MORRISON HERSHFIELD

Canadian Consulting Engineering Awards 2011

Rapid Bridge Replacement of the Aberdeen Avenue Bridge Over Highway 403

Presented to:
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PROJECT HIGHLIGHTS

The replacement of the Aberdeen Avenue Bridge in the City of Hamilton marks a new milestone in engineering – the first multi-span highway bridge to be replaced in North America using rapid bridge replacement (RBR) technology. In August 2010, the 82m long four span bridge with a 1,500 tonne deck over Highway 403 was replaced with a new continuous, jointless structure in just 51 hours, a full day ahead of schedule and up to two years earlier than if conventional construction methods had been used. The overall success of this project opens up vast opportunities for the use of RBR in bridge works, fully recognizing its potential to benefit our society.

This accomplishment greatly exceeded the owner's, the Ministry of Transportation Ontario, expectations and has set a benchmark for future similar projects. Through the success of this work, the client has gained confidence in the potential to expand this previously limited technology. This project was presented at an international conference for bridge engineers, as an innovative example of refining existing technology, overcoming its previous limitations, and expanding the application to the rehabilitation of a variety aging structures.

A "non-routine" design is always challenging. With limited previous examples to draw from, the RBR of the Aberdeen Avenue Bridge was a "first of its kind" project where engineering expertise and experience were relied on to ensure that all details would work as expected. All designs were developed for the first time for a multiple span structure, adding to the overall complexity of the project. The project team was responsible for generating and developing innovative ideas to address all aspects of the work and working restrictions, as well as for refining details to overcome the traditional weaknesses of RBR in such a project. The design team included many outside experts from various areas of the industry and Ministry of Transportation who provided ongoing review and valuable insight. This allowed the engineer to improve the overall design as well as provide greater flexibility and margins.

The innovative design was based on the engineer's clear understanding of the rapid bridge replacement process, as well as the site conditions and governing requirements posed by the engineering and environmental challenges. Additionally, stakeholder requirements were incorporated into the solutions.

There are several important design elements and innovations to highlight with regard to this complex project. The key construction technologies, Heavy Lifting Technology (HLT) and Lateral Jacking and Sliding Method (J&S), were combined to optimize time available during the traffic restriction period. Combining these different technologies and planning the site to ensure that the different methods worked together while not interfering with each other was critical. The design of the flexible link slabs was customized to connect individual deck panels in-situ, which allowed rapid curing and completion of the links to withstand traffic. Suitable staging areas had to be created, and the sites were prepared in advance to provide sufficient space for the construction of the prefabricated panels. As well, modified link slab and temporary bridge over designs were used for connecting prefabricated panels. Precast approach slabs were used to shorten construction time of bridge approaches. New and innovative traffic planning approaches were implemented to avoid highway closures, and the temporary connection of interchange ramps was allowed to permit vehicles on the highway to bypass the site without creating havoc and potential danger to traffic in the City.

One of the major challenges faced by engineers in bridge replacement projects is traffic management. The fact that Highway 403 is a major east-west corridor in Southern Ontario, with an annual average daily traffic count of 105,000 vehicles, comprised of both commuter and commercial traffic, made the Aberdeen Avenue Bridge an ideal candidate for rapid bridge replacement. Traditional bridge construction usually takes place over multiple construction seasons, extending public inconvenience and traffic delays. Imagine the ability to avoid the conventional two construction seasons of traffic disruption and congestion, not to mention costly traffic staging with temporary barriers, lane markings, work zone signs, lane and shoulder width reductions. Reducing

disruptions in the area of this critical access point to Highway 403 for commercial, industrial, institutional and residential traffic was of great benefit to the City of Hamilton.

There is also a potential for environmental concerns during construction activities on roads and highways. Traffic in construction zones tends to be very slow moving with more stop and go movements, resulting in increased emissions from vehicles. Dust, construction debris and noise pollution are also common concerns. With the replacement of the Aberdeen Avenue Bridge in just 51 hours, these environmental concerns were greatly reduced and any remaining impacts were mitigated.

