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TRANSPORTATION RESEARCH BOARD

Resurfacing, Restoration, and Rehabilitation Projects: Geometric Design

Tuesday, October 2, 2018
2:00-3:30 PM ET

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REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Discuss NCHRP Research Report 876: Guidelines for Integrating Safety and Cost-Effectiveness into Resurfacing, Restoration, and Rehabilitation (3R) Projects.

Learning Objectives

At the end of this webinar, you will be able to:

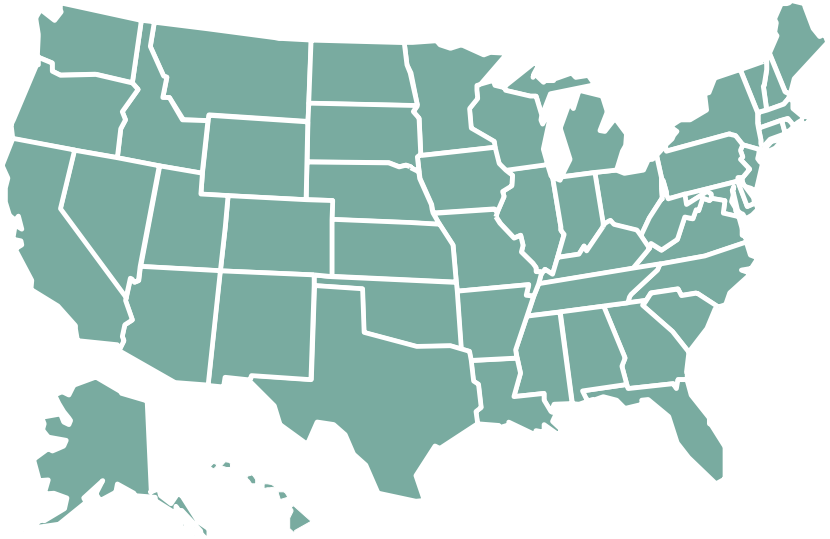
- Describe how to utilize a performance-based approach to design decision making for 3R projects
- Determine how to assess which 3R projects should be resurfaced with accompanying geometric improvements and what those geometric improvements include
- Describe how to apply spreadsheet-based benefit-cost analysis tools in making geometric design decisions for 3R projects

NCHRP Research Report 876: Guidelines for Integrating Safety and Cost-Effectiveness into Resurfacing, Restoration, and Rehabilitation (3R) Projects

Developed through NCHRP Project 15-50

NCHRP is a State-Driven Program

- Sponsored by individual state DOTs who
  - Suggest research of national interest
  - Serve on oversight panels that guide the research.



- Administered by TRB in cooperation with the Federal Highway Administration.

Practical, ready-to-use results

- Applied research aimed at state DOT practitioners
- Often become AASHTO standards, specifications, guides, syntheses
- Can be applied in planning, design, construction, operations, maintenance, safety, environment

Today's Speakers

- Priscilla Tobias, *Arora & Associates*
  - Background and Objectives of Project
- Doug Harwood & Dan Cook, *MRI Global*
  - Content of the Guidelines
  - Overview and Demonstration of Analysis Spreadsheets
  - Ongoing Validation Effort
- Moderated by: Ray Derr, *TRB*

GUIDELINES FOR INTEGRATING SAFETY AND COST EFFECTIVENESS INTO 3R PROJECTS (NCHRP PROJECT 15-50)

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NCHRP 15-50 PANEL

- Priscilla Tobias, Arora and Associates, P.C., Panel Chair
- Jonathan Marburger, JEO Consulting Group, Panel Member
- Simone Ardoin, LaDOT, Panel Member
- Moreshwar Kulkarni, MD SHA, Panel Member
- Dr. John Mason, Penn State, Panel Member
- Aurora (Rory) Meza, Bridgefarmer and Associates, Panel Member
- Larry Sutherland, WSP, Panel Member
- Dale Widner, Caltrans, Panel Member
- Jeff Shaw, FHWA, Panel Member
- Doug Harwood, MRI Global, Principal Investigator

RESEARCH OBJECTIVE AND SCOPE

- To develop guidelines for safe and cost-effective practices for resurfacing, restoration, and/or rehabilitation (3R) projects to update or replace TRB Special Report 214.
- The primary focus of the guidelines will be on two-lane rural roads and should address both the roadway and roadside.
- May 2015, the panel decided to include freeways based on feedback from agencies.

