WORK ZONE SAFETY ANALYSIS, INVESTIGATING BENEFITS FROM ACCELERATED BRIDGE CONSTRUCTION (ABC) ON ROADWAY SAFETY

Quarterly Progress Report
For the period ending November 30, 2020

Submitted by:
Seyedmirsajad Mokhtarimousavi, Research Assistant
Islam Mantawy, Ph.D., Research Assistant Professor
Atorod Azizinamini, Ph.D., PE., Director of ABC-UTC

Graduate Student: Seyedmirsajad Mokhtarimousavi, PhD Candidate

Affiliation: Department of Civil and Environmental Engineering
Florida International University
Miami, Florida

ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

Submitted to:
ABC-UTC
Florida International University
Miami, FL

1. Background and Introduction

Due to the growth of highway renovations and construction projects in the state of Florida, the number of work zones has increased. Work zones create traffic congestion and the attributes of work zones have significant impacts on the risk of crash occurrence. According to statistics from the American Road and Transportation Builders Association (ARTBA), Florida is among top three states for work zone fatal crashes with a total of 67, 73, and 71 fatal crashes resulting in 73, 80, and 76 fatalities in 2015 to 2017 respectively (ARTBA 2018). Work zone crashes constitute approximately 1.55% of the total crashes (i.e., 2,112,783), with 9,142 injury crashes between the years 2015 and 2017 in Florida (S4A 2018).

Another important aspect of work zone crashes which needs to be considered by decision makers, is worker safety. Among the total number of work zone crashes in 2017 in the state of Florida, around 43.4% were associated with worker presence, in which 16 workers were killed. The worker fatalities in 2017 are 33.3% and 45.45% higher compared to 2016 and 2015, respectively (ARTBA 2018). The significant loss of workers' lives and injuries resulting from work zone crashes indicates the emergent need of a comprehensive and in-depth investigation of work zone crash mechanisms.

The cost of crash and its associated costs is another adverse effect of construction work zones. As it was mentioned in (Mohan and Gautam 2000), according to the US DOT National Highway Traffic Safety Administration (NHTSA), the direct costs of work zone crashes in 1997, including 658 fatalities, 36,000 injuries, and 52,000 property damage only crashes was $5.74 billion in Unites States. It has been reported in many previous studies that there is a meaningful deference in crash severity and crash rates between with and without work zone presence conditions (Mallela and Sadavisam 2011). Moreover, in a recent review from Yang et al. on work zone safety analysis and modeling, it was stated that over 85% of previous studies regarding work zone crash frequency demonstrate an obvious increase in crash frequencies during work zone operations (Yang et al. 2015). Hence, in order to prevent imposing millions of dollars on society each year, it is necessary to investigate the possible causes associated to crash severity and frequency to improve work zone safety. In addition, applying innovative construction methods like Accelerated Bridge Construction (ABC) dramatically decreases onsite construction duration, thus improve roadway safety.

2. Problem Statement

According to Manual on Uniform Traffic Control Devices (MUTCD), bridge construction/reconstruction is categorized as long-term stationary work zones since the construction duration is basically over three days. This long roadway occupancy and its related components such as lane closures, lane width reductions, changes in road geometry, and the

presence of construction workers increase the crash occurrence risk. Accelerated Bridge Construction (ABC) is an advanced method of project delivery with the aim of reducing the on-site bridge construction timeline without losing bridge quality (Ralls 2007). This innovative bridge construction method can be employed for either constructing new bridges or replacement of existing bridges with a significantly lowered traffic disruption during implementation.

So far, there is no such study that assesses the roadway safety enhancement aspect of ABC implementation method. In addition, most of the existing safety research has focused on the traveling public and not on worker safety. To fill this gap, at first glance, this project seeks to identify the contributing factors that affect the severity of work zone crashes associated with worker presence and crash frequency at bridge construction work zone locations. Then, provides quantitative evidence of how much benefits can be obtained through the ABC implementation as compared with conventional on-site bridge construction from roadway safety points of view.

