BLUFFDALE BRIDGE OPTIONS
PROJECT ID: CEEN_2018CPST_001

by

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A Capstone Project 30% Completion Report

Submitted to

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Executive Summary

PROJECT TITLE: BLUFFDALE BRIDGE OPTIONS
PROJECT ID: CEEn_2018CPST_001
PROJECT SPONSOR: City of Bluffdale, Utah
TEAM NAME: RSR Engineering

This report summarizes the results of the Bluffdale Bridge Options Capstone Project at 30 percent completion.

A bridge that spans across the Utah & Salt Lake Canal at 14400 South exhibits evidence of corrosion which may be affect the functionality of the bridge. As part of the overall project objectives, RSR Engineering (the Team) has been tasked to analyze the current bridge loading capacity, provide recommendations for rehabilitation, and provide possible funding sources to mitigate the damage.

At 30 percent completion, the Team has completed the preliminary analysis of the current loading capacity for the bridge. This analysis is based on the results of a site visit, performed in accordance with current AASHTO code requirements. Based on the primary results, the bridge in its current state is acceptable under H20 loading requirements.

Completion is expected by the beginning of April 2019. At 100 percent completion, the full analysis will include a complete analysis of the loading capacity and a full analysis of bridge rehabilitation options. By completion of the project in April 2019, the Team will present the following deliverables to the City: Monthly status reports, a final report with design alternatives, a spreadsheet for analysis, a three-dimensional model of the structure, and a presentation delivered to the City Staff and City Council summarizing the results of the project. More details regarding the content and timing of these deliverables will be discussed below.

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Introduction

The jurisdiction of the City of Bluffdale (the City) includes a bridge spanning across the Utah & Salt Lake Canal at 14400 South. Based on the latest UDOT Bridge Inspection Report, the current condition of the bridge includes delamination of precast members, exposing prestressing strands at the bottom of several girders. The City is concerned that the bridge may not be able to support the loads required for its present and future use. As part of this project's scope, RSR Engineering (the Team) has been tasked with analyzing the current bridge loading capacity, providing recommendations for rehabilitation, and researching funding sources the City could use for the rehabilitation.

The requirements of the project have been phased into two segments: analysis of current bridge structure and evaluation of options for rehabilitation and repair. Analysis includes a site visit, research of bridge inspection options, creation of a three-dimensional model of the structure, and determination of acceptable limits of the bridge capacity. The Team anticipates completion of these steps on January 18, 2019. The remainder of this report will enumerate the current status of these steps as of December 10, 2018. The evaluation will include research of bridge deterioration, research of bridge rehabilitation options, and a cost comparison of rehabilitation options. The Team will complete these steps by early April 2019.

By completion of the project in April 2019, the Team will present the following deliverables to the City: Monthly status reports, a final report with design alternatives, a report of the structural analysis, and a presentation delivered to the City Staff and City Council summarizing the results of the project. More details regarding the content and timing of these deliverables will be discussed below.

Schedule

As of December 10, 2018, the following have been completed:

- October 19: Site Visit 1 – measurements of the bridge, photos to record current bridge condition, and visual inspection of the bridge damage
- November 1: Report of existing structure conditions completed (based on visual inspections and model)
- December 10: 30% completion report – this report will contain a status update on the bridge analysis, the report of the bridge conditions, and a description of potential rehabilitation options. The full analysis will not be complete by this date

The following will be completed by the end of April 2019:

- December 31: Structural Analysis completed, load capacities of the bridge determined. The final report will not be compiled, but preliminary results will be available
- January 18: Results of the structural analysis compiled and presented to the City
- February 1: Possible remedies researched with a list of all possibilities compiled into one report
- March 22: Completed economic analysis of all remediation options, sources of funding located, expected bridge life span for each remedy determined, final report completed
- Early April: Results presented to the City and BYU ASCE student chapter. The exact date of the final presentations has yet to be determined, but it will take place at the beginning of April.

The Team will meet weekly for one hour to compile our individual weekly efforts. Each team member will be expected to spend 2 hours per week on the project during the 2018 calendar year; that expected hourly requirement will be increased to 4 hours during the 2019 calendar year until the project is finished. Weekly status reports will be provided to the client and our faculty advisors. These reports will contain detailed explanations of the project status, problems encountered, proposed solutions, and any necessary modifications to the schedule proposed above.

Meetings with BYU faculty members will be scheduled as needed. Professor Christine Isom, Dr. Kevin Franke, Dr. Spencer Guthrie, and Dr. Fernando Fonseca have agreed to assist the Team in the analysis process. The level of involvement of each of these faculty members will depend on the structural status of the bridge and the complexity of the analysis, determined at the time of the first site visit. The results of these meetings will be included in the weekly status reports.