BACKGROUND

- Resources are extremely limited and constraints with right-of-way and environmental impacts, make new construction and reconstruction an infrequent option for state DOTs.
- 3R projects provide an opportunity to make cost-effective, practical improvements to the geometric design of existing highways and streets while addressing the pavement condition needs.
- 3R policies vary significantly across state DOTs from basic resurfacing and pulling up shoulders to a one step below reconstruction.
- AASHTO Highway Safety Manual (HSM) 1st Edition, published in 2010, provides a quantitative method to allow for consideration of various design elements and an opportunity for performance based designs.

KEY CONSIDERATIONS

- Crash Modification Factors (CMFs) which represent an estimate of the effectiveness of a particular geometric design (i.e. lane width, shoulder width/type) or traffic control feature or particular treatment have been developed and are readily available.
- Benefit-cost is regularly used in safety countermeasure and project selection.
- Performance measures and targets for pavement and safety are now driving decision-making and the expenditure of limited resources. Implementation of the guidelines and tools from NCHRP 15-50 can support those efforts.
- More emphasis is being placed on data-driven decisions and performance.
- The guidelines and the tools to support implementation would be user-friendly, adaptable to an agency's data, and defendable.

KEY CONSIDERATIONS

Research:

- Would evaluate the need to include FHWA's 13 controlling criteria as well as other design elements, as appropriate, with TRB special report 214 serving as a starting point.
- Integrate relevant information from AASHTO Green Book, HSM, Roadside Design Guide, MUTCD, Highway Capacity Manual, etc.

KEY CONSIDERATIONS

Guidelines:

- Based on current knowledge of geometric design elements and impacts on safety and operations, and the trade-offs between costs and benefits.
- Apply to projects regardless of their funding source.
- How other pertinent factors (e.g., pavement surface, pavement markings, and road user characteristics) should be factored into the decision process.
- How the methodology could be applied to address other roadway classifications
- Discussion of tort liability issues.

IMPLEMENTATION BENEFITS

- Excellent way to explicitly integrate safety into the project development process.
- Support Asset Management and Performance Based Design
- Opportunity to revisit existing 3R policies and leverage limited resources.

Guidelines for Integrating Safety and Cost-Effectiveness into Resurfacing, Restoration, and Rehabilitation Projects

NCHRP Project 15-50

October 2018

Research Objective

- Develop guidelines for safe and cost-effective practices for resurfacing, restoration, and/or rehabilitation (3R) projects to update or replace TRB Special Report 214

Scope

- Focus on rural two-lane highways, but also consider rural multilane highways, urban/suburban arterials, and rural and urban freeways
- Consider both roadway and roadside improvements
- Consider 3R projects regardless of funding source (Federal and state/local projects)

Key Issue for Candidate 3R Projects

3R projects are usually initiated because of the need for pavement resurfacing:

- Which 3R projects should be resurfaced WITHOUT accompanying geometric improvements?
- Which 3R projects should be resurfaced WITH accompanying geometric improvements? (and which geometric improvements should be implemented?)
- How should highway agencies make such decisions?
- How can highway agencies make better decisions given current safety knowledge?

Key Issue for Candidate 3R Projects (contd.)

- Consideration of design improvements assumes that the pavement will be resurfaced and looks at the crash history, traffic operational performance, and additional costs and benefits of potential design improvements.

Key Products of the Research

- 3R design guidelines document
- Two spreadsheet-based benefit-cost analysis tools

Alternative Approaches to Presenting Design Guidelines

- ~~Dimensional design criteria~~

3R Design Guidelines in TRB Special Report 214

Minimum Lane and Shoulder Widths

Recommended Minimum Lane and Shoulder Widths for Rural Two-Lane Highways

	10 percent or more trucks[c]			Less than 10 percent trucks	
Design year volume (ADT)[a]	**Running speed[b] (mph)**	**Lane width (ft)**	**Combined lane and shoulder width[d]**	**Lane width (ft)**	**Combined lane and shoulder width (ft)[d]**
1-750	Under 50	10	12	9	11
	50 and over	10	12	10	12
751-2,000	Under 50	11	13	10	12
	50 and over	12	15	11	14
Over 2,500	All	12	18	11	17

[a] Design volume for a given highway feature should match average traffic anticipated over the expected performance of that feature.