The high profile nature of this project brought increased awareness to the public of the contributions by consulting engineers. The consultation program for this project was extensive. In addition to traditional consultation methods, the project was well received by local media, increasing public interest in the historic event. The entire bridge replacement was videotaped, and a website link was provided to allow the public to view the replacement live. Updates were also provided via Twitter. A public viewing area was constructed for spectators to view the replacement from a safe distance without impacting the contractor's operations. Because of the significant public and media attention the project generated, the engineers who were already striving to produce a flawless, first-of-its-kind design faced additional pressure to meet public expectations. The evolution of the design included many enhancements, with continuous checks and balances along the way to ensure a successful outcome.

In conclusion, rapid bridge replacement provides significant benefits to road users, construction workers, the local economy and the environment. Compared with conventional construction, this method minimizes traffic disruptions, improves construction site safety, and reduces rehabilitation time. Now, with the Aberdeen Avenue Bridge experience, RBR has expanded to multi-span bridges, making this fast construction technique even more versatile and attractive. The techniques and innovations developed in this multi-span RBR set the stage for broad future applications of this technology.

ABERDEEN AVENUE BRIDGE RAPID BRIDGE REPLACEMENT: OVERVIEW OF THE STAGING AREA & BRIDGE

Ontario

MORRISON HERSHFIELD

FULL PROJECT DESCRIPTION

NEW APPLICATION OF EXISTING TECHNIQUES / ORIGINALITY / INNOVATION

July 26, 2010: Site prior to Rapid Bridge Replacement

In the summer of 2010, Aberdeen Avenue Bridge at Hwy 403 in the City of Hamilton was replaced using rapid bridge replacement (RBR) technology to restore it to a safe and serviceable condition. Originally constructed in the early 1960's, the bridge was a conventional 4-span continuous slab-on-steel girder bridge with a deck area of some 1,300 m^2. After over 40 years in service, the bridge deck was deteriorated and required replacement.

To demonstrate the applicability of RBR technology to ***major, multi-span bridges in congested locations on trunk highways***, the Ministry of Transportation (Owner), and Morrison Hershfield Limited (the Engineer) decided to develop a design and details to replace the Aberdeen Bridge deck over one weekend. This was done instead of a conventional staged method which would have required about two construction seasons to complete.

July 31, 2010: Paving newly installed bridge

Since there were no previous examples of similar construction, it was up to the project team to generate and develop innovative ideas to address all aspects of the work and working restrictions, as well as to refine details to overcome the traditional weaknesses of RBR in such a project. As an added value and in response to a request from the local municipality, the design had to address what to do with vehicles that might mistakenly end up at the closed highway site. A strategy was developed to allow motorists to bypass the work zone without having to find their way within the complex city road network.

The innovative design was based on the engineer's clear understanding of the rapid bridge replacement process, as well as the site conditions and governing requirements posed by the engineering and environmental challenges. Additionally, stakeholder requirements had to be incorporated into the solutions. Since there were no similar projects that could provide complete reference and basis for this design, the engineers were required to analyze each step of the construction. To ensure success, the engineer was required to modify designs and predict potential risks, construction deviations and tolerances to make a design concept work seamlessly on site. Industrial experts, contractors and materials suppliers, to name a few, were invited to discuss constructability issues and risk assessment so that the design could be refined. This is a good example of innovation and thinking creatively to solve an engineering problem.

Many innovations developed for this project will form important reference for future similar works, including:

- Modified link slab and temporary bridge over designs for connecting prefabricated panels
- Combing different technologies and planning the site to ensure different methods work together while not interfering with each other

- Creation of a suitable staging area(s), opening up new options for congested sites
- New traffic planning approaches to avoid highway closures

Apart from engineering designs, most of the contract documents were prepared specifically for the project to allow proper site control, incident management, risk management, public relations and event recording.

Assembled Self Propelled Modular Transporter (SPMT) stationed in the staging area

COMPLEXITY

Since this is a "first of its kind" project, there were limited previous references to draw from, and all designs were developed for the first time for a multiple span structure. This added to the overall complexity of the project. A "non-routine" design is always challenging since it has never been tried. Therefore, engineering experience and judgement was relied on to make sure all details would work as expected.