3. Objectives and Research Approach

Taking above-mentioned into consideration, this project aims to identify the contributing factors that affect crash severity and frequency of work zone crashes through the conjunction of the results from conventional statistical models and machine learning techniques. This can provide a more comprehensive interpretation of work zone crash severity and frequency outcomes. The analysis sheds light on the internal probability patterns of crash contributing factors, as well as their overall impacts. In addition, it seeks to assess the impact of ABC implementation to enhance work zone safety through a benefit-cost analysis, which has not been investigated and documented yet.

In this regard, different data sources such as crash records, project information and layouts, roadway geometric features, and traffic data were combined to develop enhanced prediction models. In order to identify factors affecting work zone crash severity, a three-year period of statewide crash data was obtained from the Florida Signal Four (S4A) Analytics tool for worker-involved work zone crashes. The most significant contributing factors in terms of crash severity were investigated using logistic regression and Support Vector Machine (SVM) modeling frameworks for daytime and nighttime conditions separately. In addition, likelihood ratio tests were conducted to examine the overall stability of model estimates across time periods.

Identifying factors affecting work zone crash severity is important, however, factors affecting crash frequency also need to be studied by considering individual work zone location. Since this study seeks to assess the impact of ABC implementation to enhance work zone safety, in order to identify contributing factors for crash occurrences under work zone conditions, a number of 60 bridge locations was selected in Miami-Dade County. Then crash frequency models were developed through a Negative Binomial regression technique and Support Vector Regression (SVR).

Take abovementioned into consideration, the primary objectives of this project is three-fold:

1. Provide descriptive statistics analysis of work zone crash characteristics.
2. Model and analyze crash severity and frequency characteristics associated with construction work zones.
3. Assess the costs related to crash occurrence, crash severity as due to work zone presence for both traveling public and construction crew together with a benefit-cost analysis to investigate the benefits of implementing ABC.

4. Description of Research Project Tasks

Figure 1 shows the proposed project flowchart.

