South Carolina Department of Transportation

South Carolina's SC 61 Rural Road Safety Project

SAFETY DATA CASE STUDY

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Federal Highway Administration Office of Safety

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U.S. Department of Transportation
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Acronyms

Acronym	Description
AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
CMF	crash modification factor
EB	Empirical-Bayes
FHWA	Federal Highway Administration
FI	fatal and injury
HSM	Highway Safety Manual
ITMS	Integrated Transportation Management System
RIMS	Roadway Information Management System
RRSP	Rural Road Safety Program
SC	South Carolina
SCDOT	South Carolina Department of Transportation

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Executive Summary

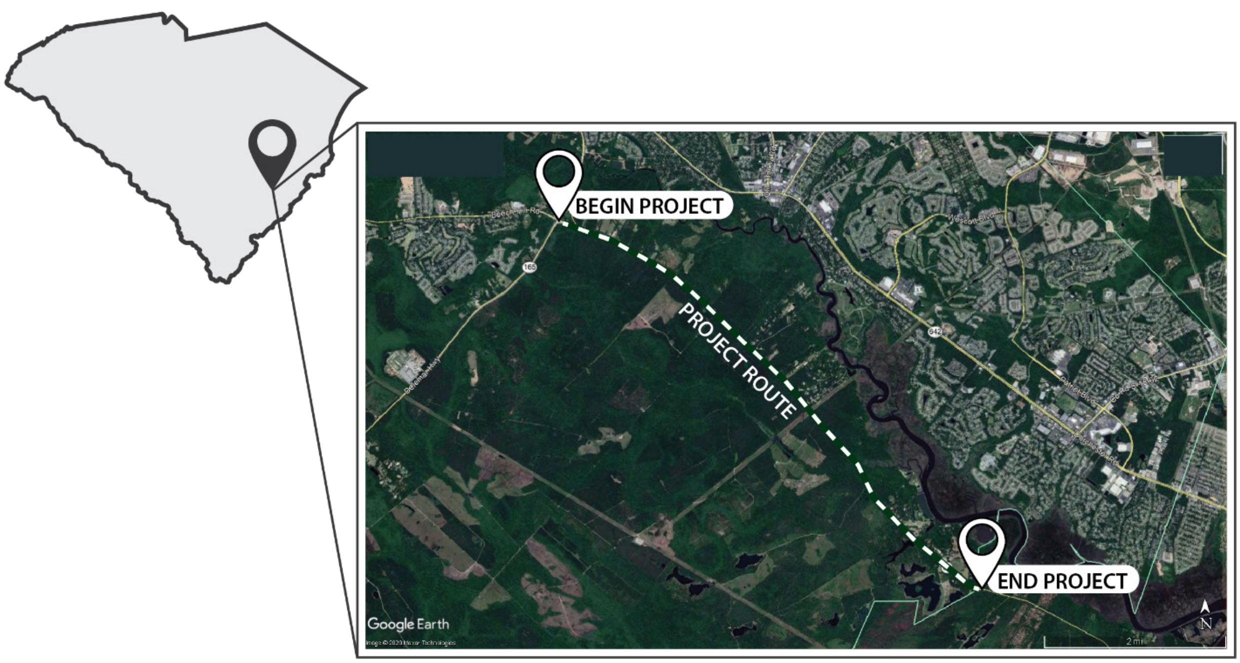
This purpose of this case study is to present an example application of the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) to support a rural road corridor analysis. The South Carolina Department of Transportation (SCDOT) Rural Road Safety Program (RRSP) focuses on improving, "safety on SC's rural roadways through engineering solutions identified to reduce the frequency of fatal and serious injury crashes occurring on these roadways" (South Carolina Department of Transportation 2020). SCDOT used HSM spreadsheets to apply HSM predictive methods from chapter 10, *Rural Two-Lane, Two-Way Roads* (AASHTO, 2010), to assess alternative designs. The spreadsheets allowed SCDOT to apply an Empirical-Bayes (EB) analysis that compared the observed crash frequency with the expected crash frequency based on the corridor's characteristics. Context and the preference of the public and local stakeholders were the governing challenges of this analysis. The historical context, Scenic Byway designation, and other natural barriers required SCDOT to consider numerous, slightly different alternatives. The goal, as well as the key challenge of the public engagement, was to present the HSM analysis as clearly and concisely as possible. The general public appreciated seeing the differences in crash prediction associated with changes to the cross-section relative to the "No-Build" option, and it demonstrated that SCDOT had taken the time to consider stakeholder input. This helped make the case that the surrounding landscape should be gently modified to improve safety.

