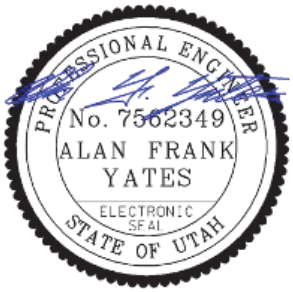
Michael Baker
INTERNATIONAL

ROCKVILLE TRUSS BRIDGE

REHABILITATION FEASIBILITY STUDY



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February 5, 2016

Performed by Michael Baker International

For the Town of Rockville, Utah

PURPOSE

PROJECT DESCRIPTION

This report documents the evaluation performed by Michael Baker International on the feasibility of rehabilitating the existing single lane Rockville Truss Bridge (Bridge Road/200 East over the Virgin River, UDOT structure number 053019C). The bridge, which is the only remaining Parker Truss Bridge in the State of Utah, was built in 1924 and is listed in the National Historic Register.

The engineering analysis was done according to current Utah Department of Transportation (UDOT), Federal Highway Administration (FHWA), and American Association of State Highway and Transportation Officials (AASHTO) bridge design and construction standards. The analysis includes a structural evaluation, remaining service life determination, and a comparison analysis to a bridge replacement.

The analysis does not address hydraulic conveyance or abutment scour. At the time of this report, there are no known hydraulic capacity or foundation scour issues.

BACKGROUND

PROJECT HISTORY

In 2012, UDOT performed a load rating of the Rockville Truss Bridge which resulted in the bridge being posted for 14 tons. The 14 ton restriction was less than required to support waste disposal vehicles. As a result of the loading restriction and concern from the Town of Rockville, UDOT commissioned the *Improvement Alternatives for the Rockville Bridge over the Virgin River* Report. This report evaluated the following alternatives and developed the corresponding cost estimates:

1. Construct a new 2 lane bridge adjacent to the exiting bridge and keep the existing bridge – $3,400,000 (approximate 75 year service life)
2. Remove the existing bridge and construct a new 2 lane bridge – $3,200,000 (approximate 75 year service life)
3. Rehabilitate the existing single lane truss bridge – $2,100,000 (approximate 30 year service life, with additional maintenance at that time for an additional 25 years)

UDOT's Local Government Administration and the Joint Highway Committee (JHC) reviewed the study and recommended to the Utah Transportation Commission in 2013 to provide $3.2 million in federal funding to the town of Rockville for alternative #2, bridge replacement. The JHC noted that Alternative #2 was chosen because it provided the best long term cost-to-benefit ratio and upgraded the bridge from single lane to two lane.

When the residents of the Town of Rockville learned of the funding and plan to execute a bridge replacement project, many voiced their opinion that they would prefer to keep and rehabilitate the existing bridge due to its historic registration and significance. In the most recent Rockville Town Survey, dated May 14, 2015, 74 percent of the respondents expressed their preference to restore the existing bridge and have it remain the only access for automobiles and pedestrians. To address this public concern, the Town of Rockville commissioned this report to provide additional analysis and detail on the feasibility of rehabilitating the existing bridge. The goal of this report is to better educate the Town of Rockville on the

costs and risks of rehabilitation and provide a basis of discussion with UDOT on reevaluating the selection of Alternative #2.

Previous Evaluations

This report utilized the following documents previously developed by UDOT:

- *Bridge Rehabilitation Recommendation Report for the Rockville Bridge over the Virgin River – 053019C*
- *Improvement Alternatives for the Rockville Bridge over the Virgin River*
- Historical NBIS Bridge Inspection Reports and Bridge Records
- Load Rating Analysis which identified a 14-ton load posting (2012)

Bridge Rehabilitation Scope and Cost Estimate

See Table 1 for a summary of the scope items and estimated cost from the *Improvement Alternatives for the Rockville Bridge over the Virgin River* report.

