ABSTRACT

When a project is initiated, one can expect to encounter challenges – that is a given. This was the case for BNSF bridges 69.0 and 71.3 in neighboring Franklin and Osage Counties in Kansas. Bridge 69.0 is a single 200’ pin-connected through truss that carries double main tracks and the new structure consists of deck plate girder and precast concrete double box beam spans totaling 317'-3". The existing Bridge 71.3 consists of seven spans combination of precast concrete, steel and 150’ truss spans for a total of 269'-6" between bulkheads. The new Bridge 71.3 has four spans of deck plate girders for a total length of 291'-3” between abutments. Due largely to record train volumes a redesign was requested.

Project challenges included re-survey and design of structural, track, and site civil, re-permitting, ROW acquisition, re-evaluating construction cost bid items and changing overall scope of construction, engineering, and owner involvement.

This presentation will detail numerous challenges encountered and lessons learned including:

1) Details on the in-line change out to off-line construction
2) Adaptability of all parties involved to overcome issues
3) Working safely within time/work constraints around train traffic and Owner Schedule
4) Take away – Lessons learned from this unique scenario and expectations on similar future bridge replacement projects.

Working through these challenges has been key to maintaining safety, quality, budget, schedule, and the overall success of the project.
INTRODUCTION
Two aging bridges located along the BNSF Southern Transcon Line Segment 7100 on the Kansas Division, Emporia Subdivision in neighboring Franklin and Osage Counties in Kansas have fulfilled their lifespan and were up for replacement. Since original construction in 1907 trains have been passing safely over the Marais Des Cygnes River at both the Bridge 69.0 and Bridge 71.3 locations for about 112 years. In late February 2018 construction began toward replacement.

The existing configuration of Bridge 69.0 in Franklin County is a single 200 ft. long Parker pin-connected through truss bridge that carries double main tracks. The abutments for bridge 69.0 are cast-in-place concrete founded on sandstone (See Figure 1a). This structure is being replaced with four deck plate girder (DPG) spans and one precast concrete box beam span totaling 317 ft. long founded on drilled shaft piers and driven 14x102 H-pile with precast concrete abutments (See Figure 2a – note that there is no precast concrete box beam span shown; we’ll get to that…).

The existing configuration of Br. 71.3 in Osage County upriver from bridge 69.0 consists of seven spans - two precast concrete box beam spans, four steel I-beam spans and one 150 ft. long Pratt pin-connected through truss for a total bridge length of 269 ft. The original abutments were founded on sandstone; spans added in approximately 1943 were precast box beams founded on cast-in-place concrete; and steel I-beam spans at each end founded on driven wood piling (See Figure 1b). This structure is being replaced with a four-span 291 ft. long deck plate girder bridge (DPG) with drilled shaft piers and precast concrete abutments sitting on driven 14x102 H-pile (See Figure 2b).
Figure 1a – Original layout of bridge 69.0

Figure 1b - Original layout of bridge 71.3
An average of 140 trains per day operate over the bridges on the two main tracks with a timetable track speed through this location of 70 miles per hour (mph) for freight and 79 mph for passenger. As part of a BNSF Structures program to replace aging pin-connected truss bridges, BNSF planned for the bridge replacement in-line to minimize additional track curves to an offset alignment.

Figure 2a – Plan view of bridge 69.0 as-bid with in-line construction

Figure 2b – Plan and profile views of bridge 71.3 as-bid with in-line construction
RE-DESIGN

As can be seen in Figure 2a and 2b above, the issued for bid design was for in-line construction. This construction required coordination for required track windows for steel h-pile driving at the new abutment locations outside of the existing bridges in the existing embankment. The remaining piers and drilled shafts could be constructed below and around the existing bridge without disrupting trains. Once all the new substructure was completed, an extended outage window for both main tracks would be necessary to remove the existing superstructure and place the new superstructure.

During the preliminary coordination with BNSF for dedicated pile driving track windows as well as initial discussion of a future extended window to change out the bridges; it was determined that traffic volumes were at a level that would not allow substantial time to accomplish the new abutment pile driving or proposed extended window on this line. It was the outcome of these discussions that led to the initial planning for alternative options.

Alternative alignment planning was at first conceptual and largely behind the scenes while Ames Construction continued progression of installing temporary work bridges along the North and South sides at each bridge maintaining their critical path schedule for a planned changeout of both bridges around January 3, 2019. The conceptual planning consisted of several on-site meetings walking both the North and South sides looking at the alternatives and brainstorming the pros and cons of each along with possible construction schedules for each.