[b] Highway segments should be classified as “under 50” only if most vehicles have an average speed of less than 50 mph over the length of the segment.

[c] For this comparison, trucks are defined as heavy vehicles with six or more tires.

[d] One foot less for highways in mountainous terrain.

Alternative Approaches to Presenting Design Guidelines

- ~~Dimensional design criteria~~
- Minimum AADT levels to initiate consideration of specific improvement types (acceptable approach)

Potential Design Guidelines Based on Benefit-Cost Analysis

- Lane Widening
  - If existing lane width is 9 ft:
    - widen to 10 ft for AADT ≥ 3,000**
    - widen to 11 ft for AADT ≥ 2,000
    - widen to 12 ft for AADT ≥ 3,000
  - If existing lane width is 10 ft:
    - widen to 11 ft for AADT ≥ 3,000**
    - widen to 12 ft for AADT ≥ 3,000
  - If existing lane width is 11 ft:
    - widen to 12 ft for AADT ≥ 12,000

**Do not consider unless physical constraints or high costs make additional widening impractical

Alternative Approaches to Presenting Design Guidelines

- ~~Dimensional design criteria~~
- Minimum AADT levels to initiate consideration of specific improvement types (acceptable approach)
- Performance-based analyses (preferred approach)

Performance-Based Analyses for 3R Projects

- Geometric design improvements should be considered as part of a 3R project in the following situations:
  - an analysis of the crash history of the existing road identifies one or more crash patterns that are potentially correctable by a specific design improvement, or
  - an analysis of the traffic operational LOS indicates that the LOS is currently lower than the agency's target LOS for the project or will become lower than the target LOS within the service life of the planned pavement resurfacing (typically 7 to 12 years)
  - a design improvement would reduce sufficient crashes over its service life to be cost-effective (i.e., anticipated benefits will exceed the anticipated costs)

Performance-Based Analyses for 3R Projects

PRIORITIES

- In the absence of any of the three situations defined on the previous slide:
  - there is no indication that a geometric improvement is needed
  - improvement funds would be better spent on other 3R projects

POTENTIAL EXCEPTIONS

- Geometric design elements without effectiveness measures (CMFs), e.g., pavement cross slope
- Such exceptions are addressed in design guidelines

Organization of Guidelines

- Section 1 – Introduction
- Section 2 – What Are 3R Projects?
- Section 3 – Process for 3R Project Development
- Section 4 – Managing a 3R Program to Reduce Crash Frequency and Severity
- Section 5 – Application of Benefit-Cost Analysis for 3R Projects
- Section 6 – Project Design Guidelines
- Section 7 – Summary of 3R Design Guidelines
- Section 8 – References
- Appendix A – Users Guide for Spreadsheet Tool 1
- Appendix B – Users Guide for Spreadsheet Tool 2
- Appendix C – Updated Crash Cost Estimates

Benefit-Cost Analysis Tools

- The tools implement a systemic or risk-based approach:
  - decisions are driven by HSM crash prediction models
  - actual site-specific crash history data may also be used, if available
- The tools can be used to:
  - review individual candidate 3R projects to assess whether design improvement would be cost-effective in conjunction with a 3R project
  - review representative sites to establish AADT-based guidelines for consideration of design improvements

Benefit-Cost Analysis Tools

- The tools address projects on:
  - rural two-lane highways
  - rural multilane highways (divided and undivided)
  - rural and urban freeways
- Decisions are made by the highway agency; the tools merely supply information to inform those decisions

Benefit-Cost Analysis Tools

- Highway agencies can customize the tools with local data for:
  - unit construction costs or overall project cost
  - right-of-way cost per acre (user option to include/exclude right-of-way costs)
  - crash costs
  - service lives for specific improvement types
  - discount rate/minimum attractive rate of return
- Safety effectiveness of projects (CMFs) will be based on HSM or literature values
- User may supply actual site-specific crash history data

Benefit Cost Analysis Tools

- Spreadsheet Tool 1 – analysis of a single design alternative or a specific combination of alternatives for a given site
- Spreadsheet Tool 2 – comparison of several design alternatives or combinations of alternatives for a given site

Tools developed in Microsoft Excel® for easy application.

