OSBORNE STREET BRIDGE REHABILITATION AND WIDENING

1 INTRODUCTION AND BACKGROUND

Situated in the central part of Winnipeg (Manitoba, Canada), the Osborne Street Bridge is a major river crossing comprised of twin bridges spanning over the Assiniboine River. This Bridge is one of Manitoba's busiest routes for vehicle, cyclist and pedestrian traffic. The Bridge connects downtown Winnipeg with Fort Rouge and other southern suburbs. To the south of the bridge is Osborne Village, which is Winnipeg`s most densely populated neighbourhood, as well as the second most densely populated neighbourhood in Western Canada. The north part of bridge has the Provincial Legislature and with its architectural details depicts the rich history that embodies this neighbourhood.

Eclectic combinations of early 1900s architecture standing alongside modern high rises adorn the limits of this project. To the north of the bridge are two landmark buildings, the Manitoba Legislative (Legislative) building as well as the two Great-West Life corporate buildings. The existing twin bridges were constructed in 1976 to replace a 1912 structure. The site map of the project limits is provided in Figure 1.

1.1 Description of Existing Bridge Structure

The existing twin bridges accommodated traffic in two directions and are comprised of two 33.5 m middle spans and two 28.9 m end spans. The northbound structure accommodated two traffic lanes on a roadway width of 8.8 m and a 2.3 m sidewalk on the east side concrete curb. The southbound structure accommodated three traffic lanes on a roadway width of 10.6 m, and a 2.3 m sidewalk on the west side concrete curb. Traffic in the opposing directions was separated by a concrete median slab, which ran along the length of the bridge and also the approach roadway. In addition, the two structures were separated by a narrow longitudinal joint in the median curb. Each superstructure consists of seven pre-stressed concrete I-girders, which were made continuous for live load with post-tensioning through the bridge deck. The girders supported a 178 mm (7 in.) thick deck slab, along with a 51 mm (2 in.) thick asphalt overlay. The constantly varying bridge deck sloped at a maximum of 3% from west to east and drainage was provided through metal drain pipes. The superstructure was supported on expansion disc bearings at both abutments and at the end piers, and fixed disc bearings at the middle pier. The substructure consisted of abutments that were shared by both structures, and three separate wall piers for each structure. The north abutment was an open box type with a roof slab comprising of 9.5 m long multi-beam pre-stressed concrete channel girders.

The bridge was originally designed for an AASHTO HS-25 truck loading and was posted for a gross vehicle weight of 50 Tonnes (490 kN).