Assumptions & Limitations

Several assumptions were required to simplify the analysis process. The bottom reinforcement strand for several of the girders has been deeply affected by corrosion, so it must be assumed that the bottom strand in each girder is no longer aiding the bridge in moment-carrying capacity. In addition, the geometry of the girders was simplified into rectangles, with a portion at the bottom of each web eliminated in the compression strength analysis. This was done to account for the spalling of concrete of the bottom strands and to account for variation within the shapes of the girders. Although the assumed rectangular shapes do not match the slight inclination of the webs indicated on the plans, the in-place girder webs appear to deviate very little from vertical; thus, we determined that a simplification of the geometry would provide only a slightly more conservative estimate than the true values. Additionally, HS-20 loading was assumed to represent the loading conditions for the bridge. As this is a standard method of evaluation for the type of bridge and environment, this assumption can at least make for easy comparison with other analyzes and should provide good results.

Using only unobtrusive methods for evaluation of the bridge, several other assumptions were required. First, we assumed that, save the bottom strand, the rest of the strands indicated on the design are all still present and viable. Based on a comparison of the engineering specifications to the current in-place structure, this assumption may not be fully accurate; there appeared to be several discrepancies between the two which will be discussed further in the results section below. However, without access to a more expensive or intrusive method, this assumption is required. As such, the results of this analysis can only be considered approximate until more comprehensive methods can be used.

Design, Analysis & Results

Our preliminary analysis indicates that the current state of the bridge is adequate to hold the required loading under H20 loading, but further deterioration of the girders may result in the bridge being structurally inadequate. Completion of the analysis will provide the exact calculations used to reach this conclusion. The complete analysis report with numeric results will be presented to the city at the end of this year.

The data gathered during our site visit provided several results regarding the reasons for deterioration. After comparing the current in-place structure against the designed plans, the double T-girders do not match those placed on site. The concrete cover at the bottom of the on-site girders is only 0.75 inch, far less than the 1.5 inches specified in the plans. Based on our preliminary analysis and discussion with faculty, this is likely a large contributor to the earlier-than-expected deterioration of the bridge girders. Additionally, the type of bridge designed and placed is simply not ideal for its use. Bridges that are wider than they are long, as this one is, typically exhibit greater temperature/shrinkage problems, leading to increased cracking and higher corrosion potential.

Based on the current conditions, we have begun compiling several mitigation alternatives. One of the options is a full bridge replacement using a system of arches and backfill from Contech. This option is comparatively less expensive in terms of cost of materials and the time required for installation than other comparable bridges. Repair options are also being pursued that will reduce the water seeping through the bridge deck and protect the girders from further corrosion, extending the life of the bridge. While these options both appear as promising alternatives, we will perform a more rigorous cost analysis to determine the best option.

Lessons Learned

One lesson learned is how best to contact other outside organizations. One of our first courses of action was to find the plans used to build the bridge. Without these plans, analyzing the bridge would first require a more comprehensive survey of the structure, including general dimensions. However, the City did not have a copy of the plans. As such, we contacted several groups in order to locate the plans. Our research indicated that UDOT and Salt Lake City would be the most likely to have records of the bridge, and we reached out to them accordingly. We quickly realized the difficulty of navigating the legal requirements of UDOT, and after several weeks, we sent an email to the City asking for help contacting the proper personnel to retrieve those documents. Using the City to help obtain the plans proved to be much simpler than attempting to gain them ourselves. Our main takeaway is that the best way to contact other government organizations is through the City. In contrast, private businesses can easily be contacted directly. While waiting to obtain the plans, we began researching options for bridge repair and/or replacement. As part of our research, we contacted many professional services directly, and we received many prompt responses.

Another lesson learned is that professors provide many great resources for both providing and leading us to resources available to help. When we first saw the designs and the existing structure, we were unsure on how to analyze the structure. After contacted several professors with expertise in bridge design and analysis (Dr. Isom and Dr. Guthrie), they provided information regarding the options and methods available to us. In addition, Dr. Fonseca provided valuable information in the methods of prestressed concrete design. Because prestressed concrete is not a topic taught in a class offered at BYU, the books and information provided by our professors provided valuable tools to produce our analysis.

Conclusions/Future Work

Despite the reduction of strength from corrosion of the bottom strand of pre-tensioned steel, our preliminary calculations indicate that the bridge in its current state is sufficient for the anticipated loading conditions of the bridge. However, our analysis of the bridge type and conditions also suggest that bridge replacement may be required in the future as the concrete continues to deteriorate. The timing and cost of bridge replacement or rehabilitation will be the focus of our research until completion.

These preliminary results provide the foundation for completion of the project by next April. As shown in the Schedule section above, the complete analysis will be compiled and presented to the City by the end of this year. January to March will consist of evaluating possible remedies and funding sources. The final report will be presented to the City at the beginning of April.

Recommendations

As we have yet to finalize our preliminary results or potential solutions, our current recommendations are limited. At this stage, our only recommendation is to begin a search for funding to repair or replace the bridge. Federal and/or State funds may be available for such a project, or it may be necessary to use city funds. Given its current condition, it is likely the bridge will require structural modifications in the next few years. Repair or replacement should be considered in the city's plan for infrastructure projects, with potential sources of funding compiled.