

MPC-493

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Project Title:

Incorporating Maintenance Costs and Considerations into Highway Design Decisions

University:

University of Utah

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Research Needs:

The strategic plan of the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Design includes goals related to incorporating costs and impacts associated with maintenance activities into design decisions. These goals include: 1) develop cost-effective solutions for delivering projects that minimize the operational and maintenance resources needed to sustain system effectiveness and functionality; and 2) support efforts to enhance the involvement of construction, maintenance, and operations personnel in the design phase of project delivery. Maintenance costs, while significant throughout the life-cycle of a project, may sometimes be underrepresented as inputs to design decisions. Important considerations may include the frequency and intensity of routine maintenance activities associated with highway and street features and materials, as well as the selection of physical highway and street dimensions to support all types of future maintenance activities and associated temporary traffic control. Maintenance activities for bridges, pavement, and drainage infrastructure are very significant budget items influenced by initial design decisions. In terms of roadway geometric features, maintenance costs and considerations may be particularly relevant to decisions related to cross section allocation, roundabouts, intersection channelization, curb returns, raised medians, indirect left-turn and U-turn treatments, vertical clearance, and pedestrian/bicyclist accommodation. Roadside features such as barriers, sidewalks, signal supports, lighting, and signs (and any related ADA characteristics associated with these features) also have significant maintenance needs. This research project will examine possible policies, procedures, and practices for including life-cycle maintenance costs and other maintenance considerations into highway design decisions.

Research Objectives:

The primary objectives of this research project are to 1) identify how transportation system- and project-level design decisions impact long-term maintenance costs and operations, and 2) recommend possible changes to standard drawings and practices that minimize maintenance costs and optimize maintenance operations while fully considering other operational and safety impacts and trade-offs.

Research Methods:

The methodology for this project will incorporate a synthesis of literature, policies, and practice; development of a comprehensive decision framework; and collection and analysis of life-cycle maintenance cost data. First, the research team will identify, review, and critically synthesize 1) relevant published literature on incorporating maintenance costs and other maintenance considerations into design decisions and 2) current and historical practices related to incorporating maintenance costs and other maintenance considerations into highway design criteria and highway design decisions. A survey of design and maintenance personnel from selected state departments of transportation (DOTs) will also be conducted to identify and characterize practitioner perspectives on 1) the frequency and intensity of routine maintenance activities associated with highway and street features and materials, 2) how the selection of physical highway and street dimensions affects different types of future maintenance activities and associated temporary traffic control, 3) how the selection of nonconventional design elements (e.g. innovative intersection designs such as CFI, DDI, or ThruTurn, or decorative fencing or other roadside hardware) affects the type and cost of future maintenance, and 4) ways to enhance and augment the involvement of maintenance personnel in the design phases of project delivery. Once this information is gathered and synthesized, the research team will develop a draft framework for incorporating maintenance costs and other maintenance considerations into highway design decisions during different project development stages. The framework will be comprehensive in a sense to identify all possible maintenance-related inputs to making design decisions; i.e., it will not be restricted by current data availability. A meeting between the research team and a technical advisory panel of practitioners (TAC) from Utah Department of Transportation (UDOT) will be held, where the panel will provide a critical review of the draft framework, give initial impressions on priorities for filling in framework elements, and recommend criteria for establishing priorities (e.g., total budget, potential for cost-cutting, etc.). The technical advisory panel will also provide suggestions and contacts for collecting data to further confirm priorities and conduct life cycle cost analysis once priorities are finalized.

The research team will then collect and analyze maintenance cost data and finalize research priorities associated with populating selected parts of the framework for incorporating maintenance costs and other maintenance considerations into highway design decisions. Life cycle costs of different design alternatives associated with the high-priority framework elements will be estimated. The life-cycle cost analysis will consider initial design and construction costs as well as long-term maintenance costs. Possible changes to standard drawings and practices that minimize maintenance costs and optimize maintenance operations will be suggested, and related framework elements will be populated, showing life-cycle cost differences between design alternatives. Known traffic operational and safety effects associated with the design alternatives identified and analyzed during the life-cycle cost analysis will also be documented as part of the decision-making framework, as they will be key considerations to any suggested changes to standard drawings and practices. A final report will be prepared and submitted that documents the entire research effort. The final report will, to the extent supported by the research findings, 1) identify how transportation system- and project-level design decisions impact long-term maintenance costs and operations, and 2) recommend possible changes to standard drawings and practice that minimize maintenance costs and optimize maintenance operations while fully considering other operational and safety impacts and trade-offs.

Expected Outcomes:

The expected outcomes of the project will include 1) a more in-depth understanding of how transportation system- and project-level design decisions impact long-term maintenance costs and operations, and 2) suggested changes to state DOT standard drawings and practices that minimize

maintenance costs and optimize maintenance operations while fully considering other operational and safety impacts and trade-offs.

Relevance to Strategic Goals:

The project scope and expected outcomes are directly related to *State of Good Repair*, as they will result in knowledge that will 1) support cost-effective solutions for delivering projects that minimize the operational and maintenance resources needed to sustain system effectiveness and functionality; and 2) support efforts to enhance the involvement of construction, maintenance, and operations personnel in the design phase of project delivery.