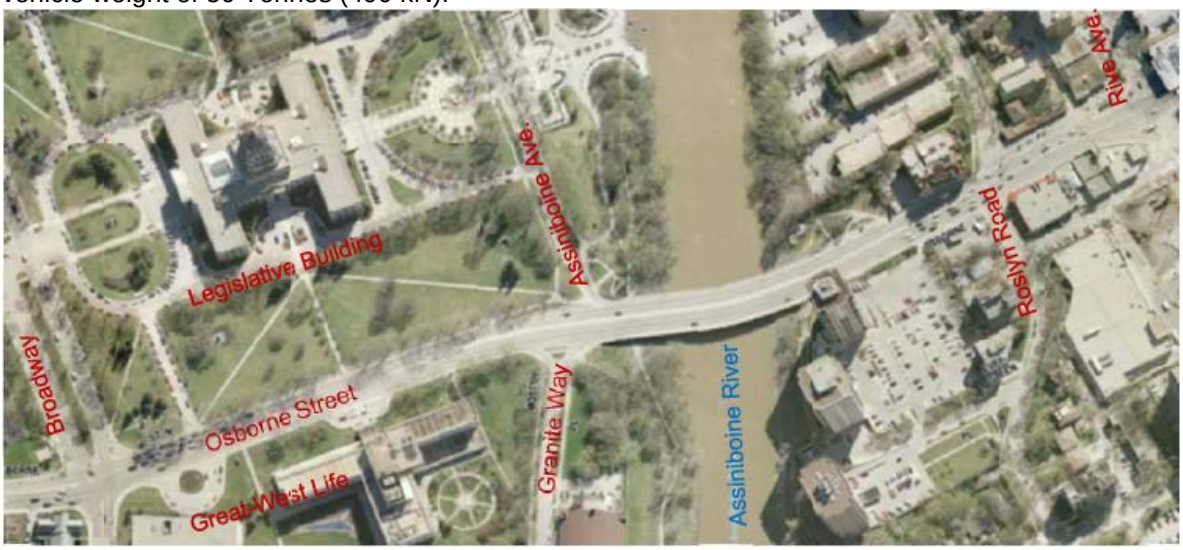


Figure 1 – Osborne Street Bridge and Associated Roadworks

1.2 Rehabilitation Needs

The Osborne Bridge structure and adjacent roadways required extensive rehabilitation:

- To repair existing deterioration caused primarily by corrosion of reinforcing;
- To upgrade roadside safety details on the bridge to current design standards;
- To strengthen the bridge to accommodate current bridge design loads; and
- To extend the lifespan of the 33 year old bridge by an additional 75 years.

The rehabilitation work also needed to improve AT across the bridge and also within the project limits. The needs of motorists, pedestrians, cyclists, and others were to be adequately met in a cost-effective manner by widening the deck overhangs as much as practically possible without having to add new girder line(s) and widening the substructure.

Through a collaborative planning process, NAC members worked together with the design team to brainstorm and evaluate potential options. What emerged were two different options that were investigated for the project. The main difference being the width dedicated to pedestrians and cyclists, while keeping the number of vehicular lanes constant. Option 1 featured a 2.7 m wide sidewalk, a 1.8 m wide bike “lane” and a concrete barrier providing separation on both sides of the bridge. Option 2 featured a 4.1 m wide multi-use sidewalk on the west side of the bridge for both pedestrians and cyclists. The east side featured a 2.5 m wide dedicated pedestrian sidewalk.

1.3 Project Challenges

There were several key issues and challenges surrounding the project due to the unique bridge site - Winnipeg's most densely populated neighbourhood, heavy usage of the facility by active transportation users, large population of fine arts exponents in the neighbourhood, active community participants and strong-willed advocates, large institutions including, Great-West Life and Legislative buildings, and key commuter access to downtown from the south and southwest parts of the City.

The neighbourhood of Osborne Village has a population of approximately 8,000 people, has nearly 554 buildings and houses more than 175 businesses. Close proximity of these dwellings and businesses to the bridge further complicated traffic management during construction. It was also necessary to minimize the impacts of noise during construction. In terms of technical challenge, not only was it necessary to ensure that the number of vehicular lanes remained the same, but it was also necessary to provide widened sidewalks for heavy pedestrian activity and to provide separation for cyclists from vehicles by either making use of “SHY” widths or having a multi-use sidewalk.

1.4 Project Scope and Methodology

Based on the rehabilitation needs and site constraints, the project was developed and then delivered in four discrete stages. Stage 1 consisted of condition assessment of the facility, conceptual design of the two bridge deck widening options, and presentation of these options to the public for feedback during the collaborative public consultation process. Stage 2 consisted of further developing the selected bridge widening option and implementing geometric improvements to the facility based on Universal Design principles. Universal Design is the practice of designing environments that can be efficiently used by people with a wide range of abilities operating in a wide range of situations. Stage 3 consisted of undertaking the detailed design of the rehabilitation, preparing tender drawings and specifications. Finally, Stage 4 consisted of undertaking rehabilitation works during two summer phases.

Not only was it necessary to engage the public through a public consultation process during all stages of the project, it was also necessary to perform traffic analysis to determine the most effective construction schedule and to minimize impacts to the traffic movements. On a broader scale, the rehabilitated bridge was required to be:

- Technically sound;

- Environmentally responsible;
- Cost effective;
- Reflective of the needs of the community and the City in general; and
- Generally understood and accepted by most of those affected.

2 ASSESSMENT OF EXISTING CONDITIONS

The condition of the bridge and roadway elements was determined predominately on the basis of visual observations, however, some non-destructive testing, such as hammer tapping of concrete for delamination was also utilized to determine extent of areas in poor condition. The condition of the roadway and the sidewalk on Osborne Street between River Avenue and Broadway was also assessed. A condition survey and laboratory testing of the bridge deck, piers, abutments, and roadway was also performed that included extracting concrete cores and performing a corrosion potential survey on the bridge deck and abutments.

