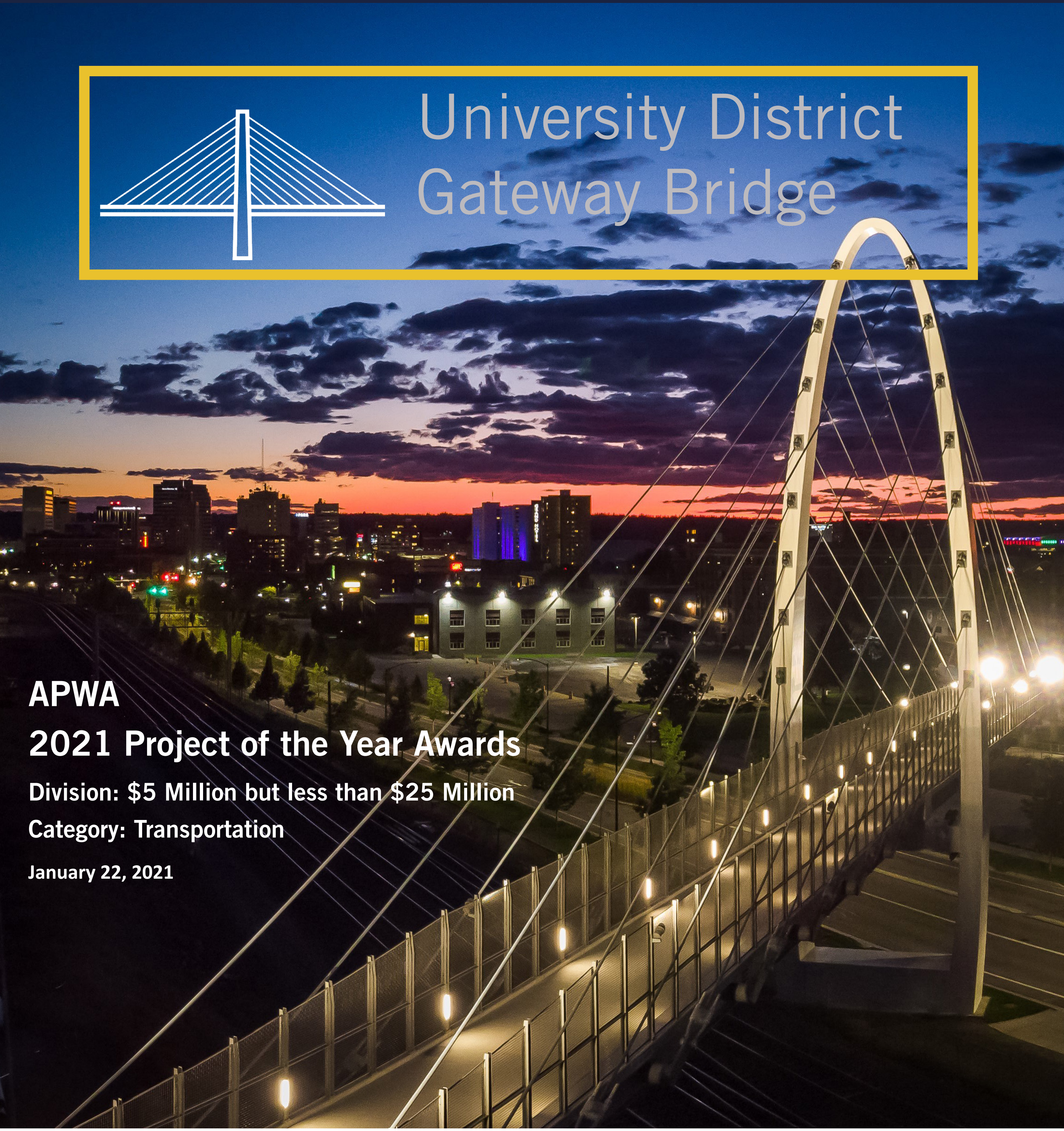
University District Gateway Bridge



APWA

2021 Project of the Year Awards

Division: $5 Million but less than $25 Million

Category: Transportation

January 22, 2021

Submitted by: City of Spokane

In conjunction with: GARCO, kpff

Introduction

History

The University District Gateway Bridge is a 460 foot-long cable-stay bridge in the City of Spokane that was built to connect the Riverpoint campus to the underutilized East Sprague neighborhood in the University District.

Background

The University District campus began to take form after the 1974 World's Fair, held in Spokane. What is today an 80-acre campus with over $600 million invested in buildings, technology, and infrastructure began as a brownfield site where rubbish from the City's 1880's fire was mixed with years of debris from the rail yard that cut through the area.

Today

Over 30 years of evolution occurred to create today's University District campus. The district's northern half includes the campus of both Gonzaga University and the Riverpoint Campus, home to satellite locations for the University of Washington, Washington State University, Whitworth University, and Eastern Washington University. The southern half includes underutilized commercial properties.

Besides completing a gap in the non-motorized transportation network, the bridge provides:

» Improved network safety performance
» Safe and efficient access for economically disadvantaged populations to jobs and education opportunities
» More continuous bicycle and pedestrian network for active transport users
» A catalyst for the redevelopment of the South University District into a mixed-use, residential, office, retail, institutional, and pedestrian-oriented district

1,012 PLANTS | number of trees and shrubs planted
120 FEET | the height of the Arch
312 TONS | total rated weight for the bridge
3,688 FEET | of tension cable used for the bridge
48,000 MAN-HOURS | total to complete the bridge

Timeline

Budgeted Actual Construction Cost	$11,113,403 $10,382,328
Award Construction	January 2017
Construction Started	March 2017
Target Completion	October 2018
Actual Completion	May 2019
Extension Time	The project was originally scheduled for completion in October 2018. Steel shortages, brought on by international trade tariffs, delayed the procurement of the material required to construct the railings. Additionally, BNSF changed their girder erection policies without notice, causing delays to the Span 3 construction, which takes place over the tracks. Accordingly, the bridge's grand opening was pushed to May, 2019.

