THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY RESEARCH CENTER
www.hsrc.unc.edu

NCHRP 17-104: Enhancement of Roadside Design Safety Prediction Models for the Highway Safety Manual

Safety Performance and Analysis Committee Midyear Meeting

June 2023

1

Project Team

- UNC Highway Safety Research Center (HSRC)
- Kittelson and Associates (KAI)
- VHB
- Bucknell University

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

2

Objectives

- Validate Roadside SPFs and associated CMFs developed in NCHRP Project 17-54
- Develop or enhance roadside SPFs to supplement or replace existing models
- Coordinate the research products with planner content for other manuals such as Green Book and the Roadside Design Guide (RDG)

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

3

Phase 1

- Task 1: Review literature and assess data sources
- Task 2: Assess state of practice
- Task 3: Review project 17-54 SPFs
- Task 4: Develop draft phase II work plan
- Task 5: Develop revised phase II work plan
- Task 6: Prepare interim report

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

4

Phase II

- Task 7: Conduct the approved phase II work plan
- Task 8: Develop implementation guidance
- Task 9: Develop final products

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

5

Task 1: Review literature and assess data sources

- Review of recent studies
  - Submitted to panel
- Panel provided comments
- Project team responded to the comments

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

6

Task 2: Assess state of practice

- Conducted survey of States
  - Determine priority of facility types (distributed survey)
  - Data and importance of specific roadside elements
- Interviewed selected States
  - Minnesota, Kansas, and Washington provide the best chances of getting the necessary data

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Task 3: Review Project 17-54 SPFs

- Critical review of project 17-54 CMFs and SPFs
- Compare 17-54 CPM to HSM and other CPMs
- Documents submitted to the panel
- Panel provided comments
- Project team responded to the comments and revised the documents

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Task 4: Draft Phase II Work Plan

- Subtask 4.1: Prioritized list of roadway types and roadside data elements
  - Priority score based on research needs (based on the survey of States)
  - Priority score based on data availability/data collection effort (average for the 3 high priority States: Minnesota, Kansas, Washington)
  - Combined priority scores to determine overall priority

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Subtask 4.1 Priority List

Roadside Element	Priority Score Based on Research Needs) (5 = high; 1 = low) (Task 2)	Priority Score Based on Data Availability/Data Collection Effort (Average for 3 States)(5 = high; 1 = low)	Overall Priority Score (higher score is higher priority)	Overall Priority
Bridge abutments	2	3.0	5.0	Low
Bridge piers	2	3.3	5.3	Low
Culvert Headwalls/inlets	3	4.0	7.0	High
Curb Type	2	3.7	5.7	Medium
Fences	1	3.0	4.0	Low
Luminaire Supports	3	4.3	7.3	High
Mailbox supports	1	2.0	3.0	Low
Median barrier presence/type	5	5.0	10.0	High
Railroad crossing warning sign	1	5.0	6.0	Medium
Retaining Walls	1	4.0	5.0	Low
Roadside Embankment/Ledge	4	2.0	6.0	Medium
Roadside Longitudinal barrier	5	5.0	10.0	High
Roadside Slope	5	2.3	7.3	High
Roadway Ditch	4	1.0	5.0	Low
Sign supports	3	4.0	7.0	High
Traffic Signal control cabinets	1	4.3	5.3	Medium
Traffic signal supports	3	4.3	7.3	High
Transverse slope/side slope	4	2.3	6.3	Medium
Trees	5	1.0	6.0	Medium
Utility Poles	4	3.0	7.0	High

10

Task 4: Draft Phase II Work Plan

- Task 4.1 memo
- WP-4.2: Approach for validating the 17-54 prediction models
- WP-4.3B1: Approach for developing roadside CPMs using regression analysis
- WP-4.3B2: Approach for developing roadside CPMs using regression analysis and crash probability
- WP-4.3B3: Approach for developing an enhanced roadside hazard rating (RHR)
- WP-4.4: Plan for compiling the data

THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY RESEARCH CENTER

Task 4: Priority of Facility Types

- Rural roads (rural two-lane, rural multilane undivided and divided) rated as highest priority by the States
  - Based on resources available, we are reasonably confident of being able to cover the rural roads
  - Developed Task 4 work plans based on this assumption
- May be able to include other roads (e.g., urban arterials)
  - Sample data collection in Task 5 will help us estimate level of effort better
  - Urban roads take more time for data collection

