Little Ivy Creek Bridge Replacement using Accelerated Bridge Construction Methods
(Technical Topic)

Mitigating overheight vehicle crashes for low clearance bridges
(STS Topic)

A Thesis Prospectus
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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

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.

STS Topic Prospectus

An overheight vehicle collision is an incident in which a vehicle, typically a commercial truck or bus, tries to pass under a bridge that is lower than their vehicle's allowed clearance, therefore colliding with the low clearance bridge. According to the US Federal Highway Administration, the third most common cause of bridge failure is bridge-vehicle collision damage (FHWA, 2013). There are a number of reasons why overheight collisions occur, and why drivers of heavy commercial vehicles sometimes fail to recognise the warning traffic signs, consequently striking the bridge. In my thesis I will present the current scope of these incidents, their impact on current transportation networks, and recommendations based on current state of practice and research.

On June 8, 1999 a Canadian commercial truck carrying an improperly loaded excavator struck the prestressed concrete superstructure of a bridge over the Baltimore Beltway in Arbutus, Maryland (FHWA 2000a). Part of the superstructure collapsed onto the traffic below, resulting in the death of one motorist and serious injury to others. A task force was formed to investigate the incident and to make recommendations on how to prevent this type of accident in the future. The task force reported that the collapse happened because of the impact of the excavator, which the driver had not loaded properly. The driver was responsible to ensure that the excavator was within the dimensions of the permit since the load was not inspected by any state authorities before leaving its facility, he hadn't done so. The task force came to the conclusion that the accident was the result of error on the part of the driver, who lacked training regarding overheight loads. Driver training courses on oversize loads and electronic height detection devices were proposed to address the issue. The task force also recommended a statewide and nationwide review of similar accidents to determine the extent of the problem thus prompting data collection on overheight collisions and research on how to mitigate them.

The Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation (AASHTO) report that of the bridges susceptible to impact by overheight vehicles, 20% have been struck with about 5% requiring subsequent repairs (Brilakis 2015). These agencies state that no nationwide database on overheight collisions currently exist, but data collected from surveys suggest that roughly 62% consider it to be a problem (FHWA 2000a). In turn both federal and state agencies prompted research on how to mitigate the issue protecting not only the longevity of the bridges in question but also that of the vehicles as well as their operators. The objective of my thesis will be to assess the extent of overheight vehicle collisions with highway bridges that caused structural damage and injuries at both the Virginia and the national levels and possible solutions.

Crashes between overheight vehicles and low clearance bridges are a frequent phenomenon occurring throughout transportation networks all over the country. FHWA reports that the third most common cause of bridge failure is vehicle crash. Similarly, transportation and bridge engineers report that the leading cause of damage to both prestressed concrete bridges and steel bridges are in fact vehicle collisions. I will take into account several factors which may prove to be influential in the analysis. Bridge clearance, location, their proximity to interstate highways, traffic patterns and the frequency of overheight vehicles on the connecting roads will all be taken into account. I will then draw parallels by correlating bridges with lower ratings to more frequent crashes and vice versa, demonstrating different trends amongst low clearance bridges in the National Bridge Inventory.

Technical Prospectus

The US Route 250 bridge over Little Ivy Creek is currently in poor condition. After inspection, the Virginia Department of Transportation is planning to replace this bridge. The current structure was built in 1932, so rehabilitation or replacement of this structure is prominent. Currently, the bridge carries roughly 11,500 vehicles a day over Little Ivy Creek. With both rehabilitation or replacement, the project will temporarily restrict traffic on Route 250 and Ivy Road between Crozet and Charlottesville. The patrons have asked VDOT to consider multiple delivery options to try and limit the closure time, preferably to a maximum of two weeks. With Conventional Bridge Construction, the estimated time to completion for this project would take three months while keeping one lane open at all times by using a signalized system. If Accelerated Bridge Construction is to be used for the rehabilitation or replacement of this bridge, a maximum closure time of two weeks is feasible. An assessment of the existing sub and super structure, preliminary planning activities, traffic control, cost evaluation and an assessment and planning for public and construction safety will be done while incorporating accelerated bridge construction tools where applicable.