Introduction

The Transportation Research Board's Safety Performance Analysis (ACS20) User Liaison Subcommittee has an on-going initiative focused on practical application of the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) (i.e., "using the HSM in the real world"). FHWA also administers the HSM Implementation Pooled Fund, which includes 22 States focused on projects to help further HSM implementation. Development of HSM case studies will assist practitioners in performing data-driven safety analysis using the advanced methods described in the HSM. The primary purpose of the HSM case studies is to highlight noteworthy applications of HSM methods, focus on common challenges, and feature agencies that overcame those challenges. These case studies serve as a source of lessons learned and noteworthy practices to help guide practitioners applying the HSM.

Background

This purpose of this case study is to present an example of a rural road corridor analysis. The South Carolina Department of Transportation (SCDOT) Rural Road Safety Program (RRSP) focuses on improving, "safety on SC's rural roadways through engineering solutions identified to reduce the frequency of fatal and serious injury crashes occurring on these roadways" (SCDOT, 2020). To illustrate the magnitude of the issue, 5 percent of the worst performing rural roads in South Carolina account for 30 percent of all fatalities and serious injuries. A 1.3-mile section of SC 61 in Dorchester County, SC is among the 55 rural non-interstate corridors identified for safety improvements through the RRSP (figure 1).



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Note: The white location pins and white dashed line were added by the authors to delineate the project bounds.

Figure 1. Graphic. SC 61 project location.

Purpose and Need

The purpose of the RRSP is to reduce roadway departure crashes on rural roads in South Carolina; these crashes account for more than half of all fatalities and serious injuries in the State. The projects developed through the RRSP focus on three objectives (consistent with FHWA's roadway departure objectives):

1. Keep vehicles on the roadway.
2. Provide for safe recovery.
3. Reduce the frequency of fatal and serious injury crashes.

To accomplish these objectives, SCDOT explored relevant countermeasures that address roadway departure crashes, including:

- Rumble strips.
- Wider and brighter pavement markings.
- Brighter and more reflective signs.
- Wider/paved shoulders.
- Wider clear zones.
- Guardrails.
- Smoother pavement edges.
- Beveling driveway pipes.

The SC 61 project was divided into two sections, 1) a 0.6-mile section north of the main entrance to Middleton Plantation, and 2) a 0.7-mile section that continues southeast and ends at the Dorchester and Charleston county line. As a scenic rural corridor in southeast South Carolina, SC 61 presented several challenges that limited the applicability of some of the roadway departure countermeasures. For instance, local officials and the general public wanted to preserve the historic and natural aesthetics of the corridor (the corridor is a designated SC Scenic Byway), and they were generally unwilling to remove trees and other vegetation as some countermeasure implementations would require (figure 2). Environmental constraints and project bottlenecks (e.g., a bridge over a river tributary) limited the applicability of other roadway departure countermeasures. SCDOT's engineers documented the impacts, trade-offs, and challenges associated with various treatments as part of the alternatives analysis.