The list of alternative options included shifting both tracks to the North, shifting both tracks to the South, and shifting one track North and one track South at each bridge location. At one point, it was even facetiously brought up to build up and over the existing bridges. The pros and cons of all options were heavily weighed and debated – permitting, potential right-of-way (ROW) acquisitions, access, safe sequences of construction, design, budget, quality, and overall impacts to existing rail traffic were among the primary considerations.

After careful, but concise consideration with BNSF, Ames Construction & TranSystems it was determined that the best fit solution would be to shift both tracks to the South at each bridge location largely due to the factors listed previously. TranSystems was approached to provide a conceptual design to minimize track centers keeping the new tracks as close as possible to the existing tracks (and bridges) to minimize additional ROW/permitting impacts while minimizing windows and still safely constructing around train traffic. The structural steel originally planned would remain unchanged due to the ongoing fabrication progress. The cast-in-place concrete pier caps at both bridges were shortened in height and overall lengths reduced with the change to an offset alignment since it was no longer necessary to span the length under the existing bridge. At bridge 69.0, because of the skewed river channel relative to the new bridge piers along with the proximity of the adjacent at-grade public crossing, an additional pier and thirty-six foot long precast concrete box beam span was added to the West end of the 69.0 bridge. The distance between the drilled shafts at this pier five was reduced within allowable constraints to miss the existing bridge 69.0 West abutment wingwall. The 71.3 bridge was also shifted to the East by ten feet to account for the skewed river channel.

As the bridge layout at bridge 69.0 and 71.3 was being resolved, additional surveys were required at both bridges for the necessary topography and ROW for design of the track/civil site work, cultural resource survey, and also wetland delineation survey at the proposed new areas for construction. While the surveys were being completed, approximate limits of construction were established for beginning the discussion with the Corps of Engineers about revision of the current permits for the offset bridge replacement alignments. Added to the design and construction was a culvert replacement identified at the West end of the 71.3 transition. The existing culvert was failing and a replacement pipe 140’ long by 48” diameter steel pipe was added to be jack-and-bored.
Finally, as part of the redesign, the inspection access had to be modified for the new piers. The redesign effort tried to utilize as much of the original design given that fabrication was already ongoing. After all elements were coordinated, the original plans were updated and reissued to the contractor. See figure 3a and 3b.

Figure 3a – Plan view of bridge 69.0 redesign with offset alignment

Figure 3b – Plan view of bridge 71.3 redesign with offset alignment

MODIFIED PERMIT SUBMITTAL
The additional survey, design, permitting, and ROW acquisition were all ongoing concurrently. Once the conceptual design was drafted and during the aforementioned surveys; a couple areas for proposed additional construction impacts were identified as potential wetlands. The areas were sampled and delineated by Olsson and Associates and met established criteria for wetland habitats. In lieu of electing to determine whether the identified areas were jurisdictional or non-jurisdictional; the areas were identified as jurisdictional and credits purchased by BNSF through approved mitigation banks. The cultural resources survey provided by Jacobs yielded no significant findings and the report was revised to reflect the additional areas proposed for construction. With the proposed shift in the tracks and added embankment, there were two locations with potential ROW impacts. Options to keep construction on the existing ROW at these locations were reviewed including wall construction options and/or steepening the proposed embankment slopes with added riprap stabilization; but the landowners were agreeable to selling and the additional ROW was acquired for construction of a standard 2:1 slope. In addition to the above permitting modifications and challenges, the hydrology & hydraulics of the new bridge configurations and locations were analyzed by Burns & McDonnell in HECRAS model with no significant changes noted from the original results. See figures 4a and 4b for the new offset track layouts.
CONSTRUCTION/ACCESS/TEMPORARY WORK BRIDGES
After design was finalized and approved; and modified permits were approved; construction of the temporary bridges was completed as originally planned by Ames Construction. With the new offset alignment, the temporary work bridges located on the South side of the existing bridge were located right under the new proposed alignments and conflicted with the construction of the new substructure.