2.1 Existing Bridge Assessment

Based on the condition survey of the bridge structure, the following observations and recommendations were made to address rehabilitation needs of the facility as noted in Section 1.2:

- The condition of the overlay varied from fair to poor and it was recommended to remove the asphalt overlay.
- The pedestrian handrail appeared to be in good condition but did not meet current City standards.
- Sections of deteriorated areas on the bridge girders were observed. Application of corrosion prevention system was recommended.
- The condition of the exterior overhang soffit and the soffit below the median curb was observed to be in poor material condition. Full depth replacement of the deck overhangs was recommended.
- The condition of the abutment diaphragms varied from fair to poor and it was recommended to repair the abutment diaphragms and apply corrosion prevention system.
- Water leakage from the expansion joints over the abutment bearing seats had resulted in deterioration of the concrete surface. It was recommended to repair the deteriorated areas and apply corrosion prevention system.
- Abutment bearings displayed material and performance deficiencies and replacement was recommended.
- The deck expansion joint assemblies required replacement as the joint gaps were too narrow to install new seals.
- The water soluble chloride content test results indicated that the chlorides had not infiltrated to the depth of the top reinforcing steel within the traffic lanes. The corrosion potential survey also corroborated the chloride content results by indicating reinforcing steel corrosion was occurring within small areas of the deck slab. Although the results of chloride content and corrosion potential values recommended a typical removal of 15% of the deck area, it was decided that accurately predicting removal quantities based purely on half-cell potential readings and chloride content results possessed certain limitations. Therefore, in order to ensure that there were no implications on user costs, rideability, structural adequacy, and public safety, it was necessary to take a conservative approach when determining the rehabilitation works required for extending the service life of the bridge for a period of 75 years. It was recommended that, a partial depth deck replacement be performed that also included replacing the top mat of black reinforcing with stainless steel reinforcing.

2.2 Existing Roadway Assessment

Based on the condition survey of the approach roadway, following were the observations and recommendations made to address the rehabilitation needs of the facility as noted in Section 1.2:

- Joint repairs and renewals, and concrete curb replacement was required on the northbound roadway.

- Presence of old trolley car rails had aided in the pavement deterioration of the entire Broadway and Osborne intersection and that required rehabilitation. In addition, sections of concrete pavement replacement as well as joint renewals were required.
- Reconstruction of the sidewalks along the length of the project area was recommended. This was necessitated partly by its poor condition, but also to bring the sidewalk facilities in line with Universal Design standards.
- Majority of the drainage inlets were in very poor condition and required full replacement. Utility manholes also required adjustments for proper grades.

2.3 Traffic Count Assessment

A traffic count analysis was completed within the project area to assess existing traffic conditions. The following summarizes the analysis completed for traffic counts in the vicinity of the bridge:

- 40,000 vehicles currently use the bridge on a daily basis during weekdays.
- The traffic counts on the bridge highlight heavy usage by vehicles, cyclists, and pedestrians. Osborne Street experiences a distinct peak direction depending on whether it is morning or evening rush hour. Computer modeling analysis showed that the peak direction of traffic (northbound in the morning and southbound in the afternoon) will experience significant delays if reduced to one lane to facilitate construction. Therefore, strategies to mitigate traffic congestion during construction needed to be implemented.

2.4 Structural Analysis

The major structural elements were analyzed to determine their load carrying capacity to assess strengthening or replacement requirements to address the rehabilitation needs of the facility as noted in Section 1.2.