CITY OF SPOKANE

Management

Construction management was made successful through a joint effort involving the City of Spokane, KPFF, and Parametrix. The City contracted KPFF, who served as the technical lead and shared project management duties with Parametrix. The flow of information was managed through an all-in-one construction management software called Procore. This software was used for all project coordination, including schedules, RFIs, submittals, contacts, inspections, punch lists, meetings, etc.

Weekly construction meetings were held near the project site throughout construction, greatly contributing to the quality of communication on the project. These meetings were a chance to get the latest information on the table so that issues could be discussed as a group, ensuring that construction would move forward smoothly. The meetings were attended by Garco's project manager and superintendent, the City engineer, a BNSF representative and the CM project manager. The weekly agenda included the following topics:

- Summary of Working Days
- Site Safety Issues or Concerns
- BNSF Railway Coordination and Scheduling
- Construction Progress and 3-Week Schedule Review
- Design Clarifications
- Change Orders
- Submittals
- RFIs
- Testing/Monitoring

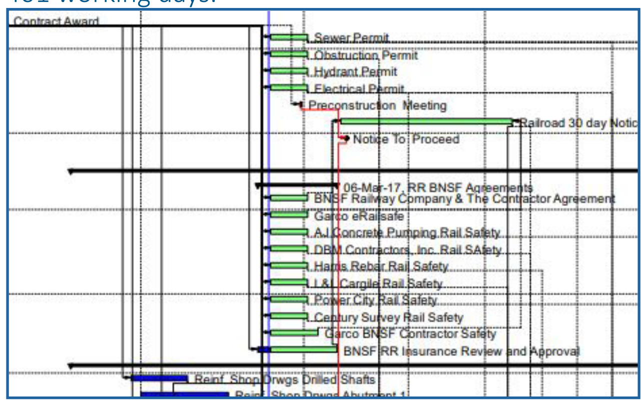
As the Prime Contractor, Garco provided overall site management and coordination. Garco utilized an experienced construction team, including a Project Manager who had previously managed construction of two other cable-stayed pedestrian bridges, to construct this highly technical project. Garco self-performed all reinforced concrete construction, structural steel erection, and cable stay installation, comprising nearly 60% of the contract value.

Schedule

Garco performed overall construction scheduling using Primavera P6 Professional software. The baseline schedule included over 300 activities to sequence the work within the contract constraints and 300 allotted working days. Additional considerations factoring into the schedule included BNSF's moratorium on operations adjacent to their tracks from October through December, a three-month limitation for closing Martin Luther King Jr. Way through the project site, and harsh weather conditions during the winter months.

Construction commenced in early March with the goal of completing all bridge substructure work and the center pylon prior to the BNSF moratorium starting in October. Unfortunately, an issue arose immediately due to conflicts between the pylon foundations, a previously unlocated BNSF gas line, and the adjacent track envelope. The project team worked together to devise a new solution within the revised parameters, but the late start on the foundation work pushed the pylon construction and subsequent steel erection into the following spring.

Additional contract days were added during construction due to delays from steel erection restrictions added by BNSF and modifications to the storm drain infiltration system, as well as added work to accommodate future development near the south landing. The project was substantially completed in 401 working days.



BNSF Coordination

Because the bridge was built over three very active mainline BNSF tracks, coordination with the railroad was paramount. This coordination began in design and continued throughout construction.

Design elements that met BNSF needs and made for smooth construction over the tracks were incorporated into the plans and specifications for the bridge. For example, the 10 foot-tall throw barriers on the main spans were carefully coordinated with BNSF. KPFF engaged with the railroad during design to design a throw barrier that would protect the tracks while meeting the architectural and pedestrian/bicycle needs of the bridge users. As a result, the design team got a variance from the typical curved fence that BNSF normally requires allowing for an aesthetically pleasing architectural fence with straight posts.

In order to minimize impact to the railroad during construction, the bridge was designed with galvanized, corrugated steel stay-in-place deck forms between the girders. Stripping typical plywood forms is a messy and time consuming process that would have been very disruptive to the BNSF operations. By using stay-in-place forms, Garco could place the deck and move onto the next step without needing to strip the forms. This saved a significant amount of time, money, and hassle for all parties involved, and reduced the impacts to BNSF.

Design & Construction Challenges

The bridge design originally called for four precast concrete members stacked two-high to construct the arch pylon. These precast pylon sections were up to 45 feet tall and weighed over 70 tons, and would have to be supported in place to allow for the splice rods between sections to cure for at least three days to attain the strength required to ensure a solid connection.

The pylon was located only 17'-6" from the centerline of the adjacent BNSF mainline railroad track and less than 10 feet from the edge of Martin Luther King Jr. Way. With the top of the pylon at 120 feet above grade, steel guy wires would have been required to extend nearly 175 feet to the south abutment to support the upper precast sections, across the active railroad tracks. Due to these site constraints and associated safety concerns, Garco decided to construct the pylon as a cast-in-place concrete structure, and submitted and received approval to do so.

Constructing the pylon in place was not without challenges either. Garco utilized a custom steel and wood deck to place the pylon in five vertical sections. An EFCO steel panel forming system and custom-made wood form inserts were used to capture the dual parabolic arches which make the pylons outer and inner shape and accommodate the tapered profile of the pylon in the other direction. Detailing and constructing these inserts was a challenging task as maintaining the symmetry while casting each lift of the pylon with cable anchorages placed exactly meant precision was paramount.

