SUMMARY PAGE

Project Title: Developing Methodologies to Predict and Quantify the benefits of Research that Creates Durable and Longer Lasting Highway Infrastructure

Person Submitting Proposal: Dr. Mark Magalotti

Proposed Funding Period: 10/01/2020 – 03/31/2022

Project Duration: 18 months

Project Cost: $27,985
**Project Title:** Developing Methodologies to Predict and Quantify the benefits of Research that Creates Durable and Longer Lasting Highway Infrastructure

**Problem Statement:** The transfer of new technologies into practice is the ultimate goal of research. Research to create more durable and longer lasting highway infrastructure has the objective of creating benefits to extend the life of highways and bridges that must be measured decades into the future. However, it is difficult to quantify and predict benefits for many of these advancements. This is due to the extended time frame and nature of the changes to realize the benefits in terms of user costs, capital costs and maintenance costs. Also, many of these benefits maybe realized in the design and construction phases of highway infrastructure projects.

**Project Objectives:** Methodologies will be developed and applied to research results developed by IRISE for several highway infrastructure projects to predict and quantify benefits.

**Project Scope:** Tasks will be performed to evaluate current methodologies used to predict changes in highway infrastructure relative to longevity and resulting cost reductions. These existing methodologies and novel methods will be developed and applied based upon successful and meaningful results from the IRISE projects being funded. The methodologies will be applied by quantifying and extrapolating data available from the IRISE partners and other publicly available information on a national or state scale for highway infrastructure and user costs.

**Task Statements:**

The objectives of this project will be realized through the completion of the following tasks:

**Task A:** Literature Review - AASHTO (American Association of State Highway Transportation Officials) provides some guidance on how to quality the benefits of improvements to highway infrastructure through their publication “User and Non-User Benefit Analysis for Highways, 3rd Edition 2010”. This methodology has been accepted by state Department of Transportation (DOTs) to determine benefit/cost ratios for different applications and options for highway improvements. This established methodology will be reviewed along with other manuals and research results that provide guidance. Because of the nature of much of the research conducted by IRISE, which addresses very specific problems with a novel design or construction change these methodologies may not be applicable. A comprehensive literature review will be compiled with a recommendation to use and/or develop a new methodology to fit IRISE projects.

**Task B:** Development of Methodologies – Based upon the results of Task A, methodologies will be developed for each of the four research projects with the goal of quantifying the benefits of the research results. These methodologies will use varying approaches to demonstrate how different types
of research projects can result in benefits to the highway system. Two basic types of benefits can result from this type of research. These benefits include user benefits, which are delay and safety benefits to public users of the highway system and reduced cost benefits. Reduced cost benefits may include capital costs such as design and construction costs or annual costs such as maintenance. The product of this task will be a methodology that will demonstrate which of these three types of benefits are applicable and how these methods will be applied to the four research projects.

**Task C: Application of Methodologies to Research Results** – It is anticipated that research results will be developed from the following projects that will be performed concurrent with this work. The following describes the potential methodologies that and how they will be applied to each project’s results:

**Landslide Best Practices**

The goal of this research is to provide a practitioner’s guide to mitigation methods for commonly occurring landslides in southwestern Pennsylvania. This guide will assist in the identification of a landslide classification, mitigation methods and construction practices. Implementation of this guidance should result in more timely and effective solutions to landslides which create partial or complete closures to segments of a highway network.

The value of this research can be quantified in two ways. The first benefit will be reduced investigation, design and construction costs. Highway agencies, using this document, will be able to determine the cause and repair method in an expedited manner and then construct the mitigation using common methods.

To determine this benefit, 3 case studies of recently repaired landslides will be conducted. These case studies will be selected to represent varying roadway classifications and volumes of traffic on the impacted highway segment. A project will be selected that involves significant utility impacts. These case studies will then determine the timeline and resulting costs associated with the mitigation implemented and a comparison to the potential reductions in engineering and construction costs associated with the best practices document. Consideration will also be given to utility repair impacts on remediation options and schedule. Once costs and reductions are identified, the costs will be quantified as reduced capital costs associated with engineering and construction.

A second benefit to be quantified will be for users of the highway network. Typically, a landslide causes a partial or complete closure of a highway segment. For each of the 3 case studies the reduction in user costs will be quantified. This will be based upon available data on the Average Daily Traffic (ADT) volume that was diverted onto a detour route. The increased users cost during the landslide closure, using established quantification methods for public user costs will...
be determined. The reduced user costs, due to the expedited engineering and construction timeline for each of the 3 case studies will then be estimated and quantified.

The final result will be an estimate of 3 typical landslide mitigation cost reductions in capital and user costs that may occur with usage of the best practices document. These 3 typical cases will then be applied to all previous landslide mitigation projects over the past 3 years, where data is available, in Southwestern Pennsylvania, to extrapolate total benefits if the best practices document was utilized.

**Joint Design Optimization**

The goal of this research is to determine current sealant types, reservoir designs and construction practices and evaluate, the effectiveness of these practices and identify opportunities for improvement. New joint designs should result in longer lasting joint seals which require less frequent repairs or reconstruction.

The benefits of longer lasting joint seals can be classified into two impacts. The first benefit will be reduced maintenance activities to repair or reseal the joint. The second benefit would be longer lasting pavements to reduce repair/reconstruction costs of the concrete pavement slabs. While both types of benefits could be realized by the improved sealant types this analysis will focus on the reduced maintenance activities.

