TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Date: _Sept. 30 , 2021_
Lead Agency (FHWA or State DOT): ______Indiana DOT____________________________

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* ***TPF 5-281***		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) X Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)
Project Title: **Center for the Aging Infrastructure: Steel Bridge Research, Inspection, Training and Education Engineering Center – S-BRITE**		
Name of Project Manager(s): **Tommy E. Nantung**	**Phone Number:** **(765) 463-1521 ext. 248**	**E-Mail** tnantung@indot.in.gov
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:** 9/1/2013
Original Project End Date: **10/1/2015**	**Current Project End Date:** **INDEFINITE**	**Number of Extensions:** None

Project schedule status:

X On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date**
$1,585,000*	**$943,981**	**85%**

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date**
$45,990	**2.9%**	**85%**

*Additional partners have joined S-BRITE and others have renewed participation, hence total project budget has increased.
**Since end date has been extended, project percentages have been updated (estimates)

Project Description:
The objective is to develop the Steel Bridge Research, Inspection, Training, and Education Engineering Center (S-BRITE Engineering Center) focused on existing steel highway bridges. This National Center will be the first of its kind and will become the leading education, training, research, and engineering center related to all aspects affecting the existing aging steel bridge and structure inventory. Although the Center will be focused on highway bridges, it will also support stakeholders of steel railroad bridges as well as steel ancillary structures, such as lighting towers and sign supports. The Center will contribute to improved asset management decisions for DOTs, FHWA, and other partners relative to existing steel bridge inventory.
This impact will be realized through:

- Research
- Training
- Technical Support

Progress this quarter (includes meetings, work plan status, contract status, significant progress, etc.):

- Continued to provided DEN support to all partners.
- Based on the survey conducted following the "S-BRITE Update Webinar" held in the first quarter, a project focused on developing performance testing and certification criteria for bridge inspectors (centered on steel bridges) was selected. The draft scope of work was developed and is attached to this document.
- Held training at S-BRITE US Army Corps.
- Field visited Big Bend Dam for the US Army corps to assist in weld inspection.
- Provided half-day fatigue design/inspection seminar on-site for South Dakota DOT.
- Scheduled on-site training course "inspecting steel bridges for fatigue" the week of October 18. 2 separate courses will be offered that week.

Anticipated work next quarter:

- Prepare budget for proposed study on developing performance testing and certification criteria for steel bridge inspectors once comments are received on draft scope.
- Offer S-BRITE course on retrofitting steel bridges for fatigue on campus as soon as travel restrictions are lifted for partner states.
- Continue with DEN support for all partners;
- Continue to work with DOTs to obtain items for bridge component gallery;

Significant Results:

1. Training of employees from several State DOT.
2. DEN support has provided solutions to various DOT problems.
3. S-BRITE research results are being disseminated

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the Agreement, along with recommended solutions to those problems).

Potential Implementation:
S-BRITE continues to have tremendous impact and benefit for owners, designers, and fabricators of steel bridges

Development of Performance Testing and Certification for Steel Bridge Inspectors

Submitted to:

S-BRITE Partner Agencies

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Introduction

An inspector's ability to reliably identify surface and subsurface defects in steel bridge components is critical to protecting the traveling public and the longevity of the infrastructure. Ensuring that inspectors are adequately qualified must be a high priority, particularly in field conditions where access limitations and unfavorable environmental conditions may exist. The Federal Highway Administration, individual state departments of transportation, and relevant standards provide guidelines for inspector qualifications based on certifications that focus on required training and experience of the inspector. These guidelines do not provide a mechanism to assess if the training and experience has resulted in the inspector being capable of reliably detecting and characterizing critical defects in the field. As a result, bridge owners cannot be assured that a given inspection task will be successful in detecting key defects. Additionally, very little (if any) data how well a given inspector actually performs in the field or the variability which can be expected between different inspectors are available to support engineering decisions.

As stated, while various training programs exist for educating individuals tasked with inspection bridges in the US, there is not a systematic performance testing methodology that can be used to assess the capability of a given inspector. In other words, while training exists, meaningful metrics to assess the effectiveness of the training on the work force do not. As a result, the probability of detection (POD), the accuracy of inspection data, and damage characterization data provided by a given inspector are unknown. Under these conditions, there is no way for the bridge owner to be assured that a given inspection is achieving the risk mitigation expected, and bridge safety could be compromised.