Further challenges were created by the site topography, as the pylon was cast in place with live traffic almost directly underneath and crane operations had to be suspended while each train passed. With an enormous amount of planning, preparation, and patience from the jobsite crew, Garco was able to successfully construct the pylon and create a structurally sound and elegant piece.

A survey was conducted twice for every lift to ensure it was precisely in the predetermined location. The overall quality of the cast-in-place concrete was excellent, with minimal finishing required.

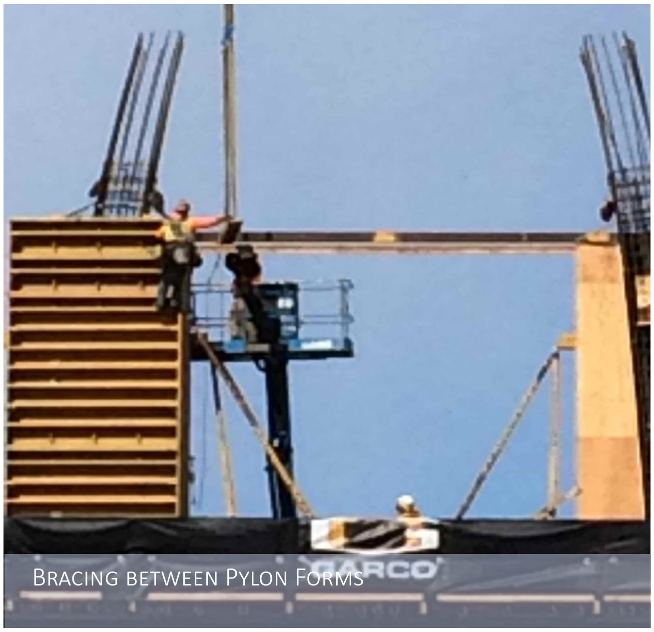
Wood Infill Forms for Arch Peak

Installation of Custom Deck for Upper Levels of Pylon Construction

Reinforcing Steel Cage Being Set for One Pylon Leg

Constr. Schedule, Mgmnt & Control Techniques (cont.)

Management, Schedule, BNSF Coordination, & Challenges

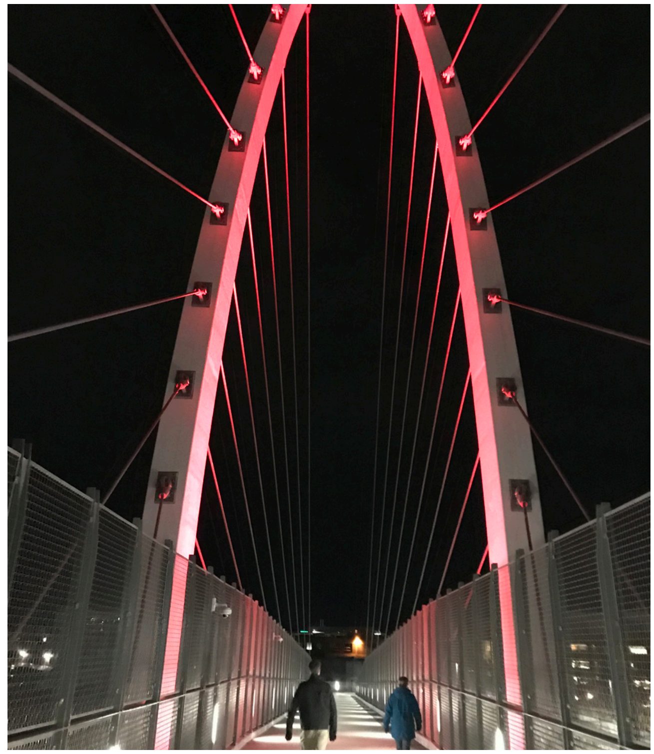


Bracing between Pylon Forms

Construction of Pylon Lift 4

Forming the Peak of the Pylon

Pylon Topping Out Concrete Placement



Safety Considerations During Design

In order to make the bridge a safe and inviting space, KPFF worked with MW Engineers and LMN Architects to provide lighting and CCTV Cameras on the bridge. The goal of the lighting was to provide enough light for safety, but to direct it away from the BNSF railroad tracks below the bridge. This was accomplished by placing the lights inside the stations of the railings and barriers along the length of the approaches and the bridge. Two cameras were placed on the structure to assist campus security in monitoring the bridge. The downcast lighting provides a warm inviting glow to the pathway at night with sufficient illumination to support the use of the cameras.

Job Safety

This project was extremely challenging from a safety standpoint due to the large amount of elevated work, at heights up to 120 feet, and construction over active rail lines and roadways. In addition to complying with WISHA requirements on this project, Garco was under heavy oversight from BNSF as well. Garco resolved many of the potential issues with extensive forward planning, including preassembly of components to the maximum extent practicable, conversion of the pylon to CIP construction instead of precast, and thorough engineering of all critical hoisting activities.

In accordance with their internal policies, Garco conducted daily safety briefings at the crew level, weekly safety meetings with all personnel on site, and weekly project inspections. All personnel received a site safety orientation, and visitors were escorted while onsite. Site specific training in fall protection, rigging and signaling, and rescue and recovery was conducted to ensure that all personnel were fully educated. Additionally, Garco and their subcontractors conducted a safety briefing with the BNSF flagger each day to avoid conflicts with the train schedule, and resequenced the day's work plan accordingly.

The proximity to parking lots for university students and staff on the north end of the project had the potential to incur conflict with public pedestrian movements through the jobsite. Garco created alternate routes for pedestrians to reduce these conflicts. In addition, the project team worked cooperatively to enact a longer closure of MLK Jr Way to eliminate vehicle traffic under the bridge spans during critical construction periods.

Due to these efforts, Garco achieved their goal of zero reportable incidents during construction of the project, while working over 48,000 man-hours. The attention to safety made the project a success and allowed all personnel to return home without injury.