A familiar user, with access to site-specific data for a project, can evaluate a project design alternative in 5 to 10 minutes.

Spreadsheet Tool 1 – Benefit-Cost Analysis for a Single Design Alternative

- User selects a single design alternative (or combination of alternatives) of interest and applies the spreadsheet-based tool
- Can be used to look at more than one candidate alternative, but a separate analysis must be conducted for each alternative of interest
- Developed in Microsoft Excel® without using macros so that it will be very portable between computer systems and Excel versions

Spreadsheet Tool 1 – Benefit-Cost Analysis for a Single Design Alternative

- Input data elements that must be provided for every project:
  - road type
  - section length
  - AADT
  - terrain
  - pavement type (flexible/rigid)
  - horizontal alignment
  - lane width
  - shoulder type and width
  - roadside slope
  - presence of shoulder and centerline rumble strips
  - crash history (optional)

Spreadsheet Tool 1 – Benefit-Cost Analysis for a Single Design Alternative

- Input data elements with default values:
  - user can replace any default values with local data for all analyses or for a particular analysis
- Data elements with default values:
  - unit construction/implementation costs
  - average embankment height by terrain type
  - pavement and subgrade depths
  - crash costs
  - service life of improvement(s)
  - discount rate
  - SPFs and calibration factors
  - crash severity and crash type distributions

Spreadsheet Tool 1 – Benefit-Cost Analysis for a Single Design Alternative

- Output results:
  - present value of implementation cost (not including resurfacing cost)
  - expected crash reduction
  - annual and present value of safety benefits
  - benefit-cost ratio (B/C)
  - net benefits (B – C)

Benefit-Cost Analysis

- Spreadsheet Tool 2 functions as follows:
  - for a specific candidate project site, user enters existing roadway geometrics and traffic volume
  - user specifies a range of design improvements to consider
  - user specifies maximum available improvement budget
  - tool determines the specific improvement (or combination of improvements) that maximizes the benefits while not exceeding the budget constraint

Spreadsheet Tool 2 – Benefit-Cost Analysis for Comparison of Several Design Alternatives

- Developed in Microsoft Excel® with macros (some users may need assistance from their IT Department to use the spreadsheet)

Spreadsheet Tool 2 – Benefit-Cost Analysis for Comparison of Several Design Alternatives

- User selects a set of design elements to consider:
  - If the user selects lane width and the existing lane width is 9 ft, alternatives with 10-, 11-, and 12-ft lanes will automatically be considered
  - If the user selects shoulder width and the existing shoulder width is 2 ft, alternatives with 4-, 6-, and 8-ft lanes will automatically be considered
  - etc.
- Spreadsheet analyzes the selected alternatives and all combination of them
- Output displays all alternatives (or combinations of alternatives) with benefit-cost ratio that equals or exceed 1.0

Implementation of 3R Guidelines

- FHWA has provided any guidance on implementation of the 3R guidelines
- NCHRP project for trial implementation of the research results is underway
- We are seeking four agencies to apply the design guidelines and spreadsheet tools in planning their annual 3R program:
  - on-site training and technical support will be provided
  - comments will be sought to:
    - assess the value of the research products
    - help to improve the research products
- If interested, contact:
  - Ray Derr (rderr@nas.edu)
  - Doug Harwood (dharwood@mriglobal.org)

Questions ?

Today's Speakers

- Ray Derr, *Transportation Research Board*, rderr@nas.edu
- Priscilla Tobias, *Arora and Associates, PC*, Ptobias@arorapc.com
- Doug Harwood, *MRIGlobal*, dharwood@mriglobal.org
- Dan Cook, *MRIGlobal*, dcook@mriglobal.org

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