TABLE 1 - BRIDGE REHABILITATION ALTERNATIVE SCOPE COST ESTIMATE

	ITEM	ESTIMATED COST
BRIDGE WORK		**$1,373,000**
	Strengthen Steel Components of the Bridge	$500,000
	Replace the Paint System	$500,000
	Restore Bearings and Expansion Joint	$31,000
	Replace the Decking	$90,000
	Miscellaneous Preservation Work and Safety Upgrades	$73,000
	Mobilization (15% Assumed)	$179,000
ROADWAY WORK		**$23,000**
	Traffic Control	$23,000
	Right-Of-Way Acquisition	$0
ENGINEERING		**$345,000**
	Design Engineering	$150,000
	Construction Engineering	$80,000
	UDOT Administration/Environmental Evaluation	$105,000
	Public Involvement	$10,000
TOTAL	Project Cost	$1,751,000
	Contingency (20%)	$348,000
	Total Cost/Required Funding	**$2,089,000**
	Town's Contribution (6.77% Match)	$141,500

Structural Analysis

Load Carrying Capacity Evaluation

The structural evaluation for this report used a finite element computer model to determine the load carrying capacity and structural performance under various conditions. Key improvements of this evaluation compared to the previous evaluation performed by UDOT includes:

- Narrow truss diagonal chords were modeled to only carry tension forces. This more closely models real world load paths and avoids false predicted failure modes of these members buckling under compression.

- A site inspection was conducted to identify and gather specific data to complete the computer model as accurately as possible
- The gusset plates and riveted connections were evaluated
- The effects of the locked up expansion bearings were evaluated

The analysis verified the current posting of 14 tons and identified the specific components that are limiting the loading. The limiting components are the stringers along the underside of the deck, the floor beams, and the diagonal chords in the first and last interior truss panels. To obtain an acceptable load rating, these members will need to be strengthened. See Figures 1 and 2 for identification of these members.

FIGURE 1 - DECK SYSTEM COMPONENTS

FIGURE 2 - TRUSS MEMBERS AND CONNECTIONS

The gusset plates and rivets that connect to the limiting truss members were analyzed and determined to not control the load rating. Gusset plates are plates that connect the truss members (see Figure 2). The analysis was done according to the 2014 Interim Revisions to the AASHTO Manual for Bridge Evaluation.

Typically, these connections are designed to have greater capacities than the members that connect into them and it appears this approach was used in the original design.

The heaviest vehicle that is expected to routinely cross the bridge is the local waste disposal vehicle which has a fully loaded weight of 23 tons. Another important vehicle is the local fire truck which weighs up to 20 tons. Based on this information and the overall condition of the bridge, it was determined that the optimal load rating goal of this bridge is 25 tons. For comparison, a typical non-posted highway bridge carries a minimum of a 36-ton vehicle. To obtain a 36-ton capacity, the bridge strength would need to be increased by approximately 150 percent from the current 14-ton rating. Such an extensive retrofit is well beyond the available funding and would significantly alter the bridge – ultimately compromising the historic nature.

The expansion bearings on the north abutment are locked up due to debris and deformation. The resulting change in stress had not been captured previously. The analysis determined that the most significant effect is that during extreme temperatures there is a significant increase in compressive and tensile stresses in the top and bottom chords, respectively, which were likely not intended in the original design. By replacing these bearings, the bridge performance will be restored to the proper function. These increases in stress have minimal effect on the diagonal chords. See Figures 1 and 2 for identification of truss chord members.

Local Strengthening

In order to meet a load posting limit of 25 tons, the limiting members will have to be strengthened. See Figures 1 and 2 for visual representations. The following is a list of the limiting members and the recommended actions:

Stringers

All of these beams will need to be replaced with stronger beams. The total number of stringers is 110. The contractor will need to stagger the removal so that the floorbeams and trusses do not deform. The corrugated steel and asphalt decking will need to be removed to perform the work.

Floor Beams

The interior floor beams will need to be strengthened. There are 9 interior floor beams. This can be accomplished by bolting cover plates to the bottom of the beams. Bolting is the preferred method of attachment instead of welding which is prone to fatigue issues.

Diagonal Chords in the First and Last Interior Truss Panels

The diagonal chords in the first interior truss panels will need to be stiffened for improved resistance to compressive buckling. This applies to 4 diagonal chords. The recommended solution is to bolt plates to the double angles.

Remaining Service Life Determination

The remaining service life was determined by evaluating historical bridge inspection data, fatigue life, and traffic volumes.