Safety	
Total Hours Worked	48,000
Lost Time from Injuries	0
Project OSHA Incident Rate	0

Working with BNSF & Their Schedule

Working adjacent to and over three BNSF railroad tracks, including their mainline between Chicago and Seattle/Portland, required close coordination with trains passing every 12 minutes on average. A BNSF inspector was on site for nearly the entire project, and all operations that necessitated materials or equipment to be placed over the tracks required track shutdowns with extremely short work windows.

This required pre-planning all activities that could potentially affect the train schedule and flexibility to adapt when BNSF altered the agreed schedule. Given these requirements, we emphasized planning and scheduling for every employee and every task. A briefing with BNSF's inspector was held daily where we had to adapt our schedule to the number of trains and their projected arrival times for the day.

Garco took several measures to limit the number and duration of track closures needed. These included proposing an alternative plan to shop-paint the completed girder assemblies. Although the design called for field painting, shop painting yields a superior finished product, avoided the need for numerous track closures to allow for man-lifts to work over the tracks, and allowed Garco to provide over $76,000 in credit to the project Owner due to decreased costs from this method.

In addition, Garco did everything possible to install all secondary components on the girder assemblies prior to hoisting each bridge section, including installation of all of the metal decking between girders; attachment of temporary bridge overhang brackets to the girders; and construction of the wood overhang walkway, formwork and handrail.

While these measures required significant additional construction engineering effort to appease the bridge designer and BNSF, they avoided the need to operate manlifts and cranes over the tracks, greatly reducing the track closures necessary and enhancing safety for BNSF and Garco employees.

Garco also spent an immense amount of time planning the erection of the girder assemblies to proceed with the least impact possible. BNSF only allowed for a maximum 4-hour track closure to install Span 3, consisting of two girder assemblies with a combined weight of 68 tons. Due to BNSF requirements, the girder assemblies could not be passed between cranes to allow erection in one piece, but had to be set in two sections simultaneously and spliced in the air by our ironworkers.

Despite multiple delays due to BNSF operations, this critical lift was successfully achieved in only 2.5 hours of the allotted 4-hour window.

Community relations during design, construction, and for the lifespan of the bridge are the underlying reason for the project's success. The main objective of the crossing is to serve the people of the community, which it does by connecting the East Sprague neighborhood and fostering development therein.

Connectivity

- The bridge is part of a network of walkways, trails, and sidewalks that allow people to walk and bicycle throughout the district in multiple directions.
- The bridge is a critical connection across a major transportation barrier, allowing the higher education functions and recreational amenities on the north to interact with commercial and living spaces on the south.
- Because it is the only such connection within the district, its use is prominent.

Clarity

- The bridge serves as a symbol for co-joining the academic and urban communities.
- This symbolic role is significant enough to suggest a scale and form that is amplified beyond the basic functional and structural requirements.

Character

- The bridge has multiple identities. It is visible from a distance. The bridge is a landmark that allows for people to be oriented to where they are within the city and the district.
- The approaches to the bridge includes trees and other landscaping as well as benches and lighting to enhance the experience.

Comfort

- The bridge accommodates a wide range of users of all ages and types – commuters, walkers on a leisurely stroll, people with disabilities, and bicyclists.
- The bridge offers a high degree of comfort with convenient access, personal safety, and non-slip surfaces.

Catalyst

- As a distinct piece of architectural engineering, the bridge has energized its surroundings with a new image and value.
- Private investment has been stimulated and enhanced through creating an ambiance that includes the bridge, attractive approach and streetscapes, landscaping, and public spaces.
- Because the existing context within the University District is evolving, the bridge conveys both stability, vitality, and transforming neighborhood.
- The bridge and its associated connections serve as a demonstration of more sustainable methods of circulation in the district and downtown.

Minimizing Public Impact

Garco minimized the project's impact on the public was by finding a creative location to stage their construction.

It became apparent early on in the project that Garco would require a large staging area to accommodate the massive girder sections, a job shack, roles of wire rope, rebar, etc. However, space was a premium on the north side of the railroad tracks. Accordingly, Garco proposed using MLK Blvd as a staging zone. Normally, this would be a great inconvenience because it would render the city street unusable. However, MLK was under construction at the time, meaning it was already closed to the public.

The City agreed that MLK was a suitable staging site and allowed Garco to proceed. The construction was finished in time to clear the street before MLK was reopened to traffic.

Community Relations (cont.)

Protecting Public, Minimizing Inconvenience & Improving Relationship

Bridge 101

The University District Gateway Bridge on the day it opened began providing users with easier and safer access to Spokane's university and medical districts.

The campus area north of the bridge does not contain room for new housing for the universities; therefore, a planned seven-story apartment building and a three- to four-story building at the southern terminus will provide much-needed housing for the universities.

The project truly was a team effort with stakeholder outreach and public involvement integral parts of the process. KPFF gave a presentation "Bridge 101," a lesson in bridge design that was presented both to the Mayor's Advisory Committee and during our stakeholder presentations. This provided insight into the key decisions (i.e., criteria was for bridge design, how criteria could be met, and why specific alternatives could or not be considered). This insight helped the stakeholders understand the process and provided boundaries for expectations. This produced a trust between the stakeholders and design team, and allowed decisions to be made relatively quickly.

