I15 CAPITOL/CEDAR INTERCHANGE – HELENA, MT

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BIOGRAPHY

Dustin Hirose, PE, is a Project Manager and Highway Bridge Section Manager with HDR in Missoula, MT. His experience includes the design and management of bridge projects of various types over the past 20 years.

SUMMARY

This project involved reconstructing Interstate 15 between the Capitol Interchange and Cedar Street Interchange in Helena, MT. The focal point of the project was the replacement of a pair of bridges that span over the Montana Rail Link (MRL) rail yard. The new bridges are about 800ft long and span 14 railroad tracks. Impacts to the rail yard and to interstate traffic between the two closely spaced interchanges were key criteria during the project design phase. The project was delivered through a unique approach to identify risks early and develop strategies to mitigate those risks.

The project included a comprehensive Bridge TS&L Study which served to identify and manage risk early. Both MDT and the MRL rail engineers were at the table throughout the Bridge TS&L phase. By including the railroad in the bridge type selection process, the team was able to obtain buy-in early during project development, avoid iterations, and ultimately accelerate project delivery.

Maintenance of traffic during construction was important due to traffic volumes and weaving movements on the interstate between the closely spaced interchanges. There were no acceptable detour routes. Interstate traffic would need to be shifted onto one side of the interstate while reconstructing the opposite side. This required single lane, head-to-head traffic during construction on the narrow existing bridge. It was important that one of the new bridges could be built in a single construction season to avoid head to head traffic and crossovers during the winter. A detailed evaluation of construction sequencing was completed during the design phase in order verify that construction activities near the tracks could be completed within the allowable track work windows, and to verify that one bridge could be built in each season ahead of the winter shutdown.

The bridge foundations were a critical item considering cost and risk during construction. MDT, HDR, and geotechnical engineers worked to develop a pile test program early in the design phase to determine that the required axial, lateral, and uplift capacity could be obtained at shallow depths. Ultimately, the test program resulted in a reduction of construction schedule of approximately 1 month and a cost savings of about $3M.

Two superstructure types (concrete and steel) were designed to increase competitive bidding and allow for flexibility in the contractor means and methods. The winning bid came in lower than estimated and was recognized by NSBA for low cost/high value.

This unique approach to project development helped to reduce risk during construction, reduce schedule, and ultimately reduce cost.

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Introduction

This project was located within the city limits of Helena, MT on Interstate 15. The project was administered by the Montana Department of Transportation (MDT) and included reconstructing the interstate to increase capacity, and replacing a pair of functionally obsolete and seismically deficient bridges that span the Montana Rail Link (MRL) rail yard.

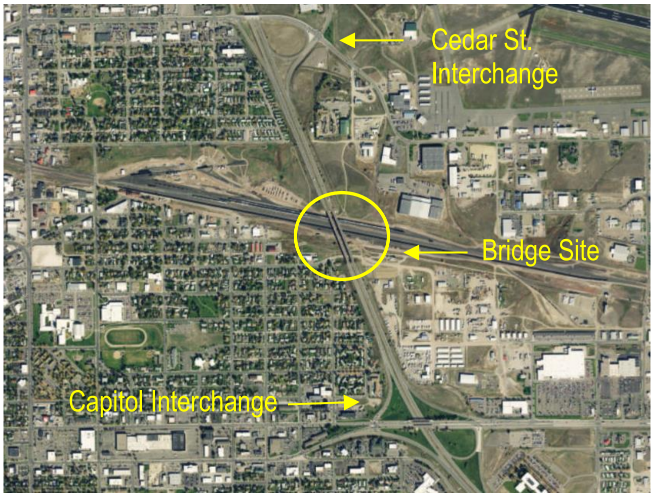

Figure 1: Project site

Constructing the new bridges over the busy rail yard, which consisted of 14 active tracks, would be one of the significant project challenges. A key project element was coordination with the railroad and developing a bridge design that could be built while minimizing impacts to rail yard operations.

Maintenance of traffic during construction was another important project element. The bridges are centered between the Cedar Street Interchange, located at the north end of the project, and Capitol Interchange which is at the south end of the project. This section of interstate exhibits high volumes of traffic along with weaving movements between the closely spaced interchanges which are less than a mile apart. With no acceptable detour routes, traffic had to be maintained on the existing facility during construction. Furthermore, the project would take two full construction seasons to build and it was imperative that one of the new bridges be built in the first construction season so that the interstate could be restored to 2-lane, 2-way traffic during the winter shutdown period.