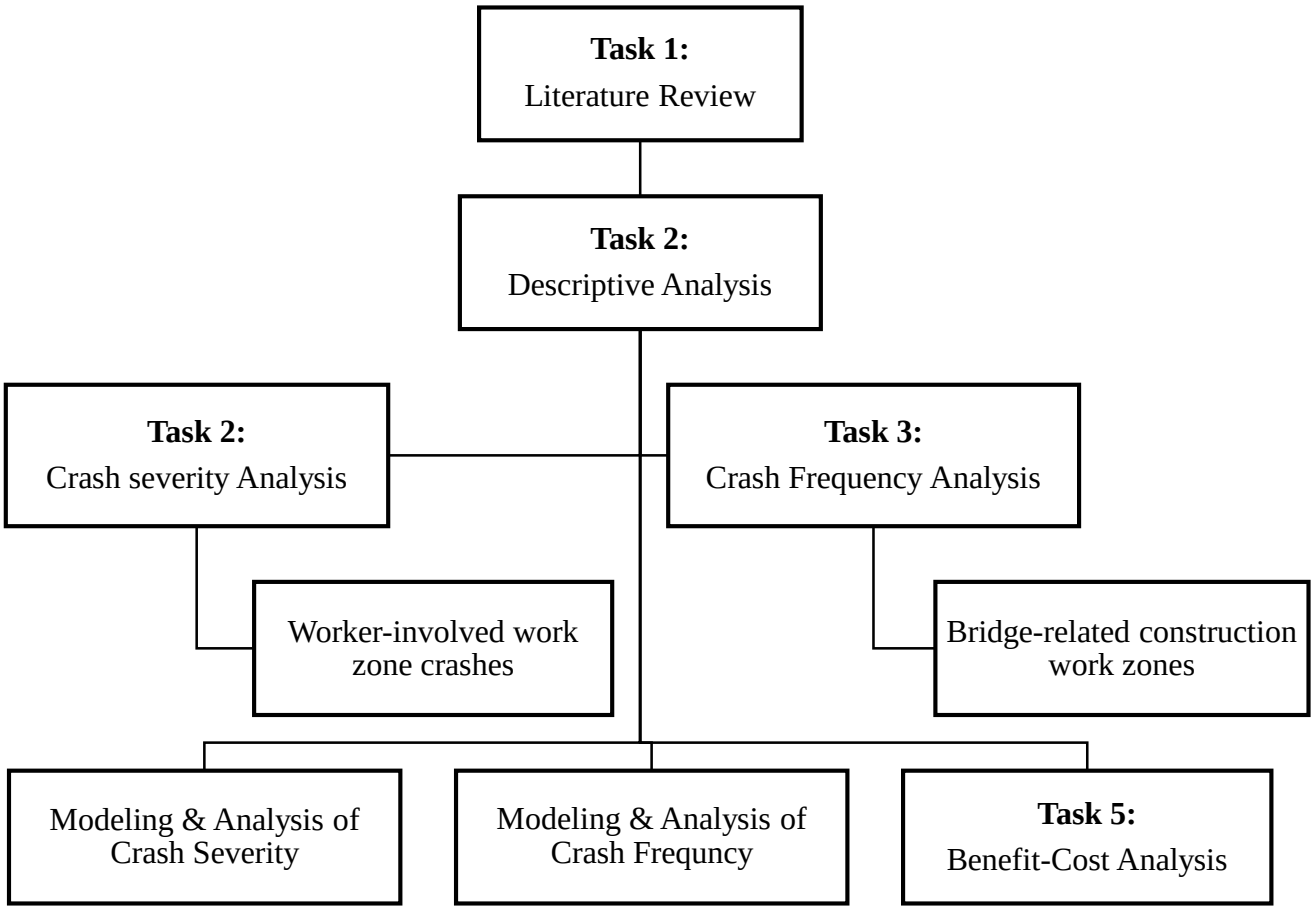

Figure 1: Project flowchart.

Task 1 – Literature Review

Conduct a comprehensive review of the literature on construction work-zone crash analysis. A detailed literature review related to crash severity and crash frequency was conducted and organized in statistical methods which are the primary method used in traffic crash severity and frequency analysis, machine learning methods which recently widely applied in transportation studies including traffic safety analysis, and the corresponding work zone related studies.

Progress: This task is completed.

Task 2- Descriptive Analysis

Provide a detailed descriptive analysis of crash data with a focus on work zones in the State of Florida. A three-year period of statewide crash data was collected from January 1, 2015 to December 31, 2017. Crashes that occurred in work zone areas with worker presence were then extracted from the crash records. The dataset contained a total of 2,113,678 crash records, with 1.55% of the crashes occurring in work zones (i.e., 32,669 occurred in work zones). Out of the total number of work zone crashes, 44.50% were associated with worker presence. The purpose of conducting a descriptive analysis of work zone-related crash severity is to provide an initial view of data distribution within work zone crash severity levels. The purpose of conducting a descriptive analysis of work zone-related crash severity is to provide an initial view of data distribution within work zone crash severity levels.

As for crash frequency, all work zone crashes involving workers were included in the descriptive analysis. The Florida work zone crash frequency and related parameters for the years 2015 to 2017 were described in the following order: crash frequency by temporal variables, crash attributes, environmental condition, driver characteristics, and work zone characteristics.

Progress: This task is completed.

Task 3– Crash Severity Analysis

Crash severity analysis through logistic regression and machine learning techniques is conducted with the focus of worker-involved work zone crashes. The applied techniques include binary mixed logit, random forest (RF), parameter transferability, SVM, and the CS algorithm used to tune the SVM parameters. The premise behind the application of the logit model and the corresponding parameter transferability test is two-fold. First, the logit model is used to determine significant factors that contribute to work zone crash severity. Second, the parameter transferability test statistically confirms whether the contributing factors to work zone crash severity are different by daytime and nighttime conditions. The identified variables in the logit model are then investigated in detail using the enhanced SVM approach.

Progress: This task is completed.