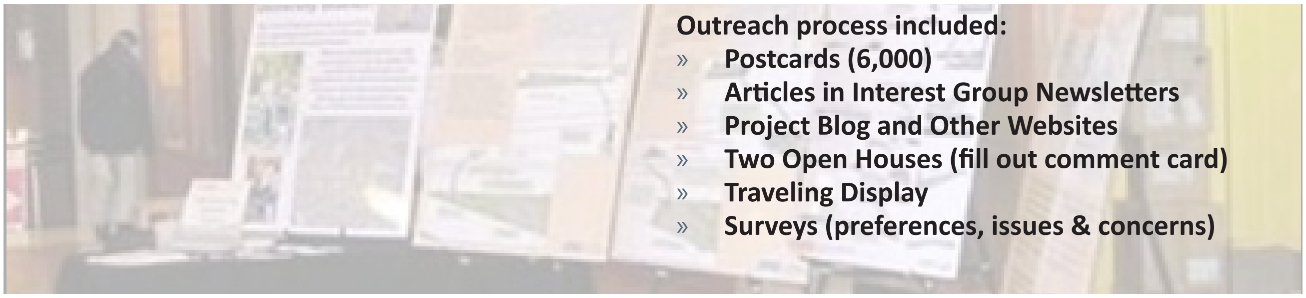
Outreach

A major component of the stakeholder outreach was the formation of the Mayor's Advisory Committee. The Mayor's Advisory Committee comprised individuals who understood and could represent the interests and concerns of both key stakeholders and the general public. Organizations and interests represented included the following:

- Bike Perspective
- City of Spokane – Economic Development
- City of Spokane – Capital Programs
- Spokane Transit Authority
- University District Board Director
- University District Advisory Council
- Washington State University

Outreach was broad and included but was not limited to the following stakeholders:

- Elected Officials and Public Offices
- Twenty-Five Adjacent Property Owners
- University District Organizations
- Neighborhood Groups (East Sprague, International District, Logan, Riverside)
- Academic Organizations (four universities and one community college)
- Special Interest Organizations (Friends of the Centennial Trail, Friends of the Falls, East Sprague Business Association, Downtown Spokane Partnership and Greater Spokane Incorporated)



Outreach process included:

- **Postcards (6,000)**
- **Articles in Interest Group Newsletters**
- **Project Blog and Other Websites**
- **Two Open Houses (fill out comment card)**
- **Traveling Display**
- **Surveys (preferences, issues & concerns)**

Social and Economic

The report entitled — "America's Next Great Academic Health Science Center," by Tripp Umbach, studied the economic impact of the expansion of the Academic Health Science Center at Riverpoint over a 20-year period. The report estimated that by 2030 the economic impact of an expanding center would generate "approximately $1.6 billion, support 9,276 jobs, and generate more than $111 million in government revenue."

A partnership with the City of Spokane and the Spokane Regional Health District completed the Spokane University District Pedestrian/Bicycle Bridge Health Impact Assessment (HIA). As part of the analysis, the HIA assessed the potential economic development effects of the proposed bike and pedestrian bridge and its link to community health.

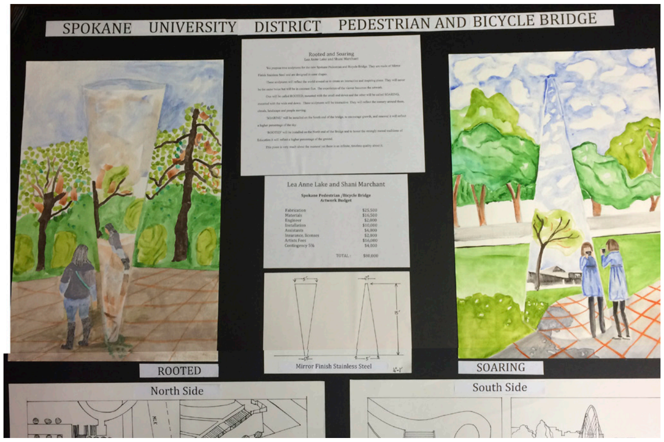
The World Health Organization (WHO) describes an HIA as "a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population" (WHO, 1999). The University District Pedestrian Bridge was the first infrastructure project that was implemented.

This HIA accounted for six health impacts: 1) physical safety, 2) perceived safety, 3) social capital, 4) air quality, 5) physical activity, and 6) economic development. These impacts were chosen because of their relevance to the study's goals of reducing vehicle miles traveled, reducing greenhouse gas emissions, and creating jobs, and their relevance to reducing some of the top causes of preventable disease and death in Washington State.

> *That bridge means opportunity for the WSU Health Sciences campus, and for Spokane. We envision a health innovation district there that will change people's lives in the region and around the globe"*
>
> - Daryl DeWald
> WSU's Health Sciences Chancellor
> WSU Insider reported

Artwork

Artwork stands at the north and south ends of the University District Gateway Bridge. "Rooted and Soaring" are two polished steel cones designed by Spokane artists Shani Marchant and Lea Anne Lake during the design phase of the bridge. Marchant is a local painter and artist known for watercolors and oil paintings. Lake created numerous public art works across the country. The abstract work entitled **Rooted and Soaring** are based on the titles of the pieces. **Rooted** is located on the developed campus side of the bridge and symbolizes weight and being anchored in the present. **Soaring** is on the underdeveloped side of the bridge and is about movement and the reflection of the sky as unlimited possibility. Each piece is about the reflective qualities of the steel, which allows viewers to see themselves and the surroundings.



Environmental Consideration

Preserve & Protecting the Environment During Construction

Governor Inslee Visiting the site in October 2018.

The University District Gateway Bridge site was once home to an industrial railyard. As a result, soil testing found higher than normal levels of arsenic, lead and cPAH, and other soil contaminates that would require cleanup in order to make the site safe for users in the future.

KPFF worked with GeoEngineers to devise a plan to clean up the site during construction. This involved excavating the top few feet of soil, where the contamination level was highest, and replacing it with clean fill. This fill was capped by cobbles in order to prevent subterranean mammals from digging through and transporting the soil below. Finally, the cobbles were topped by a layer of rich soil that would be capable of supporting the extensive landscaping vegetation to be incorporated.