To ensure a successful outcome, the design team also involved many outside experts from various areas of the industry who provided ongoing review and valuable comments. These in turn allowed the consulting engineer with MTO staff to improve the design as well as provide greater flexibility and margins. As part of the planning, construction tasks were tabulated in detail and "hour-by-hour" analyses of the construction time was carried out to confirm feasibility of the proposed work within the available closure times.

Due to the innovation and extensive public and media attention the project generated, the engineers who were already striving to produce a flawless, first-of-its-kind design were faced with additional pressure to meet public expectations. This resulted in numerous revisions, and many rounds of checking and rechecking, before the tendering was completed.

Jack and Slide Technology

Incident and risk management plans were developed and implemented during the weekend work to prepare and address issues that may potentially impact the schedule.

Some highlights of the complex design include:

1. **Combining Heavy Lifting Technology (HLT) and Lateral Jacking and Sliding Method (J&S) together to optimize time available during the traffic restriction period.**

A key aspect of the design was to adopt two heavy move technologies to expedite both the prefabrication and movement of the heavy spans. In addition, the design reduced the need for land for the staging area. The two main spans over the highway were precast in a nearby staging area, and lifted and moved into position using Self-Propelled Modular Transporters (SPMT), while the two end spans over the abutment slope were cast alongside the existing structure and moved laterally on rails into their final positions by jacking mechanisms. This required refined details to be developed to manage potential risks, as well as accurate elevations and dimensions calculations and careful site verifications.

2. **Customizing the design of flexible link slabs to connect individual deck panels in situ, which allowed rapid curing and completion of the links to withstand traffic.**

Link slabs are common details in rehabilitation works. In this particular case, special details were developed to both accommodate construction tolerances, and to allow the concrete to be fully cured (ensuring durability) while traffic is running on the new bridge deck by using temporary bridging panels.

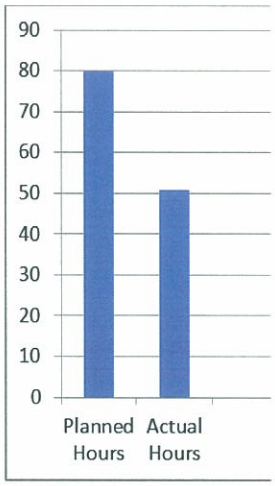
3. **Implementing advance site preparation to provide sufficient areas for the construction of the prefabricated panels.**

The bridge is located in a congested area in the City of Hamilton and a suitable staging area to prefabricate the two deck panels was not available. There are many specific requirements for a staging area, amongst which are that the area has to be flat and free of obstructions such as intervening bridges and overhead wires to allow the deck panels to be moved to the bridge locations. After careful investigation and negotiation with Hydro One, a small knoll in the vicinity of the bridge site was selected to be removed, levelled and strengthened to form the staging area.

Temporary Ramp

4. **Using precast approach slabs to shorten construction time of bridge approaches.**

Limited time was available at the end of the RBR work to cast the approach slabs to the bridge. To address this, precast slab panels were manufactured adjacent the site and lifted into place after the panels were moved into position and all the joints were placed, thus saving valuable closure time required for the entire RBR process.



Bridge Replacement Hours

5. **Allowing temporary connection of interchange ramps to permit vehicles on the highway bypass the site without creating havoc and potential danger to traffic inside the City.**

This innovative idea linked on-ramps with off-ramps for each direction of traffic on the highway at this interchange. Vehicles failing to observe advance signs were able to use these connections to bypass the closed section of the highway easily at a slower speed but without venturing onto unfamiliar roads in an unfamiliar city.

Even with its complexity, the bridge replacement was successfully completed within 51 hours. This was 29 hours ahead of the 80 hours that were originally made available for the contractor. Valuable experience was gained in the process, providing valuable insights to future designers to allow the work to be done even faster and more efficiently.