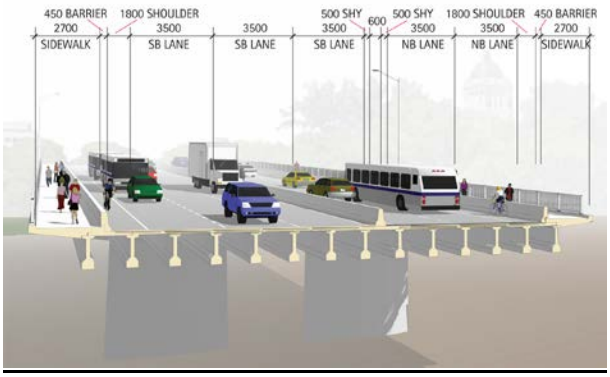
- An evaluation was completed for the moment and shear capacity of the girders. It was found that the existing girders were capable of supporting the proposed design and overload vehicle loads. Strengthening of girders was not required for the proposed live loads and the additional dead loads due to the widened rehabilitated deck slab.
- The capacity of the diaphragms was evaluated and determined to be adequate for supporting the superstructure dead load while replacing the bridge bearings.
- The substructure components were found to be adequate for both the current and proposed vehicular live loads.
- An evaluation was completed for the capacity of the bridge bearings. The capacity for the existing pier bearings was found to be inadequate. Therefore, all 12 pier bearings required replacement with new 600 ton capacity bearings to support the new design loads. An evaluation was also completed for the capacity of the abutment bearings. Abutment bearings were found to be adequate; however, as noted previously, the material condition of the bearings was poor and therefore replacement was required.
- The existing strip seal joints were leaking and required replacement. It was proposed that new modular expansion joints be installed at the abutments, which are more durable and longer lasting than strip seal joints. To accommodate the bridge deck movements, Wabo Modular Expansion Joint system (Wabo D-600) was recommended.

3 BRIDGE WIDENING AND REHABILITATION STRATEGIES

To provide a safe access and to meet the needs of all users in a cost-effective manner, not only was it necessary to widen the deck overhangs as much as practically possible, but it was also necessary to optimize the usable deck width by reconfiguring the traffic lanes. This was accomplished by removing the longitudinal joint and the median curb, and then joining the two bridge decks together followed by constructing a narrower median barrier to physically separate the opposing vehicular traffic. This resulted in shifting the traffic lanes closer to the median barrier and thereby achieving additional “SHY” widths for the cyclists. The two deck widening options are depicted in Figure 2.

A number of strategies were developed and implemented not only for the project as a whole, but also for specific aspects of the rehabilitation work. These strategies were:

- Preserve and upgrade the structure to current City of Winnipeg standards;
- Maximize the use of the existing structure in the rehabilitation;
- Incorporate low maintenance features;
- Design an aesthetically pleasing bridge, respectful of neighborhood identity on both sides of the Assiniboine River;
- Improve AT within the project area;
- Improve the roadway geometry where possible, such as at intersections and the bridge approaches;
- Maintain the roadway lane widths;
- Maintain the sidewalk width and provide a clear path for sidewalk users;
- Improve the condition and safety of the under bridge pathway;
- Minimize conflict between cyclists, pedestrians, and motorists;
- Provide access points over median curb/barrier for emergency vehicles;
- Provide room for City of Winnipeg Transit and maintain transit priority measures such as diamond lanes and Transit Priority signals;
- Ensure a safe environment for all users; and
- Provide links to the community.



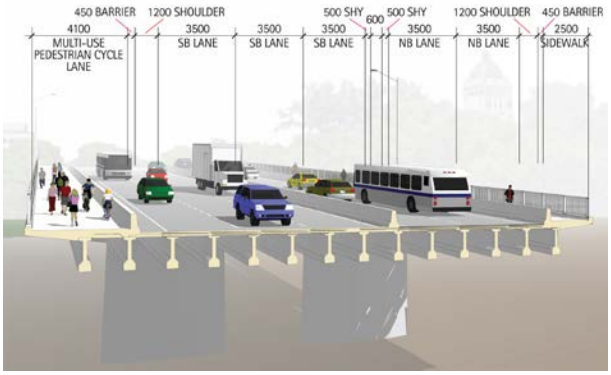


Figure 2 – Bridge Deck Widening Options

3.1 Bridge Deck Rehabilitation

The rehabilitation of a bridge deck is typically not an exact science and the strategy to extend the service life depends on many factors. These factors range from service life requirements, accuracy of the condition survey, availability of materials and technologies, location, and most importantly, the fiscal management practices of the agency.