Maintenance activities to repair or reseal joints can be costly to both the traveling public and the highway agency performing the work. During Task B, data will be requested on the current maintenance activities on several typical concrete pavements. These activities will be classified as partial depth repairs, dowel bar retrofits or joint resealing. Data will be requested for 3 locations that utilized each of the 3 repair methods. This will result in 9 case studies that will be evaluated. Data will also be requested on the costs on a per lineal foot or mile basis to conducted each of the 3 repair types along with the documented service of life for each type of repair.

The research results will estimate the extended service life using each of the 3 new joint maintenance methods, when compared to current methods. These reduced capital costs will be annualized to determine the savings for each of the 9 cases evaluated. If data is available on a network scale of annual joint repairs, from the highway agencies, total annual savings for the network will also be estimated.
Preliminary Evaluation of Pavement Surface Distresses Related to Pavement Marking

Evaluation of the benefits of this research would be very similar to the joint design project where benefits will be considered for annual maintenance savings. The benefits may include capital expenditure savings for the distress that leads to expenses such as complete resurfacing by conducting a survey of highway agencies in Pennsylvania.

This research will determine the cause and potential mitigation strategies for pavements that exhibited signs of distress leading to eventual pavement failures along pavement marking surface areas. Consideration will also be given to longitudinal joint failures. A survey of IRISE partners including PennDOT and the Pennsylvania Turnpike commission will be conducted to determine the extent and type of distress they currently experience that have required repairs. Data will be collected on the number of miles of distressed pavements that is documented, due to pavement marking induced or longitudinal joint failures, and the mitigation strategies/costs currently being used and budgeted.

When mitigation strategies are identified by the research the cost, compared to current strategies, will be estimated based upon available highway construction unit cost data. Potential savings in capital costs of pavement repairs will be estimated and applied to data obtained from the survey on the estimated number of lane miles that currently exhibit the distress and potentially require programmed capital cost improvements.

Remote-Controlled Technology Assessment for Safer Pavement Construction and QA/QC

Crashes in work zones related to construction worker safety is a serious concern for highway agencies. Many of these crashes occur during activities such as testing of during different phases of pavement construction such as excavation, placement of materials and in situ properties of materials. Automated technologies or testing procedures could eliminate many of safety impacts on construction workers that perform this testing.

The number and type of crashes that occur in work zones is varied and unclassified many times. General crash descriptions may not provide enough details to determine the construction activities or annual costs in injuries and lives due to these manually performed testing activities.

The cost in the state of Pennsylvania will be estimated by reviewing available crash data related to construction zone crashes resulting in worker injuries or fatalities. Those crashes that
involved injury or resulted in a fatality to construction workers performing pavement testing will be identified and investigated.

This evaluation may require detailed crash reports, in lieu of generalized crash data available to the public, that would be made available by PennDOT. Assuming that this information can be provided, and supplemented by news reports and other public sources, the number and type of crashes will be quantified for the last 10 years. For those crashes that can be directly be linked to pavement testing processes that were ongoing during the incident a cost value will be determined. The value will be based upon nationally developed data on the average cost for injury and fatal crashes for construction workers.

The end result will be an identified average annual cost to construction workers for these types of crashes that could potentially be mitigated by automated pavement testing technology or modified testing procedures to remove workers from high crash locations. Those technologies that are identified by the research results that are promising and can be implemented in the short term maybe be applied to the crash data developed to estimate potential savings in injuries, fatalities and costs by elimination of worker presence in the work zone.

Development of Simplified Mechanistic-Empirical Design Tool for Pennsylvania Rigid Pavements

The Mechanistic-Empirical design software (ME) is a newly accepted design method for rigid pavements being incorporated into the design process for many Departments of Transportation (DOTs) and the Pennsylvania Department of Transportation (PennDOT). This new method, while very rigorous and accurate, requires numerous input parameters that may or may not impact the final design, depending upon the localized conditions of the highway. The design process at PennDOT also includes using the AASHTO 93 traditional method of pavement design.

This research developed a simplified design method for the design of rigid pavements, PittRigid ME based upon the ME method, which provides a simplified and accelerated equivalent design tool to determine the optimum pavement section for concrete pavements. The primary benefit of this design tool is to reduce the amount of data needed to perform the analysis by determining common input parameters that meet Pennsylvania conditions and do not significantly impact the resulting design and pavement longevity. Another benefit of the ME and PittRigid methods is reduced pavement depths.

Because the primary benefit of using the ME and PittRigid methods is reduced pavement compositions a comparison of the AASHTO 93 to this new method is warranted to determine benefits. This benefit analysis will examine 3 case studies of how the ME and PittRigid method can reduce pavement sections.

In order to determine the benefit of the design tool, 3 case studies of recent pavement designs will be selected from projects provided by PennDOT that used the AASHTO 93 method to design and specify the pavement section. These case studies would have also performed the ME design for comparison purposes. The PittRigid method will then be used to conduct a 3rd analysis that is anticipated to replicate the ME design results.
Task D: Final Report – A final report with the research results will be developed. Interim reports will also be prepared at the completion of each task.

Deliverables: Final Report detailing the development of methodologies to predict and quantify the benefits of research that creates durable and longer lasting highway infrastructure

Key Personnel:

*Principal Investigator:* Dr. Mark Magalotti P.E.

*Other Key Staff:*

Other Personnel:

*Undergrad Student:* To be determined
Proposed Person-Hours by Task:

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Budget: The total project cost is $27,985

Acknowledged By:

Name
Principal Investigator