Hamilton/Halton
Engineering Week 2011
Project of the Year
Award Winner

The Aberdeen Bridge project is "an excellent example of the application of engineering in our community."
– Frank Lasowski, P.Eng. Chair of the Hamilton/Halton Engineering Week Awards Committee

ENVIRONMENTAL IMPACT

The rehabilitation of bridges in is unavoidable as our infrastructure continues to age, and rehabilitation is required to maintain our transportation system in a safe and operable condition. Construction activities on roads and highways are often sources of major environmental problems, especially in large congested cities. Traffic is often restricted through construction zones resulting in slow moving vehicles and frequent

stop-and-go cycles for each vehicle, resulting in increased products of incomplete combustion polluting our atmosphere. Also, in order to maintain traffic on the highway, bridge rehabilitation works are usually stretched out into multi-year contracts, greatly magnifying problems of dust, construction debris, as well as noise pollution. If construction is near watercourses, the chances of contaminating the waters is significantly increased due to prolonged construction and the many in-situ works such as concrete chipping, and fluids generated from construction activities.

Staging Area

Rapid bridge replacement addresses all these environmental issues. Through the success of this project, RBR is expected to be extended from small remote bridges to multi-span major highway crossings, thus fully realizing the huge potential of RBR to protect our environment from the above-mentioned harmful effects of bridge rehabilitation works. All major activities are carried out away from the actual site free of interference from daily commuters and road users. No traffic restrictions result from the construction activities, except for a few days pre-arranged for the main moving operations. Vehicles move in normal speed greatly reducing their energy consumption and rate of deterioration, lessening the negative effects on air quality around construction sites to benefit nearby residents, road users and workers.

As the bridge panels are moved in and out in large pieces, there is no extensive concrete chipping, nor major concrete pouring operations, which sometimes are sources of environmental contamination. Casting of panels can be completed effectively under controlled conditions, thus greatly increasing their durability and minimizing waste products because they are more sustainable.

"Our continuing support of innovative technology is a part of the Open Ontario plan. Our investment in our integrated transportation network will create jobs and strengthen our economy."
– Kathleen Wynne
Minister of Transportation

SOCIAL AND ECONOMIC BENEFITS

As discussed above, traditional bridge construction often requires a lengthy construction period causing prolonged public inconveniences and traffic delays often lasting for one or multiple construction seasons. With the Aberdeen Bridge experience, RBR has expanded into multi-span bridges, making this fast construction technique more versatile and attractive. The greatest advantage of using RBR for future multi-span bridge rehabilitations is the shortened onsite construction time, resulting in many benefits to society, including less noise, dust and fewer traffic disruptions. Benefits realized through higher product quality and durability go a long way to help reduce waste and speed up construction.

"This is exciting news for the City of Hamilton. The upcoming rapid bridge replacement will highlight the great work that is being done by Ontarians for Ontarians."
– Sophia Aggelonitis
MPP Hamilton Mountain

For conventional construction with a drawn-out construction period, complicated work zones and frequent ingress and egress by construction vehicles alongside busy traffic can pose safety problems. A shortened construction period by RBR with highway closures for a very limited period will help to improve construction safety by reducing risk exposure.

"By reducing the amount of time needed to replace the Aberdeen Bridge, we are ensuring a smoother flow of traffic, which will benefit the community and the local economy."
– Ted McMeekin
MPP Ancaster-Dundas-Flamborough-Westdale

Additionally, owners and users will see a significant cost savings when renewing our infrastructure using this innovative method. Construction costs and the cost of maintaining detours and staging works on major

highways are very expensive. User costs rise with increased traffic disruption on major highways where traffic volumes are high.

The techniques developed in this multi-span RBR set the stage for future applications of this technology. The consultation program for this project was extensive. In addition to traditional consultation methods, the project was well received by local media, increasing public interest in the historic event. The replacement was videotaped around the clock, along with a website link to allow the public to view the replacement live. A live Twitter feed also provided updates. A public viewing area was constructed for spectators to view the replacement from a safe distance without impacting the contractor's operations. Due to the public and media attention the project generated, the engineers who were already striving to produce a flawless, first-of-its-kind design, faced additional pressure to meet public expectations. As a result, the evolution of the design included many enhancements, with continuous checks and balances along the way. The Aberdeen Bridge project was a good example to the public of the consulting engineer's art.