Garco took this already environmentally beneficial plan and made it even greener. The removal of contaminated soil would require a massive amount of truckloads of soil to be hauled off site, then even more truckloads of soil to be brought back in. All this freight amounted to a considerable carbon footprint as well as a cost to the City.

Garco proposed an on-site operation in which the soil would be screened to separate the rocks and cobbles, which did not contain contaminates, from the contaminated soil. These rocks and cobbles were then reused on site, reducing the amount of waste generated and number of truck-miles traveled.

Design elements focused on reducing environmental impact were utilized throughout the project. Some examples include precast permeable pavers and the use of pervious concrete at the ramp landings.

During construction, Garco established and maintained Temporary Erosion & Sediment Control measures during the duration of the project to reduce and filter stormwater runoff. Concrete washout water was collected and disposed of offsite, and steel remnants, asphalt, and concrete rubble were recycled. Concrete curing was done with chemical sealers as much as possible to reduce the use of construction water and infiltration.

Shop painting of the bridge girders also eliminated the generation of pollutants from sandblasting and painting operations.

Techniques

Cable-stayed bridges are rather unique in general, and relatively uncommon. The bridge derives its integrity from the steel cables suspended from the center pylon which support the bridge superstructure.

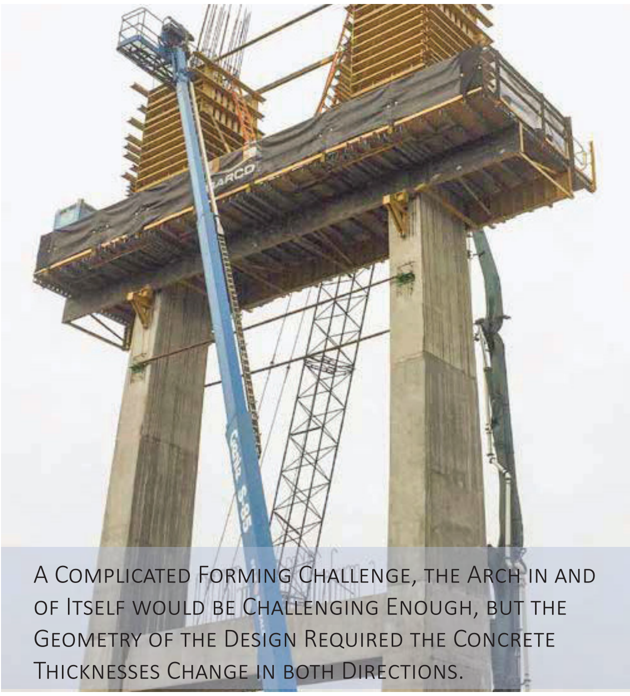
The University District Gateway Bridge girder assemblies would have sagged over 2.5 feet under their own weight (no concrete deck, curb, fencing or pedestrian occupancy load) without the support of the cables.

In order to construct the bridge, Garco's ironworkers installed 3,688 feet of 2 5/8" diameter galvanized structural strand cable in a total of 32 assemblies. Due to the asymmetric spans – 240 feet to the north and 174 feet to the south- each pair of cables required a different tensioning force.

Garco designed and constructed a custom hydraulic jack system to provide precisely the correct amount of force into each cable. In addition, Garco surveyed and graded the bridge to achieve the desired deck profile while tweaking the cable tensions after all stay cables were in place.

As noted previously, building the concrete arch as a cast-in-place element was a unique construction technique requiring custom-form inserts made of wood ribs individually cut for each vertical foot of the pylon structure. The rib dimensions were calculated and constructed to provide exact offsets to all four faces of the arch, accounting for the two different parabolic arches on the exterior and interior as well as the continuous taper on both sides.

The cross section of each leg of the pylon changes from 8'-6" x 4'-6" at the base to 4'-0" x 1'-6" at the apex. The platform supporting the arch forms was a very unique design as well, which allowed for "jumping" the platform from level to level without ever fully removing it from the arch. Construction of the pylon was featured in EFCO's FormMarks magazine.



A Complicated Forming Challenge, the Arch in and of Itself would be Challenging Enough, but the Geometry of the Design Required the Concrete Thicknesses Change in both Directions.

Height — Elevator or Ramps

The height of the approach landings was a key concern of the City's, related to safety and user acceptance. With landing heights as high as 30 feet, options included both elevator and ramp configurations. It was decided during the development of the landings that any approach height above approximately 25 feet created a ramp length that was simply too long (350 to 500 feet). Consequently, any configuration requiring a height of this magnitude would use an elevator. Although the elevator options created the least footprint, the general public and the advisory committee all felt that elevators were the least desirable alternative.

For the general public, concerns related to the elevator were about safety and access for bicycles and strollers. For the advisory committee, the concerns were regarding ownership of the elevator (e.g., whether it would be the University or the City), as well as the associated operation, maintenance activities, and costs. This single issue was instrumental in the overwhelming selection of ramps as the preferred alignment.

The selection of ramps for the approaches was the key decision that moved the structural solution from the shortest, perpendicular path across the rail and roadway corridors to a skewed bridge alternative. By skewing the bridge and adding length to the bridge spans themselves, part of the vertical height that would be traveled by users would be taken up in the slope of the bridge deck. This reduced the height of the landings at both ends of the bridge and in turn reduced the lengths of the approaches.

Wind — Users and Trains

Due to the thin profile of the bridge deck structure, the bridge was designed and checked for wind loads that might be uncomfortable for users or possibly damage to the bridge.

Also, the bridge was checked for winds that could occur naturally or be generated by locomotives traveling under the bridge. Specific objectives were to determine the response of the bridge to vortex-induced motions, to determine critical flutter wind speeds, and to determine the buffeting responses of the bridge to a design wind speed in its final configuration.