Statement of Project Scope

From the above problem statement, our team began to develop a project scope. Using research, internal and external discussions, and critical analysis of the problem statement, we defined four primary areas of work (AOW) for our project: geotechnical engineering and design, structural engineering and design, cost/benefit analyses of design and construction methods, and constructability assessments and analyses of design and construction methods. In the geotechnical engineering and design AOW, we need to define the existing geotechnical conditions, as well as define any changes to the existing conditions that may become necessary as the project design develops. The structural AOW will encompass all substructure and superstructure engineering calculations and design work. Cost/benefit analyses must be used while making choices between design alternatives as well as construction methods. Finally the constructability AOW serves to inform all cost/benefit analyses as well as ensure that final designs and construction methods are realistic and feasible.

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

Project Schedule

Our current progress and future plans as defined in our schedule are described in detail below in their respective sections. Our project schedule was developed using the following process. First, work items were defined and ordered, moving from beginning of project to final deliverable. Then, where possible, work items were scheduled to be completed simultaneously. Finally, project team members were assigned to individual work activities. Individual work activities will be scheduled to greater degrees of detail as they are encountered. Our final schedule shows an expected project completion date of April 17th, 2020.

Current Progress

We started by defining the scope of our project to get a better understanding of the specific goals and deliverables that are required. Afterwards, research on accelerated bridge construction was done to better acquaint ourselves with the tools available to us that are provided by the FHWA. Most recently, an existing conditions report was done by the structural group to help determine and summarize the condition sub and superstructure elements that are in place currently.

As the geotechnical group, we began with looking at the soil boring reports, taken from Standard Penetration Test data, to determine allowable bearing capacities. At this stage of development, we have calculated an allowable bearing capacity for each layer of soil tested at each boring station. As a group of four, each “geotechnical engineer” was assigned a boring log and we used those to derive the allowable loads on the proposed footings. In doing so, the whole project team will then be able to start designing the bridge based on these load capacities and begin to weigh the different construction methods. Along with bearing capacity, we also used the logs, in tandem with the geotech analysis document that was provided, to analyze the current soil conditions under the proposed footings such as moisture and sinkage. With the input of the structural team, specifically the different construction methods that they plan to use, we can begin comparisons and use our knowledge on the soil conditions and capacities to provide input on how feasible each method will be.

Future Plans

By the end of the fall semester, in addition to the work completed thus far, our team will also provide three project alternatives, cost benefit analyses of these project alternatives, and an analysis comparing traditional bridge construction methods to an accelerated method for our preferred alternative. The project alternatives will provide our team and the client with design alternatives depending on the desired path of construction. These alternatives will allow for variations in design if restricted/limited by budget or differing existing conditions discovered in the field during construction.The two cost benefit analyses will clarify the differences in project expenses and their corresponding benefits, allowing our team to identify the bridge construction method and design alternative that will be the most feasible and beneficial to the client, VDOT. These analyses will also give our team a better understanding of whether or not the additional construction expenses associated with the prefabrication of bridge elements for the ABC method will be financially advantageous in comparison to the traditional construction method.

Works Cited

Charette, R. N. (2017). Low Clearance Ahead: Can Predictable IT Crashes Be Avoided?. *Computer (00189162)*, 50(10), 86 - 91.

Dai, F., Park, M., Sandidge, M., & Brilakis, I. (2015). A Vision-Based Method for on-Road Truck Height Measurement in Proactive Prevention of Collision With Overpasses and Tunnels. *Automation In Construction*, 50, 29 - 39.

Gagnon, J. W., Loberger, C. D., Sprague, S. C., Ogren, K. S., Boe, S. L., & Schweinsburg, R. E. (2015). Cost-Effective Approach to Reducing Collisions With Elk by Fencing Between Existing Highway Structures. *Human-Wildlife Interactions*, 9(2), 248 - 264

Federal Highway Administration (FHWA). (2000a). Highway Statistics 1999, Office of Highway Policy Information, Washington, D.C., Table HM-81