Based on the above factors, a conservative, yet a cost-effective solution was implemented to rehabilitate the bridge deck, which included removing the existing asphalt overlay and waterproofing membrane followed by rotomilling approximately 40 mm of the deck slab to reach within 6 mm of the top layer of existing steel reinforcement. Following completion of rotomilling the removal of deck slab concrete continued beneath the top layer of existing steel reinforcement by means of hydro-demolition. The existing top mat of reinforcing was proposed to be removed, but the condition of the existing post tensioning (PT) strands was unknown and assessing the extent of any potential damage was difficult without exposing the strands. Repairing of the strands to increase deck capacity was complex and would not have been effective over the remaining life of the structure. But due to the original construction staging format, it was necessary to salvage and rely on the tendons during rehabilitation. Therefore, a combination of repair of the PT strands by Grabb-IT splice system and use of traditional deck reinforcement was proposed to be used for restoring any lost capacity of the PT strands. Detailed

inspection of the PT strands was part of the general contract and was required to be performed subsequent to hydro-demolition works.

A galvanic corrosion protection system consisting of discrete DAS anodes was proposed to be installed at the locations of exposed PT strands, and on bottom mat of reinforcing at blow through locations. The proposed deck slab included a 50 mm thick HPC overlay complete with a 235 mm thick deck slab, with top layer of UNS S24100 stainless steel reinforcing. The selection of stainless steel reinforcing was based on life cycle costs and the potential user costs. It was decided that the additional upfront cost of the stainless steel rebar was a good investment because it would increase the durability of the deck and substantially minimize future bridge rehabilitation requirements, which would be an inconvenience to bridge users.

3.2 Geometric Improvements

As noted previously, the Osborne Street Bridge is one of the most heavily used downtown crossings in Winnipeg. Geometric considerations were necessary along the approach roadways and the bridge to reduce points of conflict between motorists, cyclists, and pedestrians with consideration to the City of Winnipeg's Universal Design Policy.

Vehicular Traffic Lanes: Geometric improvements were constrained due to the existing right of way. Reconfiguration of the centre median allowed for adjustments to lane widths and for provision of a 1.8 m shy distance for cyclists around the vicinity of the bridge.

Cyclists: Cycling infrastructure on the bridge was inadequate and caused many cyclists to ride on the sidewalk where they conflicted with pedestrians. Property acquisition at the bridge transitions was limited due to site constraints and costs. This limited the extension of the 1.8m shy distance only over the bridge. A pedestrian/cyclist activated signal, "the first of its kind in Winnipeg" was constructed to facilitate E-W crossing at the north end of the bridge, which also provided a suitable connection to the existing AT infrastructure. This signal was preferred over a pedestrian corridor as the signal could be timed with the adjacent signals at Broadway and Roslyn, thus maintaining progression of traffic on Osborne Street.

Pedestrians: Features such as curb ramp alignment and installation of detectable warning tiles, removal of obstacles in the accessible path of travel, and reconfiguration of sidewalk paving patterns to assist visually impaired persons were designed. High level lighting on and under the bridge and well-pruned plantings leaving clear sightlines, were other ways of addressing City of Winnipeg's Universal Design standards and crime prevention and improving safety on, around, and under the bridge for all users.

Transit: Measures such as transit priority, diamond lanes, and transit priority signals are presently in use and were retained.

Figure 3 – Geometric Improvements for all bridge users

4 PUBLIC CONSULTATION PROGRAM

The Osborne Street Bridge public consultation was planned and implemented to provide an opportunity for the public to have input on the City of Winnipeg's plan to rehabilitate the bridge through a Collaborative Planning Process. This process was based on collaboration and informed public participation, and it brought together the shared knowledge and expertise of many to plan and then implement the best possible project. The consultation program comprised of the following internal and external stakeholders and the know-how they provided:

- Residents and community groups – local knowledge;
- Special interest groups – stakeholder concerns;
- City of Winnipeg representatives (Public Works, Planning Property and Development, and Transit) – project mandate, terms of reference, city policies; and
- Consulting team – technical expertise.

The goal of the collaborative planning process was for all affected and interested parties comprising of project stakeholders and City of Winnipeg representatives, supported by the consulting team, to work together in developing a plan for the Osborne Street Bridge rehabilitation project.