The temporary work bridges were supported on sixteen and twenty inch end bearing pipe pile with layout shown below in Figure 5a and 5b. The proposed drilled shaft locations were survey located on the South temporary bridges and checked to ensure there were no conflicts with the piers or spans of the South temporary bridges. Construction of the 6.5 foot diameter drilled shafts and 6 foot diameter rock sockets began as re-design was being finalized. 5/8" thick steel casings were vibrated in to depth; and concrete was placed by tremie in the wet at all shaft locations after cleanout and camera verification. Figures 6, 7, 8, and 9 below depict the new construction largely overtop of the South temporary work bridges.
Given the conflict of the temporary work bridges and new bridge construction, the sequence of critical path construction was drastically altered with the new alignments at each bridge for crane and drill rig access. South temporary bridge was removed as work was completed, and placing the structural steel spans before construction could be completed on an adjacent pier at each bridge. In addition to these alterations, steel sheeting was driven at each new abutment location along the South sides of the existing bridges at the abutments in order to be able to install the new precast abutments with the new alignment proximity to existing rail bed. These adjustments were factored into a re-issuing of bid items with changes in concrete quantity, reinforcing steel, added embankment, additional shoring, subballast, subgrade stabilization shot rock (through the wetland areas), multiple mobilization moves between the bridges, as well as others required for the change in alignment and work involved.
Figure 6 – Vibrating in bridge 71.3 pier 4 South drilled shaft permanent casing after relocating crane mat decking for template installation and re-establishing temporary handrails
Figure 7 – Shows bridge 71.3 South temporary bridge spans 9 and 10 removed and pier 4 cap
Figure 8 – Progress at bridge 69.0 stripping pier 4 cap before placement of span 4
Figure 9 – Setting main 2, span 4, South deck plate girder pair at bridge 69.0
The overall sequence of construction for the bridges went as follows:

**Bridge 69.0**

- Pier 2 North shaft
- Install PZC steel sheeting wall for abutment 6 and pier 5 construction
- Pier 4 North shaft
- Pier 4 South shaft
- Pier 5 South shaft
- Pier 5 North shaft
- Abutment 6 pile driving and set precast concrete abutment pieces
- Removal of South temporary bridge span 11 and bent 12
- Pier 5 cast-in-place cap
- Set span 5 concrete box beams
- Pier 4 cast-in-place cap
- Removal of South temporary bridge spans 10 & 9 and bents 11 & 10
- Install PZC steel sheeting wall and tie backs for abutment 1 construction
- Set span 4 80' DPG pairs
- Removal of South temporary bridge spans 8 to 4 and bents 9 to 5
- Pier 3 North shaft
- Pier 2 South shaft
- Pier 3 South shaft
- Removal of South temporary bridge spans 3 to 1 and bents 4 to 1 (including shoring abutment and tie backs)
- Pier 3 cast-in-place cap
- Pier 2 cast-in-place cap
- Abutment 1 pile driving and set precast concrete abutment pieces
- Set span 1 60' DPG pairs
- Set span 2 60' DPG pairs
- Set span 3 80' DPG pairs

**Bridge 71.3**

- Pier 4 North shaft
- Pier 3 North shaft
- Pier 4 South shaft
- Pier 2 North shaft
- Removal of South temporary bridge span 9 and bents 10 (West to East)
- Pier 4 cast-in-place cap
- Abutment 5 pile driving and set precast concrete abutment pieces
- Set span 4 80' DPG pairs
- Removal of South temporary bridge spans 8 to 4 and bents 9 to 5
- Pier 3 South shaft
- Pier 2 South shaft
- Pier 3 cast-in-place cap
- Removal of South temporary bridge spans 3 to 1 and bents 4 to 1 (including shoring abutment and tie backs)
- Set span 3 80' DPG pairs
- Pier 2 cast-in-place cap
- Abutment 1 pile driving and set precast concrete abutment pieces
- Set span 2 70' DPG pairs
- Set span 1 60' DPG pairs

Within the above sequences of construction for each bridge work also included NX coring at each proposed drilled shaft location prior to construction, cross-sonic-logging (CSL) testing of each shaft following installation, access changes for certain activities (crane pad building, drilled shafts...
template installs/removals, temporary handrails), crane utilization concurrently for both construction (pre-tied rebar cages, formwork, inspection access installation, structural steel erection, etc.) and deconstruction of temporary work bridges (pulling temporary work bridge crane mat decking, cap beams and vibratory removal of pipe piling); in addition to ongoing site organization of the previously unplanned removals of the temporary work bridge materials. Walkway brackets, grip strut walkway planking, inspection access platform supports and ladders were mostly done after completion of the main sub and superstructures at each bridge. Some of this work was done from the superstructure, and some was completed from the ground where access was still available with an aerial work platform.