Historical Bridge Inspection Data and Service Life Projections

UDOT bridge inspections are done according to the National Bridge Inspection Standards (NBIS). The bridge superstructure is rated using a value between 0 and 9. The following describe this rating system and the type of typical treatments:

- NBIS 7 and above – "good" condition and are candidates for preservation treatments
- NBIS 5 and 6 – "fair" condition and are candidates for rehabilitation treatments
- NBIS 4 and below – "poor" condition that will require major rehabilitation or replacement

Figure 3 shows the NBIS condition ratings of the bridge over time.

Deterioration in the bridge condition is driven by environmental effects (e.g. oxidation) on the steel members. The treatments in the rehabilitation alternative mitigate these effects and extend the service life of the bridge.

The estimated remaining service life was determined by establishing the probable end of service life using a data curve fit that follows the historical data and typical bridge performance. If no action is taken, the bridge condition will likely require replacement by 2024.

With the recommended improvements of stringer and deck surface replacement, floor beam and diagonal strengthening, bearing replacement, and bridge repainting, this bridge would be expected to perform for an additional 30 years (until 2049) at a 25-ton posting performance level. At that time, a re-evaluation with an expected maintenance action of repainting and deck surface repair would most likely provide an additional 25 years of service – moving the projected end of service life to 2074. These results are in keeping with the original rehabilitation alternative which assumed 30 additional years of service life from the time of construction.