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

WP-4.2: Validating the NCHRP 17-54 Prediction Models

- Model predicts SVROR crashes for one pavement edge

$$N_{SEVERITY} = SPF_{EDGE} * CMF_{ROADWAY} * CMF_{ROADSIDE}$$

$$CMF_{ROADSIDE} = \left[\beta_{SHLD} * X_{SHLD} * \prod_{j=1}^{m1} CMF_j\right] + \left[\beta_{UNSHLD} * X_{UNSHLD} * \prod_{k=1}^{m2} CMF_k\right]$$

- Two components in trying to validate the outcomes from NCHRP 17-54:
  - Validity of the overall predictions from the NCHRP 17-54 prediction models
  - Validity of the individual CMFs developed in NCHRP 17-54

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Validity of the Overall Predictions from the NCHRP 17-54 Prediction Models

- Compile data
- Develop predictions from 17-54 models
- Estimate the calibration factors
- Apply the calibration factors and get the revised predictions
- Assess the goodness of fit of the prediction

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

14

Validity of the Individual CMFs from NCHRP 17-54

- Multiple approaches depending on the specific CMF or adjustment factor
  - Specific approach may depend on whether the variable is continuous or categorical
  - Used in NCHRP Project 17-72
  - Estimate adjustment factors from the data and compare with the adjustment factors from NCHRP 17-54
- Propose changes to the 17-54 prediction model and/or adjustment factors

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

15

Sample Size for Validation

- Validation of overall predictions
  - Sample size needed for calibration
  - 1st edition of the HSM (at least 100 crashes a year and 30 sites) (based on judgement)
  - Bahar and Hauer (2014) proposed an alternative method
- Validation of individual CMFs
  - More difficult to assess because it depends on the specific CMF, and will depend on the data that are available

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

WP-4.3 B1 and B2: Develop Empirical Model Based on Crash Data

- B1: Regression model with AADT and other roadway and roadside variables to derive adjustment factors
- B2: Some adjustment factors based on regression model (similar to B1) and other adjustment factors based on probability of <u>encroachment and probability of a crash</u>
  - Derived from previous research and similar the approach used in NCHRP 17-72
- One model for the outside edges of roadway segments
- The other model for the two median edges of divided segments
- Will produce predictions by severity as well

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

17

4.3B3: Develop Enhanced Roadside Hazard Rating CMF

- Roadside Hazard Rating (RHR) is currently used to determine the safety effect of roadside in Chapter 10 (rural two-lane roads) of the HSM
  - RHR is from a scale of 1 through 7 determined through photographs and descriptors
  - CMF for a unit decrease (increase) in RHR is the same irrespective of the initial and final RHR values
  - RHR CMF pertains to total crashes, and CMFs for run off road crashes will be useful

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

18

4.3B3: Modeling Approach

- Multiple Approaches
  - Approach 1: Estimate a prediction model for each RHR category
  - Approach 2: Include RHR as a categorical variable in a prediction model
  - Number of miles in each RHR category may dictate which approach is more feasible

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Data Collection Procedures

- Spatial analysis
- Manual data collection
- Semi-automated data collection
  - Used in NCHRP 17-88 to get offset distance of selected roadside objects
- Emerging methods, e.g., LiDAR
  - Received raw LiDAR data from Minnesota. Requested processed elevation data – it can be used to derive roadside slope

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

20

Data Collection Plan

- Table 2 summarizes the data collection plan for identified elements of Washington, Minnesota, and Kansas
  - Data collection techniques
  - Level of effort
  - Accuracy and quality of collected data
  - Estimated data collection miles
    - About 1470 hours for data compilation and collection

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

Task 5: Revised Phase II Work Plan

- Gather existing data
  - Compile sample data through various methods
- Assess viability of analytical approaches
- Describe possible modifications to Draft Phase II Work Plan

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

22

Task 6: Prepare Interim Report

- Prepare revised phase II work plan
- Prepare interim report
- Meet with panel
- End of Phase 1

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER

23

Schedule

- Expected to complete Task 5 and Task 6 between late August to mid September

THE UNIVERSITY OF NORTH CAROLINA
HIGHWAY SAFETY RESEARCH CENTER

24

A Related NCDOT Project

- Follow-on to USDOT Safety Data Initiative
- Extract coordinates of roadside objects from videolog and overhead LiDAR
  - Videolog provides images every 26 feet
  - Artificial intelligence and machine learning
  - Challenge: Do not have specific information on the location and bearing of the cameras
    - Triangulation approach to determine this information
  - Would not directly impact NCHRP 17-104, but can be used in subsequent projects

THE UNIVERSITY OF NORTH CAROLINA HIGHWAY SAFETY RESEARCH CENTER