The collaborative planning and public consultation process unfolded in a number of distinct phases:

- Community profile and implications assessment;
- Preliminary informative publication;
- Neighborhood Advisory Committee (NAC);
- Public surveys;
- Broad public input; and
- Broad public communication about recommended conceptual plan.

The collaborative planning and public consultation process began during the initial phases of the project by developing a community profile to present an understanding of the surrounding community's values, aspirations, concerns, and interests. This information was related back to the project itself. A number of publications and surveys were delivered at distinct milestone dates of the project to neighborhoods within the project area and to the broad public as a means of providing information and also to collect feedback.

A NAC was then formed, which included representatives of sectors and communities that were most affected by this project. Committee members participated as representatives of a broader constituency to work together with the City's project representatives by providing input, identifying issues, and discussing reasonable options to enhance the project and also help mitigate impacts during construction. Formation of NAC was a vital tool in the collaborative planning process for discussing and developing feasible project alternatives. The project alternatives were presented for public input at an Open House. Based on the information received, the NAC members developed recommendations for the preferred option to the City.

The preferred choice recommended by the NAC was Option 1, primarily because it kept pedestrians safer by providing separation from cyclists. There could have been potential conflicts between pedestrians and cyclists at the transition zones. During profiling the community and representative sample survey research, it was discovered that there was a significant population of pedestrians, including a high number of seniors in many adjacent neighbourhoods. From this information, it was deduced that there were potential mobility and accessibility issues which will have to be considered when evaluating the two options. Option 1 provided a much safer alternative by avoiding potential pedestrian – cyclist conflicts. Furthermore, Option 2 also required property acquisition within the project area, thereby significantly increasing the overall cost of the project.

Building on the knowledge and wisdom of local community organizations, specialized interest groups, and the City of Winnipeg, creative solutions were developed to best meet the goals of the project. The City

also maintained an information web page with periodic updates during the course of the project. A few of the important issues bought forth during the consultation program are discussed in the following Sections.

4.1 Integration of Public Art

Based on the input from collaborative planning and public consultation with the NAC, the City partnered with the Winnipeg Arts Council to incorporate public art into the bridge. Aesthetic treatments that included public art were one of the key elements requested by the public.

A team of local artists were hired quite early in the design phase to work directly with the design team. This seemingly simple innovation ensured that the public art was truly integrated into the project and did not seem as an accessory or an after-thought. Public art was integrated into the project by providing a subtle gateway, appropriately transitioning between the Osborne Village and the grand Legislative building and the surrounding grounds. The theme of the art, “From Here Until Now”, celebrates the area’s unique history and quirky character into a surprisingly delicate concrete-and-aluminium poem.

Work included placing contrasting concrete tones and stainless steel trimming in the sidewalk overlay that depicted Osborne neighbourhood’s physical map. The bridge handrails, through LED lighting and text inscribed in digitally-cut aluminium plates transformed the existing balusters (pickets). Many of the inscribed texts were inspired from surveys in which residents related anecdotes or wrote about their memories, dreams and hopes. Two illuminated gateway zones at both bridge entries displayed four important architectural moments of the neighbourhood’s history (the Legislative building, the Roslyn Apartment Building, the Granite Curling Club, and the Evergreen Towers), this was accomplished through renditions fabricated with water jet-cut aluminium plates and LED lighting. The end result is not an immense, attention-grabbing monument but rather a slow, quiet, and interactive experience that highlight the vibrancy and community spirit of the neighbourhood.

Figure 4 – Osborne Neighbourhood Map Concept on the Sidewalk

Figure 5 – Illuminated Handrail

This concept truly reflected the thoughts expressed by the residents of Osborne Village and the surrounding community during the public consultation process, and treats the bridge infrastructure itself

as art by integrating the art components within the structure. This process was truly a collaborative endeavor between the City of Winnipeg, the Winnipeg Arts Council, the community, and the design team.