The time-dependent aerodynamic loading on an oscillating large-scale section model was obtained experimentally in the wind tunnel. At the large scale of the section model (1:10), fine geometric details, which have been shown to be very important, were reproduced with accuracy. The time-dependent aerodynamic loading on the bridge deck section was characterized by a series of flutter derivatives and static aerodynamic coefficients. The aerodynamic loads that contribute towards an aerodynamic instability, or buffeting response, of the entire bridge consisted primarily of the aerodynamic loads on the bridge deck, the pylon, and the cables. Wind loads on the bridge deck were determined from wind tunnel tests on the section model. Wind loads on the pylon and cables were determined using aerodynamic coefficients.

Bedrock Stronger than Concrete

During the geotechnical explorations, engineers discovered that the bedrock at the site is the infamous blue basalt. This rock, which is found all over Spokane, is 10 times stronger than concrete and has been responsible for countless schedule and cost overruns due to its incredible strength. Garco needed to excavate 65 cubic yards of this material to install the drilled shafts alone. Further excavation was required to trench out for the infiltration facilities and for the spread footings at the abutments.

Garco had to use special techniques to remove the basalt. The process started with a series of 6” diameter drill holes through the rock for the full depth of the excavation. This matrix of holes weakened the rock allowing more conventional drilling and chipping to take place. By understanding that the blue basalt would be a challenge, Garco was able to build extra schedule and budget into their plan to deal with it.

The University District Gateway Bridge is 460-foot-long cable-stayed foot-bridge in Spokane, WA. The three-span bridge crosses MLK Jr Way and three Burlington Northern Santa Fe (BNSF) railway tracks to connect the Riverpoint Campus to the developing East Sprague neighborhood to its south. The bridge consists of rolled steel girders supported by 32 stay cables that connect to a 120-foot-tall concrete arch, positioned between the roadway and the railroad tracks. The bridge includes additional items such as lighting, conduit for future fiber optic connections, throw barriers, and railings. Both approaches meet ADA requirements and include landscaping, art, lighting, and public gathering space. The Transit Plaza at the south abutment is approximately 35 feet wide and 270 feet long with sufficient space to turn a transit shuttle bus.

Early on in the planning process, it became clear that a simple girder bridge would not meet the complex geometry requirements of the site. The engineers would be required to utilize a more unique design concept to span a BNSF corridor, a new City corridor (East Martin Luther King Jr. Way), and a future light rail corridor.

It is intuitive that the most efficient way to connect two points is a straight line. When first looking into structural alternatives to span the barriers within the University District, bridges perpendicular to the BNSF, City, and light rail corridors were initially thought to be the obvious solutions. These solutions would be the shortest structures providing the most direct route. However, it was decided after review that this would not be the safest, most economical, or accepted solution.

The topography of the site and the vertical clearance requirements to existing facilities were key challenges. The height of the approach landings was set by the distance from the bridge walking surface to the at-grade ground surface. This distance defined by the combination of the bridge depth, the required vertical clearance above the railroad, roadway, and transit corridors was as high as 30 feet. This **vertical grade change made it challenging to bring users from the bridge to the ground surface in a safe and accessible manner.**

The first step in meeting the challenges of the bridge's vertical height was the depth of the bridge structure. Reducing bridge depth translated into reducing the length of travel for users while increasing their acceptance. Structural depth was minimized by locating foundations where possible to reduce span length and utilizing structural alternatives that located major supporting elements above the bridge deck. **Locations for foundations were sparse.** The campus terminus needed to minimize the impact to one of the university parking lots. Any intermediate foundation would need to be tucked within a narrow strip of property between the railroad and roadway while allowing BNSF access to railroad facilities and providing a safe distance to the traveling public. The resulting available foundation locations resulted in a main structure consisting of two spans measuring 240 and 170 feet, with an additional curved 46 foot span at the north end.

The cable-stayed bridge style was a two-to-one favorite coming out of the second public outreach process. The final bridge solution was an unequal-span cable, stayed bridge with a 120-foot-tall concrete arch central pier.

The bridge actually changed the city skyline and made its way onto the official city's medallion.

Mayor Condon Speaking at the Opening Celebration.

Tensioning of Stay Cables & Value Engineering

Tensioning of the stay cables proved to be extremely complex. The flexibility of the pylon allowed a significant amount of movement which would cause the tension in the cables on the opposite side to change during the jacking operation and deflect the intended profile. Despite some setbacks during this process, Garco and KPFF worked collaboratively to refine these adjustments and achieve a smooth profile for users to enjoy.

While no formal value engineering processes were conducted, Garco's proposal to shop-paint the girders provided a direct cost savings in excess of $76,000 to the City. Further, the elimination of field painting and preassembly of the girders, deck, and overhang formwork greatly reduced the number of track closures required, reducing conflict with BNSF and providing cost savings to the City as well.

Due to its stunning appearance and high-quality work, the University Gateway Bridge is well on its way to becoming one of Spokane's iconic images.

The arch balances two unequal spans, has structural elegance and is proof of Garco's ability to execute precision and detail.

The formed finish of the pylon was exceptional overall, with minimal offsets at construction joints and very little initial finishing required. The pylon was painted with alabaster (white) pigmented sealer, which greatly magnifies every minor imperfection.