Night time viewing by the public of the historic event

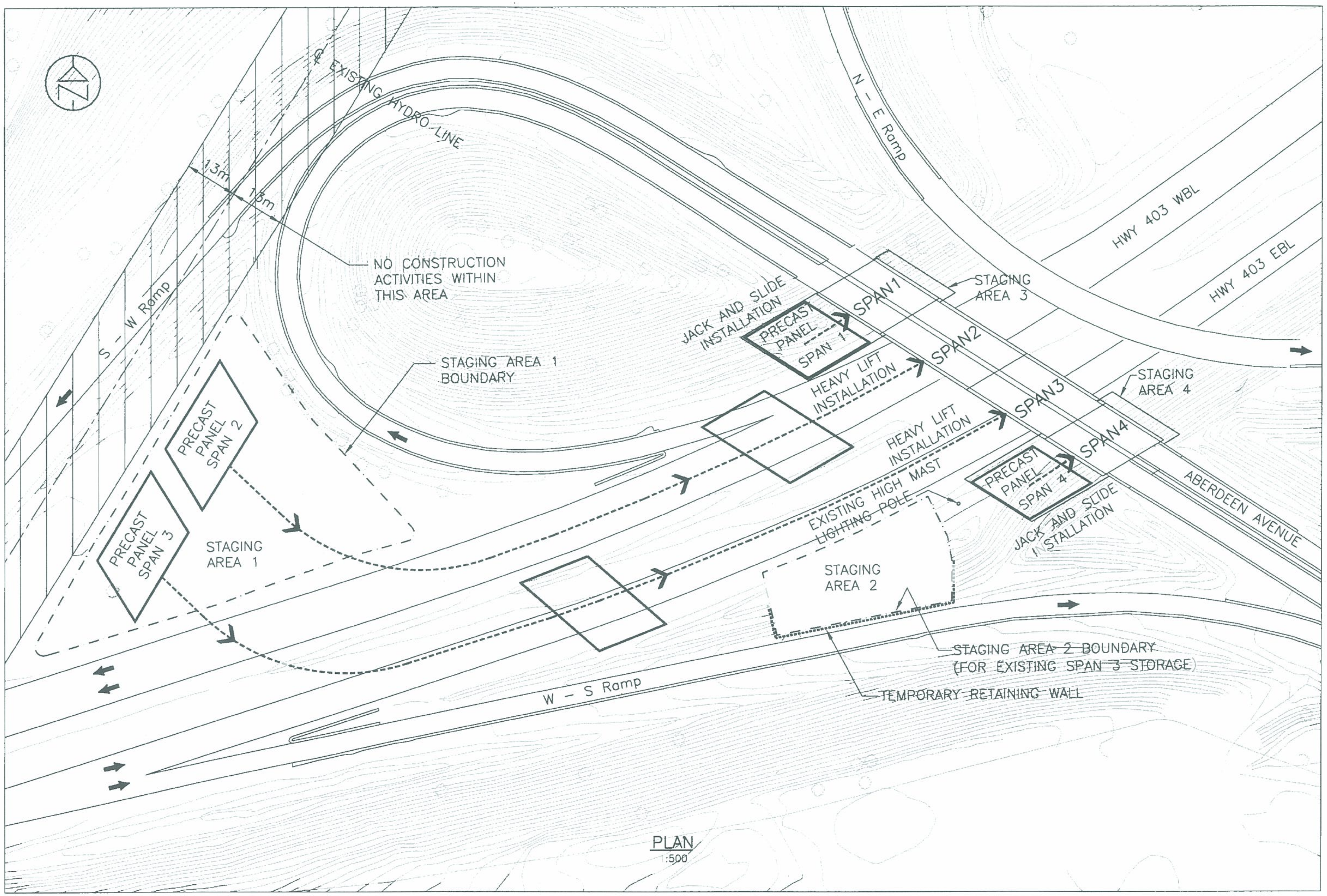
New Span 2 being installed with SPMT

MEETING AND EXCEEEDING OWNER'S / CLIENTS NEEDS

The operation was completed in 51 hours instead of the planned 80 hours of highway closure, greatly exceeding the owner's expectation by not just minimizing the impact to the public, but also setting a benchmark for future similar projects. Through the success of this work, the client has gained confidence in the potential of this technology and is prepared to use RBR in the future. In an email sent to the project team shortly after the opening of the bridge to public, the owner expressed great appreciation of the thorough planning and efforts of various parties to surpass the target. The project was also presented in the Proceedings of the 8th International Conference on Short and Medium Span Bridges, as a major highlight of the success adoption and implementation of a new technique to rehabilitate aging structures.

As part of this submission, the owner provided its support of our team through the appraisal letter. In March 2011, this project was also acknowledged in the Hamilton-Halton Engineering Week as the "Project of the Year" under the Transportation Category, and the owner (Ministry of Transportation of Ontario), the Engineer (Morrison Hershfield Limited) and the contractor and contract administrator, were all recognized by the organizing committee.

"Good work all. This is an excellent example of co-operation and teamwork between MTO staff, our consultant (Morrison Hershfield) and our contractor (Dufferin). It's been about a year and a half to get us to this point, so congratulations to all that had a roll. This is an achievement in many ways ... first multi-span RBR, and 2 different methods used. Congratulations."
– Lou Politano, Regional Director, MTO Central Region