Figure 2: Existing bridges

Project Planning & Development

In 2003, an Environmental Impact Statement (EIS), Reference (1), was completed for the I15 corridor through Helena, MT. The EIS documented the need for additional capacity and safety improvements throughout the corridor. As a result, several projects emerged and have since been completed along the corridor. The Capitol/Cedar Interchange project was one of the final segments to be completed and consisted of many complexities that required a different approach to project delivery.

The existing interstate roadway on this project segment provided two lanes in each direction between the Capitol and Cedar Street Interchanges. The roadway is on a steep grade in order to provide clearance over the rail yard in the short distance between the interchanges. Weaving movements between the interchanges along with the narrow 28-ft wide bridges, resulted in traffic accident clusters, specifically in winter months when driving conditions were poor.

The EIS identified the need to replace the functionally obsolete bridges and widen the roadway to add an auxiliary lane in each direction to reduce the weaving movements between the interchanges. The immediate need was to add an auxiliary lane in each direction. However, long term planning identified the need for an additional through lane along the corridor and within the service life of the new bridges. Therefore, the new bridges over the rail yard were built wide enough to accommodate a future 4th lane. The roadway drainage infrastructure was also designed and built with the additional capacity to accommodate a future through lane with this project.

Although the railroad and maintenance of traffic during construction were significant concerns, there were other factors such as contaminated soils, oversized loads, storm water, City of Helena coordination, noise impacts, and utilities, to name a few, that added risk to the project. MDT identified the need to deliver this project through a different approach that would serve to identify risks early on and develop strategies for mitigating those risks ahead of construction.

In 2010, MDT selected HDR to lead the design effort for the project which began with a comprehensive Bridge Type, Size, and Location (TSL) Study. Out of 23 different bridge options that were considered in all, two alternates stood out as providing the best fit concept for this site:

Concrete Alternate: 4 – span, 180-ft – 212-ft – 212-ft, 180-ft = 784-ft long, prestressed, post-tensioned spliced concrete I-girder bridge

Steel Alternate: 4 – span, 180-ft – 212-ft – 212-ft, 180-ft = 784-ft long, welded steel plate girder bridge.

The proposed design provided for a pair of structures, with identical span configurations for the northbound and southbound bridge.

Both the concrete and steel bridge alternates allowed for the same roadway design, span configuration, and bent locations in the rail yard. The estimated construction costs for each alternate were similar. Therefore, MDT elected to advertise both alternates to increase competitive bidding and provide more flexibility to the contractors.

HDR continued with developing the project final design through a custom project schedule which allowed for an accelerated delivery due to the significant planning done during the Bridge TSL study. By 2015, the project final design and right of way acquisition was complete. The project was let to construction in 2016.

Railroad Coordination

The new interstate bridges cross over the MRL rail yard which includes 14 active railroad tracks. A proactive approach to engaging the railroad early in project development was needed in order to develop a bridge design that could accommodate the needs of the highway above, and be practically built in the busy rail yard.

Figure 3: MRL rail yard

As part of the Bridge TSL study, the design team performed a comprehensive evaluation of bridge types and various span arrangements against various project criteria including impacts to the rail yard. Clear spanning all the tracks was not a practical option in this case. Intermediate bents would be necessary, and where to locate the bents required an understanding of rail yard operations. The UPRR, BNSF Railway Guidelines for Railroad Grade Separation Projects, Reference (2), was used to help establish final clearances between bridge elements and the railroad tracks. However, temporary clearances during construction, permissible track closures, and work windows that might be acceptable during construction were important variables to understand when evaluating possible span configurations for the new bridges. These variables were dependent on the specific operations within the rail yard.

Site access was another important consideration. Access from one end of the bridge site to the other during construction would require the contractor to cross the railroad tracks, move equipment and materials around a lengthy detour, or mix with the travelling public through the interstate construction zone which would be restricted to 2-lane, 2-way traffic. Speed of construction was important to both

MDT and MRL. So, having the ability to stockpile materials and equipment on both ends of the rail yard would be important to avoid the inefficiencies of having to frequently cross the tracks or travel through the construction zone with equipment and materials.