4.2 Crime Prevention through Environmental Design Measures

Through the public consultation process, residents and business owners expressed concerns about safety for themselves and their customers, and the need for a welcoming environment for all who use this facility. The existing outdoor areas located adjacent to and under the Osborne Bridge at the north and south sides of the Assiniboine River, and on the east side of Osborne Street immediately south of the bridge, were examined. The principles of Crime Prevention through Environmental Design (CPTED) were utilized to provide insight into the existing conditions. Following are the major recommendations that were implemented that also coordinated with the aesthetic and landscaping design for the project:

- Clear signage and wayfinding to identify the space, thereby increasing the level of activity of legitimate users in the vicinity and to reduce the likelihood of undesirable activity.
- Improved signage and wayfinding to create awareness of the pathway system and its functions as a gateway to the Riverwalk.
- Pedestrian/cyclist activated signalized crossing at Mostyn to offer a safe and convenient alternative route for cyclists and pedestrians.
- Lighting fixtures that provide adequate and uniform illumination levels and are both highly vandal resistant and regularly maintained.
- Architectural fence around the south abutment to act as a deterrent for illicit and criminal activities.

4.3 Traffic Delays during Construction

As noted earlier, the Osborne Village neighborhood is the City's most densely populated area and the facility handles substantial amount of traffic. Therefore, it was a foregone conclusion that any traffic restrictions within the facility would result in delays for the users. Therefore, to alleviate the traffic and pedestrian concerns during rehabilitation works on the bridge and approach roads, the work was performed in phases, thus ensuring three lanes of vehicular traffic and one pedestrian sidewalk remained open at all times.

5 CONSTRUCTION

The construction of the Osborne Street Bridge and associated roadwork was completed in two Phases, first on the northbound structure and then on the southbound structure. Phase 1 began in April 2011 and was completed in October 2011. Phase 2 began in April 2012 and was completed in November 2012.

5.1 Traffic Staging

During the two major construction phases, there was one dedicated lane of traffic for northbound and southbound direction. The direction of traffic in the center lane reversed depending on the peak hours. There were also some turning restrictions in place during the construction period, but emergency vehicles could access all routes. The three traffic lanes were delineated by poly posts and temporary median barriers to protect vehicular traffic from construction activities. During the remaining construction phases and during winter months, two dedicated lanes were available for both directions.

5.2 Construction

Phase 1 of construction began in April 2011 and was sub-divided into two distinct segments. The work involved removal of existing asphalt, handrail and sidewalk along with deck overhang, and median slab, replacement of bearings, rotomilling of deck surface above top layer of reinforcing, hydro-demolition of remaining deck surface, and removal of expansion joints. Bridge deck reconstruction initially included inspection of existing longitudinal PT strands in the deck. But due to de-bonding of majority of the PT ducts due to hydro-demolition as well as broken tendons due to corrosion, all the exposed ducts were removed and the remaining PT tendons were considered ineffective. Additional steel reinforcements were placed in these zones to achieve the required capacities. This simplified the rehabilitation process by

relying solely on traditional deck reinforcement. As a result of this change, the construction schedule was improved considerably. Reconstruction of the deck slab also included installing electrical conduits, installing a top layer of stainless steel reinforcing, casting concrete for the deck slab, casting concrete for a sidewalk slab, forming and pouring new barriers, installing new expansion joints, casting sidewalk overlay concrete that included stainless steel art strips, placing a high performance concrete overlay, and installing handrail and electrical components.

Phase 1 of Roadwork rehabilitation also began in April 2011 and was split into three segments. The work included planing pavement, removing existing curbs/sidewalks, placing new sidewalks and curbs, completing full depth concrete repairs, replacing the intersection at Broadway/Osborne, restoring landscape damaged during construction works, and placing asphalt overlay.

Phase 2 of construction began in April 2012 and the work activities were similar to those completed in Phase 1. The bridge was fully opened to public on October 26, 2012.

A small Liaison Committee was formed that comprised of representatives from the NAC, the consulting team, and the City of Winnipeg. This committee was available on an as needed basis to work through any neighborhood issues raised during construction.

6 CONCLUSION

The Osborne Bridge project was a major bridge rehabilitation and widening project that occurred with traffic continuing to use the bridge during construction. Not only did the project comprise of technical aspects of bridge rehabilitation and road reconstruction, but also included certain non-technical challenges including managing high public expectations for the project from a diverse group of stakeholders.

Figure 6 – Pre and Post Construction views of Osborne Street Bridge

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