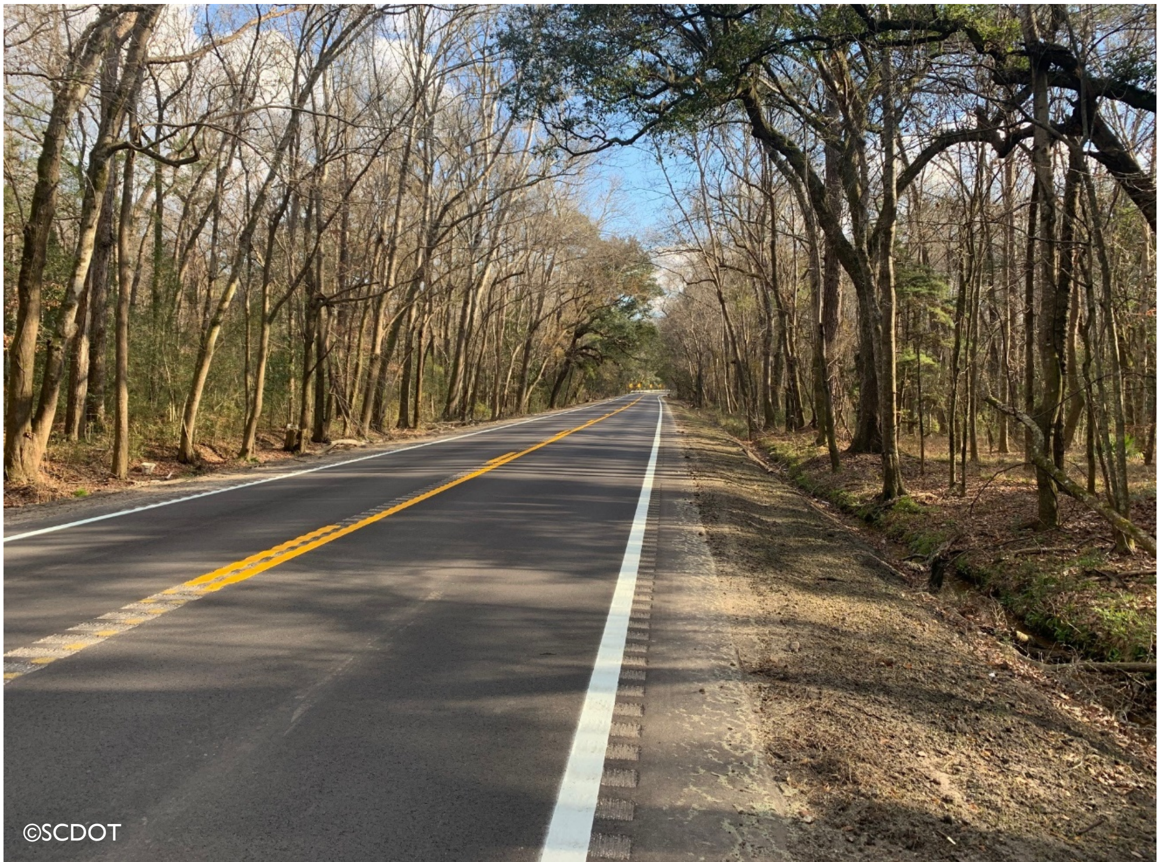

Figure 2. Graphic. SC 61 site photo of a completed section.

Project Description

- **Sponsoring agency:** SCDOT.
- **Project location:** Dorchester County, SC.
- **Project bounds and length of project:** SC 61 between milepoint 18.471 - 19.773 (1.3 miles).
- **Facility type(s):** 2-lane undivided, two-way minor arterial.
- **Area type:** Rural.
- **Project status (winter 2021):** Constructed.

Safety Performance Analysis

This section provides an overview of the analysis methods, proposed alternatives, and results.

Analysis Overview

The corridor's existing cross-section consists of two, 10.5-ft lanes with no paved shoulders. SCDOT assessed a roadside hazard rating of 6 (out of maximum 7) before any improvements or vegetation clearing occurred. Given the coastal plain nature of the area, the road is generally straight and level throughout its length. The corridor experienced a moderate level of daily traffic, with an annual average daily traffic (AADT) volume of 9,700. SCDOT assumed no change in AADT over the five years of crash history used in the analysis.