The preferred bridge span arrangement, which was common to both the steel and concrete alternates, required three railroad tracks to be relocated in advance of construction. It was more economical to move the tracks than to increase girder lengths then to span over them. As a result, the preferred bridge alternate included a balanced and symmetrical span arrangement that reduced material costs and was easier to erect. Without the extensive early coordination with MRL to identify this option, a bridge alternate with significantly longer spans, and higher cost, would have been necessary.

Figure 4: MRL rail yard

In the end, the project design team developed a partnership with MRL to design the project. Many of the items typically left for the contractor to resolve were addressed early on during the design phase. This resulted in reduced risk for all parties involved.

Construction Sequencing

The interstate corridor is located in an urban environment. Options to shift the alignment were not feasible considering impacts to properties adjacent to the highway right of way. Even if adjacent property impacts could be justified and afforded, the geometric constraints of the closely spaced interchanges made an alignment shift impractical. Therefore, the only possible way to build the project was to sequence construction such that work on one side of the interstate could be completed while traffic is maintained on the opposite side.

Figure 5: Project median crossover

Extensive traffic analysis was performed to verify that the anticipated traffic volumes could be maintained through the construction zone along with merging traffic from the interchanges without causing significant disruptions elsewhere in the system. Although the anticipated level of service during construction was not ideal, the proposed plan of having 2-lane, 2-way traffic during the first construction season would function. During the following season, the newly completed bridge, which is significantly wider than the existing bridge, could maintain at least one additional lane during construction.

Understanding that there would be head to head traffic on the narrow, 28-ft wide, existing bridge during the first season, an emergency detour plan was developed in the event an accident occurred on the existing bridge.

A critical part of the project sequencing was the requirement that the first new bridge be built in the first construction season. With this requirement, the interstate could be restored to the 4-lane configuration during the icy winter months. Having traffic negotiate crossovers, and in be in a head to head configuration on the narrow existing bridge during the winter was not acceptable.

Figure 6: Roadway crossover – First season

Considering the short, 7-month construction season in Montana along with the importance of having the first bridge complete in the first season, a detailed constructability review of the project was needed. HDR utilized a team of construction engineers to evaluate the project from the viewpoint of a contractor. One of the goals of the review was to understand if the bridges could be built by conventional methods within the needed timeframe, or if some type of Accelerated Bridge Construction (ABC) method would be necessary. Precast concrete elements, precast deck panels, superstructure launching, and other ABC options were considered with this analysis along with the cost impacts associated with each ABC option. Although there was merit in using ABC, the cost impacts did not appear to offset the user cost benefit. It was more cost effective to utilize additional equipment and workforce to complete the project using conventional methods.

Figure 7: Existing bridge demolition

MDT maintains a library of historical bid prices which are typically used to help estimate project costs. For this project, a more detailed evaluation of construction cost was performed to account for the additional equipment and work crews that were anticipated. HDR developed the cost estimate from the perspective of a contractor considering materials, equipment mobilization, labor classifications, indirect expenses, and applied escalation factors for construction elements that were subject to higher risk. In the end, this exercise helped to better define the project cost. This project required a large share of MDT’s construction program funding in a given fiscal year and it was important to have a good understanding of construction cost prior to bidding the project.

Figure 8: Erecting girders in the rail yard

Figure 9: Temporary shoring used to support the roadway during construction.

Pile Test Program

Building foundations adjacent to railroad tracks can present some challenges. To name a few, there are minimum clearances to maintain during construction, requirements for shoring excavations which can be significant if subject to surcharge loading from trains, and limited work windows available to complete the foundation construction.

Figure 10: Bridge foundation construction

HDR worked with geotechnical engineers (Tetra Tech, Inc.), MDT, and MRL to obtain geotechnical borings within the rail yard during the Bridge TSL work to develop options for the bridge foundations as part of evaluating various bridge alternates. Alternates with longer spans had the advantage of fewer foundation units, but generally required a larger foundation footprint compared to alternates with shorter spans.

Figure11 presents a schematic of the various soil types encountered at the site. A very dense matrix of cobbles and boulders was identified roughly 30-ft below the surface. The material above this layer consisted of loose fill and clay that was not ideal to support a bridge foundation. The material below this layer was relatively consistent and extended to the bottom of the geotechnical borings which were advanced to between 100-ft and 150-ft below the surface depending on the location.

