Thesis Portfolio

Little Ivy Creek Bridge Replacement using Accelerated Bridge Construction Methods

(Technical Report)

Mitigating Overheight Vehicle Collisions for low clearance bridges

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia - Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Spring, 2020

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Sociotechnical Synthesis

The US Route 250 bridge over Little Ivy Creek is currently in poor condition. After inspection, the Virginia Department of Transportation (VDOT) has determined that the bridge is in need of replacement or rehabilitation. Currently, the bridge has an average daily traffic (ADT) of 11,500 vehicles a day. Both rehabilitation or replacement will necessitate traffic be temporarily restricted on US Route 250/Ivy Road between Crozet and Charlottesville. VDOT has been asked to consider multiple delivery and construction methods, with the goal of limiting traffic impacts to a maximum of two weeks. The estimated traffic impact of conventional construction methods would be three months, while keeping one lane open at all times by using a signalized system. If accelerated construction methods are used for the rehabilitation or replacement of this bridge, a maximum traffic impact of two weeks may be feasible. Our team has been asked to determine and present the best solution possible given the above information.

Our team defined a project scope from analysis of the above problem statement. We defined three Areas of Work (AOW) as follows: geotechnical engineering/design, structural engineering/design, and project controls.

The geotechnical AOW will determine the existing soil conditions, and any changes to the existing conditions that become necessary to provide a safe, suitable foundation as the project design develops. The structural AOW will develop all substructure and superstructure designs and supporting calculations. Cost/benefit analyses of design and construction method alternatives, and preliminary cost estimating and construction scheduling of the final design are grouped under the project controls AOW.

We summarized our project scope with a Project Goal Statement as follows, “To provide a structurally sound replacement / rehabilitation of the Rt. 250 bridge over Little Ivy Creek with minimal time disruption to the travelling public, in a safe and cost-effective manner”.

The success of our final project could be measured relative to this goal statement. Unfortunately, due to the hypothetical nature of our project, and the very real and construction-heavy nature of our goals, it is not possible for us to quantify our success at this time. In practice, the success of our design would be determined during and after construction. For our purposes, we must ask ourselves the question, “Does our design seek to achieve our project goals, and are our design choices justified based upon these goals”. There is an exception; we can state with relative certainty that our design is cost-effective based on the results of our cost-benefit analysis.

The key constraints we faced while completing this project were the 2-week construction completion goal, physical space limitations, and environmental permitting requirements. We had to take care to work around these constraints in our design, while still remembering other constraints such as cost and safety. To understand the problem and design a solution, we used our knowledge of engineering and mathematics. Specifically, we used knowledge from the following areas; structural mechanics and design (particularly reinforced concrete design), geotechnical mechanics and design, transportation design, and construction management and methods. We also used several types of data in the calculations for our design. Soil boring logs were supplied by VDOT through our professors, and used as a source of geotechnical data. Because the borings were only taken in select locations, however, assumptions and interpolations were required. Knowledge of the existing conditions and geometry of the roadway and structure were required, and provided. Data on the live and dead loads the structure should be designed to support were found through existing standards such as AASHTO LRFD specifications. Design data was also collected from the VDOT Road and Bridge Standards, and Specifications. Our conceptual cost estimate required a combination of conceptual cost data found through internet resources, and many assumptions due to project time constraints.

Design Complexity

Below are some of the complexities we encountered over the course of our project, and how we managed these challenges.

Diverse Stakeholders:

Stakeholders in our project included the travelling public, VDOT, Virginia Department of

Environmental Quality (DEQ), U.S. Army Corps of Engineers, the design-build team, and local residents and businesses. We managed stakeholder relations by complying with all stakeholder standards, specifications, and permitting regulations. Additionally, in developing our constructability assessment, we specifically planned for public awareness initiatives before construction begins.

Multiple Disciplines:

An additional aspect of complexity involved in this project is the necessary implementation of geotechnical engineering, structural engineering, and construction management. Incorporating these different disciplines requires both specialization in each and an awareness of when to refer to another discipline for design guidance. Due to the size of the group working on this project, we divided early last fall into three separate teams: one focusing on each discipline. This allows the sub-teams to spend their time and effort on a single discipline, allowing them to master the specific information necessary. However, this division also means that at times certain group members will be unaware of what the other team is working on, and will need to be briefed on their progress. To be able to develop the best design possible, we need to take into consideration outputs from each of the specialized groups and also rely on each other when in doubt. To address this, we meet routinely and every group has a chance to talk about their current work and findings. We also share a google document for the whole group in which we post any new information or work done by each of the teams to make sure the others have access.

Multiple Interacting Sub-problems:

This project requires solving multiple interacting subproblems. Our final design has many issues that it has to address besides the safety and structural stability of the bridge. It has to be economically feasible and constructible, while also providing as little disruption as possible to the surrounding community and users of Route 250. While creating design alternatives and eventually selecting a preferred alternative, the underlying issues of cost and constructability were major considerations. Design alternatives were also influenced by construction methods chosen, which inevitably impact cost and time to construct, along with how the surrounding community and users of Route 250 will be affected due to traffic detours.

The team addressed this problem by ensuring communication between the sub-teams discussed previously, and investing a significant amount of energy into cost/benefit analyses of design decisions. VDOT district office was consulted to assist with our analyses, and balancing the various sub-problems. The team also visited the project site to develop a greater understanding of project conditions.

Consideration of Factors

a) Public health

i) Our project has no adverse effects on public health.

b) Safety

i) Safety was of paramount concern in our project design. The box culvert must be safe for use throughout its design life. We incorporated this into our design by meeting or exceeding all safety reduction factors.

ii) Safety of the travelling public was also considered in regards to maintenance of traffic (MoT). The public must be made aware of any traffic restrictions well in advance of their implementation.

c) Welfare

i) The welfare of the travelling public was taken into consideration in the cost/benefit analyses of various MoT options. The public's preference for a shorter, complete road closure as opposed to a longer, single lane closure, was weighted heavily in our decision to use ABC methods.

d) Global Factors

i) There are no global factors to consider, except perhaps how the usage of ABC on a wider scale can improve the public's opinion of much needed bridge rehabilitation by lessening traffic impacts.

e) Cultural Factors

i) One cultural factor impacted by our design involves the nearby churches. Although accelerated bridge construction takes a fraction of the time needed for traditional bridge construction, it will likely still impact typical access to these sites.

f) Social Factors

i) The social factors included/impacted by our design are included under "Welfare".

g) Environmental Factors

i) Environmental factors heavily influenced our project. The need for proper environmental permitting for construction, and implementation of proper construction methods to limit environmental impacts, was discussed in our constructability assessment.

h) Economic Factors

i) Consideration of economic factors was included in our cost/benefit analyses of design. Specifically, we weighed the additional cost of ABC methods over traditional methods, compared to the quantifiable and unquantifiable savings to the travelling public achieved by limiting traffic impacts.