SCDOT used HSM spreadsheets to apply HSM predictive methods from Chapter 10, *Rural Two-Lane, Two-Way Roads* (AASHTO, 2010), to assess 11 preliminary alternative designs. SCDOT engineers obtained road attributes from the State's Integrated Transportation Management System (ITMS), as well as historic crash data from the Roadway Information Management System (RIMS).

The spreadsheets allowed SCDOT to apply an Empirical-Bayes (EB) analysis that compared the observed crash frequency with the expected crash frequency based on the corridor's characteristics. SCDOT applied a calibration factor of 0.99 for the EB analysis. All design alternatives included crash modification factors (CMFs) for shoulder and centerline rumble strips (0.87 and 0.94, respectively).

Analysis Details

Table 1 summarizes the existing conditions on the corridor, and table 2 summarizes the analysis assumptions.

Table 1. SC 61 existing conditions.

Category	Type	SC 61 Characteristics
Cross-Section	Number of Lanes	2
	Median Presence	Undivided
	Lane Widths	10.5 feet
	Shoulder Type/Widths	None/Negligible
Alignment	Curve/Grade	Straight/Level
Traffic	AADT	9,700
Crash History	5-Year Statistics	44 Total Crashes 22 Injuries 3 Fatalities

Table 2. SC 61 analysis assumptions.

Category	Assumptions
HSM Chapter(s)	10
Calibration Factor(s)	0.99
CMF(s)	Shoulder rumble strips: 0.87 (CMF Clearinghouse ID #1195) Centerline rumble strips: 0.94 (HSM Chapter 10.7.1)

Results

A detailed alternatives analysis revealed minor crash reductions across the spectrum of future "Build" options, despite major proposed alterations to the clear zone. Local stakeholders requested minor alterations to the paved cross-section (1-2 ft) to assess the granular impacts of any proposed widening. Based on the small differences in fatal and injury (FI) and total crash reduction, local stakeholders asked that SCDOT only make limited alterations to the cross-section and roadside environment. Table 3 details each alternative, as well as the associated crash prediction with each alternative.

Table 3. SC 61 roadway design features and alternatives analysis.

Design Features	Alternatives										
	1	2A	2B	3	4	5	6	7	8	9	10
Lane Width (feet)	12	11	11	11	10	12	11	11	11	11	11
Total Shoulder Width (feet)	10	4	2	2	4	2	2	2	4	3	3
Paved Shoulder (feet)	4	4	2	2	2	2	2	2	2	3	3
Added Pavement Width (feet per side)	5.5	4.5	2.5	2.5	1.5	3.5	2.5	2.5	2.5	3.5	3.5
Clear Zone (feet)	20+	12	12	<5	5-10	5-10	2	5-10	12	12	5-10
Predicted FI Crashes - 10 years	9	11	12	14	13	12	14	12	11	11	12
Reduction in FI Crashes from No-Build	65.4%	57.7%	53.8%	46.2%	50.0%	53.8%	46.2%	53.8%	57.7%	57.7%	53.8%
Predicted Total Crashes - 10 years	25	30	32	39	36	33	39	34	30	31	33
Reduction in Total Crashes from No-Build	64.8%	57.7%	54.9%	45.1%	49.3%	53.5%	45.1%	52.1%	57.7%	56.3%	53.5%

Documentation and Use of Analysis Results

While the formal analysis report is not available to the public, presentation materials developed for public engagement explained the tradeoffs associated with specific alternatives. Table 4 is an example of the design tradeoffs in terms of tree removal relative to crash reductions.

Table 4. Alternatives analysis - public engagement example.