TRACK CONSTRUCTION/COORDINATION
Clearing and grubbing work began almost immediately after long-eared bat roosting season ended at the end of July 2018 shortly after permits were approved and topsoil was stripped. Four additional areas were cleared and mulched to prepare for the earthwork. The new track alignment design included a global slope stability analysis provided by Braun-Intertec based on subsurface borings done prior to construction and using proposed embankment material sampled from a nearby landowner. Ames secured permitting from the State of Kansas and an agreement with the local landowner for use of the material – turns out the landowner wanted a pond. In fill areas West of 69.0 & 71.3 unsuitable soils were identified and shot rock subgrade stabilization was necessary to bridge these locations. Embankment material was trucked in via local county roads, placed and rolled in 8” maximum compacted lifts with compaction testing performed by Terracon. Through the global slope stability evaluation of the sampled embankment material it was determined that the proposed material met design requirements for the plan embankment configuration for both short and long term at a maximum fill height of 16 feet. However, it was recommended that additional thickness of subballast or a lift of select fill material would improve stability further. Subbase course consisted of two feet of limestone screenings which met select fill requirements topped off with one foot of subballast gravel meeting Kansas Department of Transportation AB-3 gradation requirements. Much of the earthwork placement was done using orange fence protection allowing work to proceed until a headlight from approaching train was visible.

The track design included adding super-elevated curves for the proposed shift of the tracks to the South. Curves were minimized to the extent possible - curves at 69.0 were kept to zero degrees, thirty minutes while curves at 71.3 were designed to match existing one degree, twenty minutes at the West end of the shift and one degree thirty minutes at the East end of the track shift. Conversations began almost immediately after the decision to go offline on how the new tracks would be most efficiently constructed. It was ultimately decided that a track shift for both main tracks would be necessary. Track panels were delivered, stacked, then placed and bolted to the extents that construction would allow. Prior to this, ballast trains were delivered and dumped, spread, and rolled, at each of the respective 71.3 and 69.0 locations. Rail was delivered and dropped off for relay following the proposed track shifts. The track shift in-service windows were allocated for several days on two consecutive weeks. Temporary jump switches are planned to be installed to allow surfacing equipment access from the existing tracks to the new tracks. Following the track shifts; the existing ties, other track materials, and rail will be salvaged.

BRIDGE DEMOLITION AND RESTORATION
Following salvage of the existing tracks, the existing trusses will be rolled out after jacking and shimming. Rolling out the existing trusses will include driven pipe pile and supported falsework towers with slide out beams including mounted Hillman rollers. The shorter additional existing precast concrete and steel I-beam spans at bridge 71.3 will be removed by picking with a crane. In-place demolition of the trusses will be done on the pre-placed driven pile falsework pile towers. Lead paint safety precautions will be used during torching and handling of the existing coated truss members. Following demolition of the trusses, an excavator with mounted breaker attachment will be used to demo the existing abutments with the broken material being used as slope stabilization on the embankment down to the river on each side of the new bridges. The previously removed topsoil will be spread on the new embankment locations and disturbed areas will be restored by seeding.
LESSONS LEARNED CONCLUSIONS
Through all the changes, challenges, and celebration of triumphs there are several notable things to take away from the experience gained on this project:

1) It takes intense collaboration and cooperation by all involved to address the multitude of areas affected with a complete change in project scope to be successful.
2) While there are months of planning leading up to a dedicated closure window to change out bridges in-line; there are also months of planning leading up to dedicated closure windows put a new line in-service.
3) Even with the most careful planning and review; modifications of this magnitude introduced to a project mid-stream can often times lead to unforeseen or unintended results. In other words, it all looks good on paper until it’s built.
4) Due to the results of this project; there are other projects similar in scope that are being evaluated with optional off-line construction.
5) If there is a will there is a way – not just one way; and not always the easy way.
6) It was previously unmentioned that the cell service on this project was exceptionally poor; and the internet was through satellite Wi-Fi; making ongoing communications sometimes strenuous. Many areas were discovered where one ‘could not hear me now’.
7) Everyone has a unique perspective based on position, experience, knowledge, and location. Projects like this take a bit of perspective-alignment and are built for the owner’s needs. Understanding expectations up front should reduce unexpected surprises.
8) If it can be built safely, the schedule is flexible, your team is resilient, and the budget allows; a plan can be changed; and any project can be built.

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