Educational Benefits:

The project team will include two graduate students and one undergraduate student from the University of Utah's Department of Civil and Environmental Engineering. Results of the project will be incorporated into the University of Utah's CvEEN 6525, Highway and Traffic Engineering, which currently covers key issues in roadway safety management, practices for design and safety considerations in resurfacing, restoration, and rehabilitation projects, performance-based roadway design, roadside design, work zone management and design, project development and delivery.

Work Plan:

The project objectives will be accomplished through executing the following nine major tasks:

- 1. Synthesize Literature.** Identify, review, and critically synthesize relevant published literature on incorporating maintenance costs and other maintenance considerations into design decisions. Relevant design and value engineering literature that is directly applicable to the research objectives, but outside of the highway and street design discipline, will be considered on a selective basis.
- 2. Synthesize Current and Historical Design Policies and Practice.** Identify, review, and synthesize current and historical practices related to incorporating maintenance costs and other maintenance considerations into highway design criteria and highway design decisions. Information sources will include AASHTO policies and publications, FHWA publications, and reviews of online state DOT documentation. The scope of the Task 2 review is expected to include any documented maintenance considerations when making bridge, pavement, drainage, roadway geometric, roadside, and operational design decisions.
- 3. Conduct Surveys.** Survey design and maintenance personnel from UDOT as well as design and maintenance personnel from other selected state DOTs to identify and characterize practitioner perspectives on a) the frequency and intensity of routine maintenance activities associated with highway and street features and materials, b) how the selection of physical highway and street dimensions affects different types of future maintenance activities and associated temporary traffic control, c) how the selection of nonconventional design elements (e.g. innovative intersection designs such as CFI, DDI, or ThruTurn, decorative fencing or other roadside hardware) affects the type and cost of future maintenance, and d) ways to enhance and augment the involvement of maintenance personnel in the design phases of project delivery.
- 4. Develop Draft Framework.** Develop a draft framework for incorporating maintenance costs and other maintenance considerations into highway design decisions during different project development stages. The framework will be comprehensive in a sense to identify all possible maintenance-related inputs to making design decisions; it will not be restricted by current data availability. Insights gained from the results of Tasks 1, 2, and 3 will inform draft framework development.

5. Meet with TAC, Identify Data Needs. A meeting between the research team and the technical advisory panel of practitioners from UDOT will be held. The TAC will provide suggestions and comments related to the outcomes of Task 1 through 4, including a critical review of the draft framework, initial impressions on priorities for filling in framework elements, and recommended criteria for establishing priorities (e.g., total budget, potential for cost-cutting, etc.). The technical advisory panel will also provide suggestions and contacts for collecting data that are available to further confirm priorities and conduct life cycle cost analysis once priorities are finalized. The data should include historical labor and equipment costs.

6. Collect Maintenance Cost Data, Analyze Data, and Finalize Priorities. Collect maintenance cost data with assistance from contacts identified during Task 5. Analyze data and establish priorities based on criteria identified in Task 5. Prepare a technical memorandum with prioritized elements and recommendations for which elements can be addressed with the remaining project time and budget.

7. Conduct Life Cycle Cost Analysis and Populate Framework. Estimate the life cycle costs for different design alternatives for the high-priority elements identified during Task 6. The analysis should consider initial design and construction costs as well as long-term maintenance costs. Identify possible changes to standard drawings and practice that minimize maintenance costs and optimize maintenance operations, and begin to populate related framework elements, showing life-cycle cost differences between design alternatives.

Quantitative evaluations will be preferred over qualitative assessments to produce data-driven results supported by actual cost-related transactions. To date, after an initial pre-selection of 4 high-priority elements, the in-depth analyses are focused on long-term maintenance costs of 1) barrier systems and 2) drainage elements. The two remaining high-priority elements include 1) cross-section elements and temporary traffic control, and 2) intersection and interchange form and design. Supplemental data will be collected for the cross-section element as time permits before the end of the project, whereas data from local crews and other states on effective snow removal and routine cleaning practices at innovative interchange/intersection designs will be also documented as part of the final report.

8. Identify and Analyze Operational and Safety Trade-Offs. Identify known traffic operational and safety effects associated with the design alternatives identified and analyzed during Task 7. The primary source of this information will be selected published literature as well as performance prediction tools such as the Highway Safety Manual, Highway Capacity Manual, Roadside Safety Analysis Program, and others.

9. Submit Final Report and Presentation. A Final Report will be prepared and submitted that documents the entire research effort. The final report should, to the extent supported by the research findings, 1) identify how transportation system- and project-level design decisions impact long-term maintenance costs and operations, and 2) recommend possible changes to practice that minimize maintenance costs and optimize maintenance operations while fully considering other operational and safety impacts and trade-offs. A PowerPoint presentation highlighting the methodology key findings of the research will also be prepared and delivered to the technical advisory panel. The PowerPoint file used during the panel presentation can also be used for future outreach efforts, including a presentation at the UDOT annual conference.

A schedule associated with this work plan is provided on the following page.

Project Cost:

Total Project Costs:	\$100,000
MPC Funds Requested:	\$50,000
Matching Funds:	\$50,000
Source of Matching Funds:	Utah Department of Transportation

TRB Keywords:

Benefit cost analysis, Design methods, Life cycle analysis, Maintenance, Performance based specifications, Value engineering

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