Roadway Design Features	Alternative 1 Standard Typical	Alternative 2 Contextually Sensitive Design
Lane Width (feet)	12	11
Shoulder Width (feet)	10 (4 paved; 6 earth)	4 (paved)
Clear Zone (feet)	20+	12
Trees Impacted	283	58
Traffic Injury Reductions	65%	58%

The goal, as well as the key challenge of the public engagement, was to present the HSM analysis as clearly and concisely as possible while also conveying the high level of thought and consideration that went into each alternative. While most attendees opposed any alternative that removed trees from the corridor, SCDOT noted that the public appreciated the clear illustration of the alternative impacts and potential crash reductions. Ultimately, SCDOT selected an alternative of 11-ft travel-lane widths, a 3-ft paved shoulder, and no additional tree clearing.

Challenges

Context and the preference of the public and local stakeholders were the governing challenges of this analysis. The historical context, Scenic Byway designation, and other natural barriers required SCDOT to consider numerous, slightly different alternatives. SCDOT also noted several issues with data collection and methods for quantifying existing conditions. For instance, SCDOT received conflicting posted speed limit sign placement reports on the corridor, and the agency had some difficulty defining the roadside hazard rating for the area; this assessment varied according to certain proposed alternatives, and the exact rating may vary by practitioner. Finally, without a clear and obvious alternative based on predicted crash reductions alone, there was considerable desire from stakeholders to move forward with a less intrusive, more contextually sensitive alternative.

Limitations of the HSM method

According to SCDOT, HSM analysis methods have their limitations, and it is important to communicate that to all decision makers. As noted in the HSM's preface (AASHTO, 2010):

> "The information in the HSM is provided to assist agencies in their effort to integrate safety into their decision-making processes. The HSM is not intended to be a substitute for the exercise of sound engineering judgment" (Considerations and Cautions When Using the HSM).

The HSM should not be used as a tool to precisely predict the change in crashes over a 5-year period given the addition or removal of a single foot of pavement. Rather, it is a guide for practitioners to better understand the tradeoffs associated with major design decisions.

Conclusions and Lessons Learned

SCDOT's original scope was to analyze two or three alternatives for safety improvements along SC 61; however, public and local organization feedback encouraged SCDOT to analyze a suite of slightly modified alternatives (table 3). Although there was considerable pressure from the public and local stakeholders to assess very minor changes to different alternatives, SCDOT noted that this should be discouraged whenever possible. Minor changes in design specifications, especially on short analysis corridors, yield minor changes in predicted crash reductions, and the practitioner may lose confidence in meaningful differences between alternative results. Still, the HSM analysis produces useful insights that allow safety practitioners to communicate and champion safety to non-technical stakeholders. The general public appreciated seeing the differences in crash prediction associated with changes to the cross-section relative to the "No-Build" option, and it demonstrated that SCDOT had taken the time to consider stakeholder input. This helped make the case that the surrounding landscape should be gently modified to improve safety. By combining public concern with the predicted outcomes based on the HSM analysis, SCDOT was able to achieve a context-sensitive solution that will yield safety benefits for rural road users.

References

- **American Association of State Highway and Transportation Officials. (2010). *Highway Safety Manual: 1st Edition*, Washington, D.C. Spreadsheet tools available online: http://www.highwaysafetymanual.org/Pages/Tools.aspx.**
- **Federal Highway Administration. (2020). "CMF Clearinghouse" (website). Available online: http://www.cmfclearinghouse.org/index.cfm.**
- **Phone interview on June 17, 2020, with Duncan Smith.**
- **South Carolina Department of Transportation. (2019). *Data Driven Safety Analysis – Integrating Safety into All Projects* [PowerPoint Slides].**
- **South Carolina Department of Transportation. (2020). "South Carolina Department of Transportation Rural Roads Safety Program" (website). Available online: https://scdot.maps.arcgis.com/apps/MapSeries/index.html?appid=df937e9b63ce4377a3705feb9fb05466.**

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