridge industry, and SPS has been installed on several bridges worldwide. The technology is gradually gaining acceptance by bridge engineers.

SPS makes use of two relatively thin steel face plates connected by an injected thermosetting elastomer core. The final product is a composite panel with high stiffness and strength, but relatively low weight.



Deck panels are fabricated in the shop using conventional steel fabrication techniques. First, solid "perimeter bars" are welded along each edge of the bottom plate using a continuous fillet weld. The top plate is then lowered onto the perimeter bars and fillet welded all around forming a panel with a sealed void. The liquid elastomer, which cures into solid form within an hour, is injected through a port to form the core. For Dawson Bridge, the 10 mm steel face plates sandwich a 25 mm elastomer core, forming a composite deck panel with a total thickness of only 45 mm. These prefabricated panels are typically 1.9 m wide and 8.5 m long.

Risk is inherent in the application of all new technologies in all industries. Perceived risk—and its associated liability—often dissuades engineers from trying innovations that might advance the state of the art in their area of practice. Potential liability places a constriction on the pace of innovation that, in the long run, is most often a disservice to society. Striking the right balance between innovation and risk control is the key to success. Thus, when DIALOG recommended SPS—a relatively new technology—to the City of Edmonton, that recommendation came with the proviso that an intensive risk control program must be implemented, especially since Dawson Bridge is an important and expensive asset. The City of Edmonton is a progressive bridge owner that welcomes innovation, and they directed the design team to proceed with SPS as the basis of design for the deck.

The risk control plan developed for the deck comprised six key elements:

- Extensive background research in the available literature;
- Site visits by the design team to other bridges with SPS decks, and interviews with the bridge authority managing those structures;
- Development of improved connection details in consultation with Intelligent Engineering;
- Fatigue testing of full-scale sample connections in the laboratory;
- Enhanced quality control and quality assurance programs during deck fabrication and erection; and,
- Monitoring of deck performance over the lifetime of the bridge as part of the City of Edmonton's bridge maintenance program.

DIALOG judged the most important aspect of the risk control plan to be the development of new connection details between adjacent SPS deck panels. Of the handful of bridges around the world built using SPS technology, all have involved significant field welding—a method that is costly and makes quality control difficult. Risks associated with field welding include fit-up out-of-tolerance, the potential for excessive heat input that might debond the elastomer from the steel, and undesirable weld flaws that might inadvertently result in premature fatigue cracking.

Taking to heart the golden rule "shop weld and field bolt," the DIALOG design team developed unique bolted details for connecting the SPS deck panels. These details completely eliminate the need for field welding. Bolted connections drastically increase speed of erection, significantly reduce cost, and improve fatigue performance from Detail Category D (depending on the specifics of the weld geometry) to Detail Category B when using slip-critical connections.

To connect adjacent SPS deck panels, a top splice plate is fastened by a single row of countersunk pretensioned 19 mm ASTM A325 bolts. Countersunk bolts provide a flat surface for the finished deck, except for the thickness of the splice plate itself. This surface, once grit blasted, is prepared to receive a waterproof membrane and asphalt. In order to make deck detailing and construction simpler, the SPS deck in each span is planar with no cross-fall. To achieve positive drainage, the asphalt varies in thickness from 100 mm at the crown to 40 mm at the shoulders.

Longitudinal deck splices are designed to align with floor stringers below. This arrangement enables the top flange of the stringers to act as the bottom splice plate for the connection, saving both weight and complexity. The new stringers chosen—W460x74—are larger than required for flexural strength but offer a flange wide enough to accept a row of bolts on each side. At transverse deck joints, located away from floor beams to avoid clashes, bolted splice plates are used both top and bottom. In all cases enough bolts are used so that sealing requirements are met and negative moments in the deck can be transferred across the supporting stringers. This very simple approach to connections makes the deck very easy to fabricate and simple to erect. Using similar bolting details, the traffic barriers along the length of the bridge are also bolted down through the deck to the edge stringer.

Also as part of the risk control plan, three small 1:1-scale samples of the longitudinal bolted deck connection detail were built and tested under fatigue loading at the University of Alberta with the assistance of Professor Gilbert Grondin, Ph.D., P.Eng. Those tests demonstrated that the new connection detail can withstand fatigue loads nearly double in magnitude to those expected in actual in-service conditions.

REAPING THE BENEFITS OF INNOVATION

Because the composite steel deck panels could be fabricated entirely in the shop and bolted quickly into position on the bridge, erection of the deck was completed in only six weeks during July and August 2010. This speed allowed the $17 million rehabilitation to be finished in only 12 months: the bridge closed to traffic on January 4, 2010, and reopened on December 20, 2010. A traditional concrete deck would have extended the project schedule to at least 18 months, added millions of dollars of extra truss strengthening work, and caused numerous other technical issues.

The Dawson Bridge project has successfully advanced the state of the art in bridge technology and has achieved cost savings for the City of Edmonton, while allowing the rehabilitation work to be completed within a single construction season. Today, Dawson Bridge is fully rehabilitated with the world's largest SPS deck—the only installation built entirely without field welding—and it stands prepared to serve Edmontonians for many generations to come.

DAWSON BRIDGE REHABILITATION – PROJECT CREDITS

Owner
The City of Edmonton

Prime Consultant Bridge Engineering
DIALOG

Civil Engineering
Al-Terra Engineering Ltd.

General Contractor
ConCreate USL Ltd.

Steel Detailing and Fabrication – Stringers and Connections
Empire Iron Works Ltd.

Steel Detailing and Fabrication – Sidewalks and Truss Upgrades
Steel Design and Fabricators Ltd. (SDF)

Steel Design and Detailing – Composite Steel Plate and Elastomer Decking
Intelligent Engineering Canada Ltd.

Steel Fabricator – Composite Steel Plate and Elastomer Decking
Cemilas B.V.

Steel Erector
Steel Design and Fabricators Ltd. (SDF)

Paint
Certified Coatings Specialists Inc.