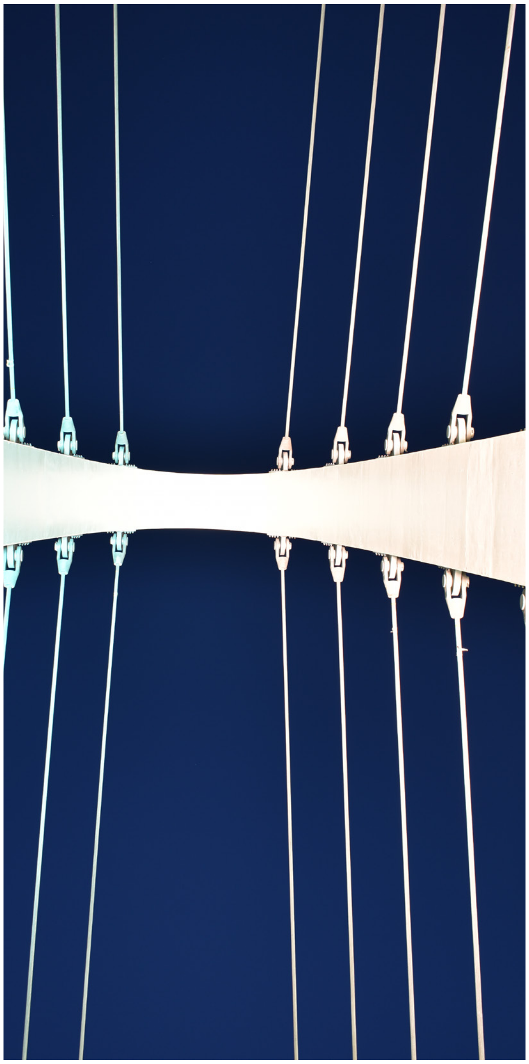
Despite finishing to specifications, after painting the pylon some of these imperfections were apparent and detracted from the beauty of the finished structure. Garco sandblasted the offending portions, provided additional concrete finishing, and repainted them in order to provide an improved completed product.

Aside from the bridge, there are numerous architectural elements in the project including the winding pedestrian ramps, railing, and sculptures.

Over 11,000 square feet of curved wall was required for the pedestrian ramps, at radii as tight as 45 feet. Garco self-performed construction of all of the radius walls as well as the handrail atop them to ensure conformity with the tight tolerances required.

Garco sourced the sculptured art pieces from a company that manufactures brewing equipment to ensure that the stainless steel art pieces were of the highest quality.

Extensive architectural finishes including colored seat walls, exposed aggregate and colored concrete patterns, and intricate concrete paver finishes were provided at each end of the bridge to enhance aesthetics.



Use of Alternative Materials, Practices or Funding

Commitment to Sustainability

Alternative Materials

The University District Gateway Bridge designers needed an alternative method to handle stormwater that aligned with the architectural qualities of the project. Sloping the grades to large drains with steel grates would have stood out in contrast with the graceful arches, elegant lightning, and pristine concrete finish work found elsewhere in the project. Accordingly, KPFF incorporated the use of permeable pavers as well as pervious concrete.

The pavers, found at the south landing, allow water to pass through the pavement to underdrain pipes, negating the need for a conventional drain system. Similarly, bands of pervious concrete are used as trench drains at the north landing. Water is transferred through the permeable paving systems, collected, and then routed to an infiltration basin constructed using StormTech chambers. The chambers and surrounding gravel are designed to infiltrate 100% of site runoff up to the 100-year design storm event. This unique runoff collection and infiltration system camouflages the stormwater facilities within the project aesthetics while providing a fully functioning drainage system with 100% infiltration.

The geometry constraints of the project required the designers to develop a creative solution to the pedestrian vibration requirements of the design codes. The natural frequency of every bridge must be kept out of a prescribed frequency range in order to avoid excitation from pedestrian footfall. If this is not taken into consideration, the bridge may bounce and sway during use, causing discomfort and potentially damage to the structure.

The natural frequency of the preliminary design of the bridge was found to violate the frequency requirements, prompting the need for a solution. The typical solution for pedestrian vibration issues is to use a deeper girder in order to stiffen up the structure and decrease its frequency to an acceptable level. However, the clearance requirements above the railroad tracks and the grade requirements at deck level did not allow for a deeper girder. In order to solve the problem, the designers used larger diameter stay cables than was required to resist the loads. Stiffer cables meant a lower natural frequency, allowing the bridge to pass the code requirements for pedestrian vibrations.

Landscape

The north and south approach landings provide opportunities for landscaping enhancements. For example, the north approach needed to blend into the multiple connections to the University, Main Avenue, and the East MLK Jr. Way corridor. Characteristics added in included a terraced land form to break up the height of the concrete walls, stamped patterns into concrete surfaces to differentiate the location, and signage to direct users.

While working with the Mayor's Advisory Committee as well as collecting feedback from stakeholders and the general public, there was considerable interest in providing sustainable green space at both landings. Other considerations in the development of the landscaping were safety rails, sufficient lighting, seating areas, signage, drought-resistant flora, traffic calming, and opportunities for future artwork.

Additional Consideration Summary

A job well done!

The University District Gateway Bridge is a unique structure within the region and within the engineering world as a whole. When illuminated at night with programmable colored LED floodlights, the structure can be seen from all over the City.

The main social impacts of the project are connectivity it provides and the future development that has already begun. Expanding the Academic Health Science Center at Riverpoint is expected to generate approximately $1.6 billion, support 9,276 jobs, and generate more than $111 million in government revenue over the next 20 years. The bridge is a key piece to this expansion as it provides non-motorized access that was previously separated by the rail corridor.

Complex and innovative engineering solutions included challenges faced during design. One challenge was the tall clearance requirements above the railroad, taking users more than 30 feet off the ground, then returning the path back to grade at slopes that met ADA requirements, and minimized the landing footprints. The solution involved using shallow steel girders supported by 32 steel stay cables connected to the elliptical concrete arch and keeping the majority of the structure above the bridge deck and sloping the grade at 1.5% provided the clearances required. Carefully placed grade breaks and precise slopes ensure that persons with disabilities could utilize the bridge.

This unique structure will serve the City of Spokane for years to come by connecting communities and spurring a much needed economic development.