NOTES:

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH GENERAL ARRANGEMENT.

STAGING AREAS FOR SPANS 1 AND 4

1. PREPARE THE STAGING AREAS FOR THE PREFABRICATION OF SPANS 1 AND 4.
2. CONSTRUCT FOUNDATIONS AND TEMPORARY SUPPORT STRUCTURES WITH SPECIAL FEATURES SO AS TO FACILITATE ?JACK AND SLIDE?INSTALLATION.
3. PRE-FABRICATE SPANS 1 & 4.
4. REMOVE EXISTING SPANS 1 & 4 OFF SITE.
5. INSTALL NEW SPANS 1 & 4 BY ?JACK AND SLIDE? METHOD.

STAGING AREAS FOR SPANS 2 AND 3

6. PREPARE THE STAGING AREAS FOR THE PREFABRICATION OF SPANS 2 AND 3.
7. CONSTRUCT FOUNDATIONS AND TEMPORARY SUPPORT STRUCTURES FOR THE PRE-FABRICATION OF SPANS 2 AND 3 SUPERSTRUCTURE.
8. CONSTRUCTION ACTIVITIES SHALL BE CONFINED WITHIN THE STAGING AREA AND SHALL NOT ENCROACH INTO THE HYDRO LINE PROHIBITIVE AREA.
9. REMOVE SPAN 3 AND PLACE SPAN 3 IN STAGING AREA 2
10. INSTALL SPAN 3 BY HEAVY LIFT METHOD
11. REMOVE SPAN 2 AND PLACE SPAN 2 IN STAGING AREA 1
12. INSTALL SPANS 2 BY HEAVY LIFT METHOD.

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CANADIAN CONSULTING ENGINEERING AWARDS 2011	RAPID BRIDGE REPLACEMENT OF THE ABERDEEN AVENUE BRIDGE OVER HWY 403	MORRISON HERSHFIELD	DRAWING No.: FIG. 1

PROJECT PHOTOS

New Spans 2 and 3 prefabricated in Staging Area PHOTO CREDIT: Morrison Hershfield

New Spans 1 and 4 casted by the side of the existing deck PHOTO CREDIT: Morrison Hershfield

Existing Span 2 being moved away using a Self Propelled Modular Transporter (SPMT)

PHOTO CREDIT: Morrison Hershfield

New Span 2 being moved into position using a SPMT

PHOTO CREDIT: Morrison Hershfield

New Span 4 being moved into position using Jack and Slide method PHOTO CREDIT: Morrison Hershfield

New Span 4 installed PHOTO CREDIT: Morrison Hershfield

Final installation of waterproofing and paving PHOTO CREDIT: Morrison Hershfield

New Bridge almost ready to open to the public PHOTO CREDIT: Morrison Hershfield