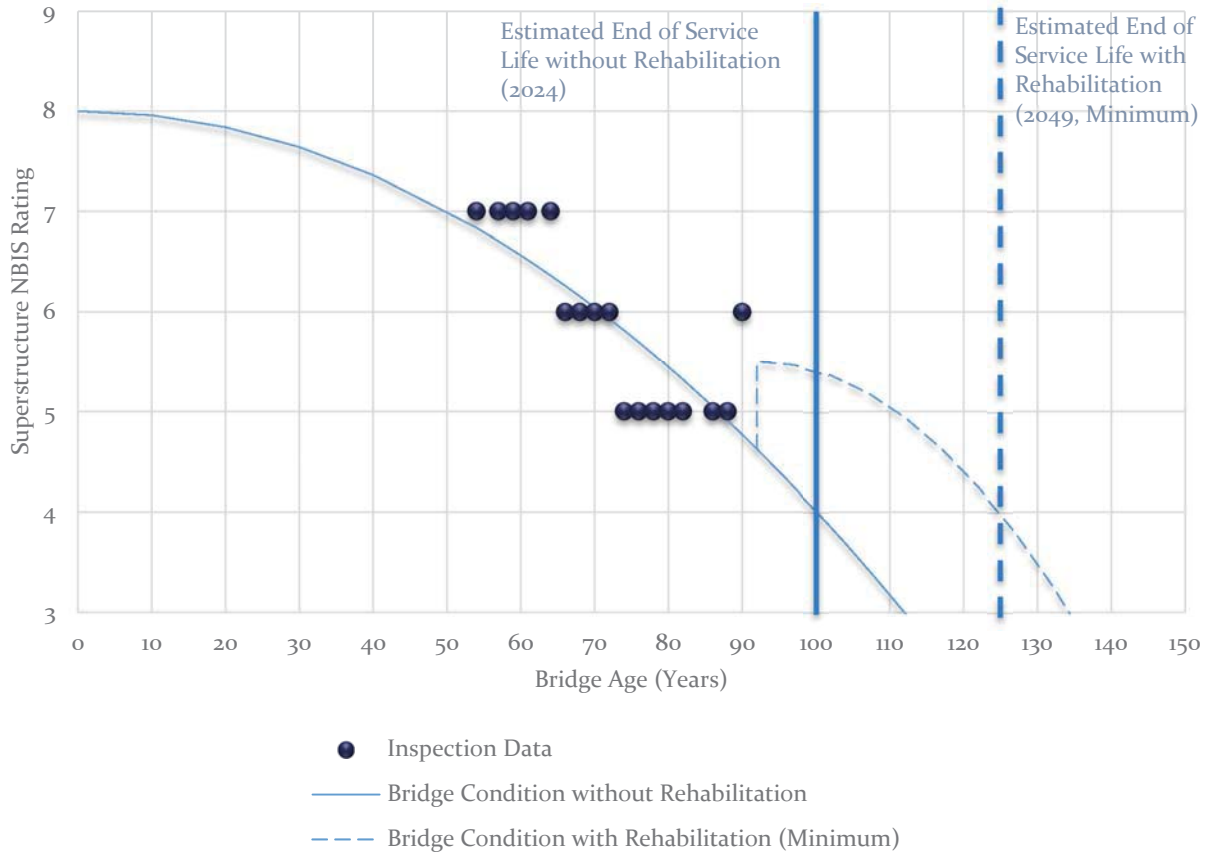

FIGURE 3 - BRIDGE CONDITION OVER TIME

Steel Fatigue

The service life of the bridge is not controlled by fatigue loading of the steel. The bridge utilizes riveted connections which are typically more resilient to fatigue. Welding, which is the most prone to fatigue failures, is not present. The resulting limitation is the base metal of the members themselves. Based on a conservative calculation approach in the AASHTO code, the relatively low volume of truck traffic on the bridge results in a fatigue life of approximately 180 years.

Traffic Capacity

The traffic capacity of a single lane does not need to control the service life. The limitations of these types of low volume roadways are typically set by the bridge owner. Some transportation agencies, such as the Wisconsin Department of Transportation, use a threshold of 1,000 Average Daily Traffic (ADT) for single lane bridges. UDOT's traffic records indicate an ADT volume of 252 in 2010. By 2030, UDOT estimates this value to only increase to 306, which is approximately 1 percent growth per year. This estimated growth rate appears appropriate considering the Town's zoning ordinances. Currently, zoning is limited to Rural Residential ½-, 1-, and 2-acre lots; Rural Agricultural 5-acre (RA-5); and Open Space 20-acre (OS-20) lots. Both the RA-5 and OS-20 allow for a single family residence.

Alternative Comparison

A common misconception of new bridges is that they will last for the full design life with no additional cost. The design life for new structures is currently 75 years. This does not guarantee the bridge will be in service for that entire time (for additional information, see the *UDOT Structures Design and Detailing Manual*, Section 2.6). To achieve that goal, the bridge will require proper maintenance and preservation treatments. The bridge will also likely require a deck replacement in approximately 40 years. The cost of these activities should be taken into consideration when comparing against a rehabilitation approach and looking at a full life cycle cost comparison to determine a benefit-cost ratio.

Table 2 provides a comparison of the alternative associated with the current funding and the rehabilitation alternative.

TABLE 2 - ALTERNATIVE COMPARISON

	BRIDGE REPLACEMENT	BRIDGE REHABILITATION
CURRENT WORK		
CONSTRUCTION COST	$3,200,000	$2,100,000
ROUTINE MAINTENANCE COST	$1,000 per year	$1,500 per year
FUTURE WORK		
YEAR	2057	2049
SCOPE	Deck Repair or Replacement	Steel Painting and Deck Repair
REMAINING SERVICE LIFE	35 Years	25 Years
APPROXIMATE COST	$1,000,000	$1,000,000
TOTAL COST PER YEAR	$4.2M / 75 years + Maint. = $57k/year	$3.1M / 55 years + Maint. = $58k/year
PROBABLE END OF SERVICE LIFE	2092	2074

Note – The information regarding the Future Work assumes proper maintenance and adherence to the load posting. Approximate costs are total project costs and are not adjusted for inflation.

The Bridge Rehabilitation alternative has an initial cost that is 66% of the Bridge Replacement alternative. Both alternatives will likely require significant work to be done in 32 to 40 years. While the Bridge Rehabilitation alternative does not provide as much service life and has more service limitations (load posting, single lane), it remains a viable alternative when considering the full life cycle costs.

CONCLUSION

In conclusion, while the Bridge Rehabilitation alternative doesn't provide as much design life as a new bridge, it is a viable option to provide the needed utility for the Town of Rockville and maintain the existing structure. The 30 additional years of service life could be extended up to a total of 55 additional years (projected end of service life in 2074) with proper maintenance and protection of the existing steel.

This evaluation verified the previously recommended scope (found in the *Improvement Alternatives for the Rockville Bridge over the Virgin River*) and provided additional clarity on the structural limitations, required improvements for a 25-ton load posting, expected remaining service life of the existing bridge, and the additional life provided by the rehabilitation alternative.