Task 4– Crash Frequency Analysis

Crash frequency analysis through logistic regression and machine learning techniques is conducted. A three-year monitoring period from 2015 to 2017 is carried out on a number of bridge locations in Miami-Dade County. During the period of observation, crash data were collected from the S4 crash database for crash records that were marked as work zone-related crashes. These crashes were extracted 300-350 ft. (adjusted) from upstream and downstream of bridge locations through overlaying analysis in ArcGIS tool. In addition to crash records, traffic flow condition, roadway and bridge geometric design features were also taken into account in order to create a unique crash dataset for performing crash frequency analysis. Then, contributing factors have been investigated employing Negative Binomial (NB) and Support Vector Regression (SVR) models.

Progress: This task is completed.

Task 5– Benefit-Cost Analysis

This task will analyze the bridge-related work zone crash-associated costs and the roadway safety benefits that can be obtained by utilizing ABC compared to conventional bridge construction methods. It will be first an evaluation of the costs associated with crash occurrence and crash severity in work zone locations. Then, the benefits of ABC implementation through a monetary assessment of the potential avoided crashes to support the decision-making process of highway construction projects. Besides, the ABC method will be evaluated if it brings more benefits than it costs in the project life-cycle.

Progress: This task is completed.

Task 5– Benefit-Cost Analysis
Progress: Final Report is being prepared and it is anticipated that it will be published in next quarter reporting.

5. Schedule

Figure 2 shows the progress of the project during the first quarter.

Item	% Completed
Percentage of Completion of this project to Date	90%

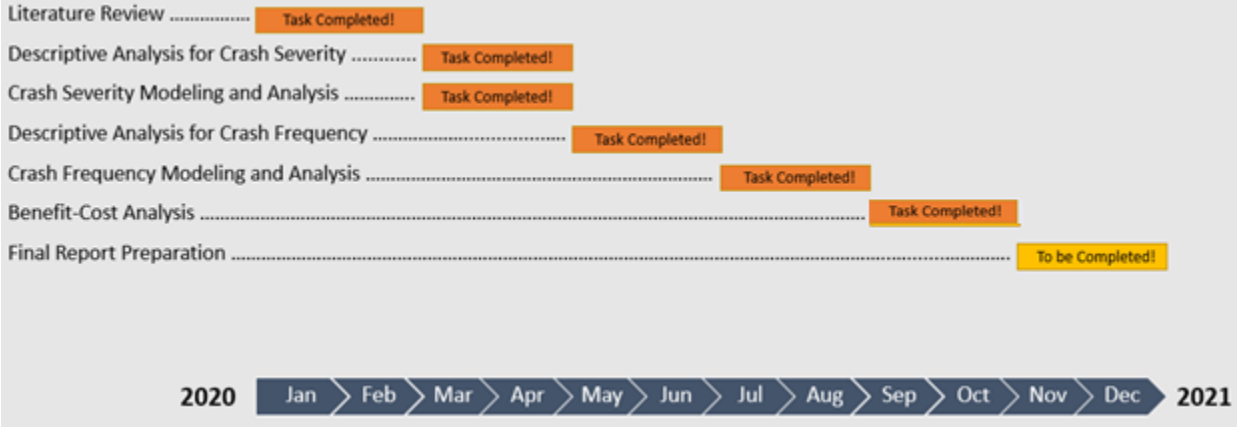

Figure 2: Project flowchart.

6. References

[1] Artba, American road & transportation builders association. National Work Zone Safety Information Clearinghouse, https://www.workzonesafety.org/

[2] S4a, 2018. Signal four analytics. The GeoPlan Center, Department of Urban & Regional Planning, University of Florida.

[3] Mohan, S.B., Gautam, P., 2000. Cost of highway work zone injuries. In: Proceedings of the Construction Congress VI: Building Together for a Better Tomorrow in an Increasingly Complex World, pp. 1196-1207.

[4] Mallela, J., Sadavisam, S., 2011, Work zone road user costs: Concepts and applications. United States. Federal Highway Administration, DTFH61-06-D-00004.

[5] Yang, H., Ozbay, K., Ozturk, O., Xie, K., 2015. Work zone safety analysis and modeling: A state-of-the-art review. Traffic injury prevention 16 (4), 387-396.