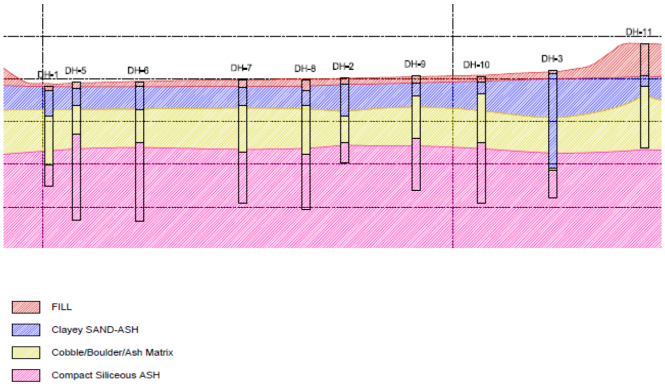

Figure 11: Soil Layers, Tetra Tech, Reference (3)

Spread footings were eliminated as a practical foundation type, since the temporary shoring would be impractical to construct given the excavation depths needed to reach the dense cobble/boulder/ash soil elevation. Additionally, this bridge site is located in a moderate seismic zone. Lateral loading controlled the design of the bridge foundations. The required footprint for a spread footing, if founded at a higher elevation, was not feasible considering the close proximity of the railroad tracks. Driven steel piling were a good foundation choice considering the axial capacity that could be achieved in the cobble/boulder/ash matrix. However, there was some concern that the piling would refuse in that layer prior to obtaining enough penetration to obtain lateral fixity and the uplift capacity needed to resist seismic loading. Therefore, initial recommendations were to use drilled shafts since they could be advanced deep enough to obtain the needed capacity. The downside of using drilled shafts was that they were the most expensive foundation option, and if any defects were found during construction, they would be very difficult to correct and have significant schedule implications.

The design team recognized some significant advantages associated with a pile foundation if the piles could obtain the needed lateral capacity at the shallow depth. In addition to a significant savings in construction cost, the construction schedule could be reduced by about a month per season with a pile foundation. With this in mind, HDR worked with MDT, MRL, and geotechnical engineers from Tetra Tech, Inc. to move forward with a pile test program very early in the design phase of the project.

Figure 12: Pile uplift load test

Figure 13: Pile lateral load test

Five steel test piles were installed at the project site. Both steel H-piles and cylindrical piles were installed to compare drivability, capacity, and penetration. As expected, most of the piles refused with minimal penetration into the coble/boulder/ash matrix. The axial capacity obtained at this elevation was sufficiently adequate for the anticipated locating. A lateral load test was performed to determine if the piles could obtain fixity and to help calibrate soil data used for analyzing the piles under lateral loading. Uplift testing was also performed for the same purpose of verifying a pile foundation would be adequate for the anticipated seismic loading. It was ultimately concluded that driven steel piling would be an adequate foundation type. The pile testing program also served to identify what equipment would be needed to install the piling during bridge construction, solidify the pile tip elevations, and provide more certainty on the total length of piling needed. Additionally, the preliminary pile footprint and number of piles were reduced due to the additional capacity that was identified by the pile test program.

Figure 14: Installation of bridge piles during construction

The program cost about $200,000 to install the test piles and perform the engineering and testing to verify the adequacy of the piles. Compared to drilled shafts, the use of piling resulted in about $3M in construction cost savings in addition to reducing the overall construction schedule.

Conclusion

Final design for the project was completed in 2015. The project was advertised for construction using an A+B format with incentive/disincentive to complete the work within the required timeframe ahead of the winter shutdown period. The construction contract was advertise in the fall of 2015 to allow for ample material lead times to begin construction in the spring of 2016. The bids received were within about 1% of each other and well below the engineer’s estimate. The construction contract was awarded to Sletten Construction with an A+B bid of about $31M.

The steel alternate prevailed with an approximate cost for structural steel erected in place of about $1.10 per pound. Considering the bridge skew, width of the structures, erection over the rail yard, and aggressive construction schedule, the cost for structural steel on this project was surprisingly well below the design team's original estimates.

Figure 15: Northbound Bridge – Erected Girders

Construction was complete in 2017 and the contractor received full incentive for completing the work within the schedule requirements of the contract.

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Figure 16: Completed northbound bridge

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