Recent experience suggests that there is considerable variability in the data commonly collected for both routine and hands-on inspections. For example, a recent study at the S-BRITE Center showed that the POD associated with visual inspection of fatigue cracks is highly variable with the 50-50 cracks size being around 1 inch. To achieve a 90% detection rate, the crack must be greater than five inches in length. This study is based on 30 "certified" bridge inspectors performing a hands-on inspection of specimens in which known fatigue cracks existed. It is also noted that this result is only based on hit-miss data. In other words, while an inspector may identify a crack, there was also considerable scatter in how the inspector characterized the crack. While an inspector may correctly find a crack, there is variability in the length of the crack that is reported as compared to the actual length. Similar findings exists for inspections performed with other methods such as ultrasonic testing (UT), magnetic particle testing (MT), or other nondestructive testing technologies.

Studies of routine inspection tasks like collecting element-level data have also shown large variation in results between qualified bridge inspectors[1]. For example, field tests studying the quality of element-level data showed significant variation in reported quantities of damage on bridge elements. Variation between different inspectors observing the same bridge elements was typically 50% or more of the quantity being reported. For example, a task where 14 inspectors assigned condition states (CS) for corrosion of steel bridge elements showed variation in the total quantity of damage in either condition state (CS) 2 or 3 was 55% for one steel bridge and 76% for a second steel bridge. Assessment of critical safety items also showed significant variation. For example, those same inspectors assessed corrosion damage in gusset plates on a truss bridge in which 14 of 72 gusset plates were in CS4, but 1/3 of the inspectors did not report any gusset plates in CS4. Among the 2/3 of inspectors that did report gusset plates in CS4, the number of gusset plates rated in that condition was between 2 and 22 gusset plates. Such a large variation in detection and rating of key safety items is of concern for bridge owners relying on the inspections to report critical conditions and identify risks.

Since owners make very important decisions based on the data collected during an inspection, it would seem that knowledge as to the overall quality of the data provided by a given inspection should meet some minimum standard. One thing to keep in mind is that the performance testing may not need to be completed by *ALL* bridge inspectors. The Research Team (RT) presently believes it may be best to identify a sub-set of inspectors who will be put this more rigorous testing (as well as training) in order to identify small teams of highly qualified individuals to inspect the most critical structures. For example, it may not be necessary to require performance testing for inspectors who only inspect the common redundant multi-girder short-span bridges. Rather, individuals successfully completing the performance testing would be assigned to inspect more critical infrastructure with the highest risk. How to best implement the results of the project are of course up to each individual owner.

In light of the above, the goals and objectives of the research are as follows:

Project Goal:

Improve the quality of inspection data for the purpose of improving the safety of steel bridges.

Project Objectives:

1. Develop procedures for performance testing of inspectors.
2. Assess the impact of performance testing on the quality of inspections.

This document describes the scope of work associated with the project entitled "Development of Performance Testing and Certification for Steel Bridge Inspectors". This project was selected from a small number of topics by the S-BRITE partners.

Project Tasks

The project is divided into a number of tasks, some of which overlap. The efforts associated with each task are summarized below.

Task 1 – Literature Review

During Task 1, a literature review will be conducted to identify reports, specifications, or procedures which document performance testing strategies and methods. Some industries already employ performance testing for inspectors, such as in the aircraft and oil and gas industries. It is likely the project can benefit from reviewing the approaches taken in other industries during this project. An annotated bibliography will be developed and included as an appendix of the Final Project Report.

Task 2 – Identify the Damage Modes and Inspection Methodologies to Include

While there are many forms of damage inspectors are trained to look for during an inspection, the scope of the research must have boundaries. The proposed tasks and activities for this research will be focused on steel bridge elements and their associated damage modes. Thus, at present, the following damage modes commonly found in steel bridges are anticipated to be the primary focus, in no particular order:

- Corrosion/section loss
- Cracking
- Impact damage
- Coating failure
- Missing fasteners or similar

It is believed that the above list covers the vast majority of types of damage that inspectors will be exposed to during the inspection of steel bridge members. However, in the early stages of the project, other forms of damage will be considered for inclusion.

In addition to the type of damage that will be included, it is important to consider the method of detecting and quantifying that damage. For example, should only visual testing (VT) be considered or should other inspection methods be included. At present, the Research Team (RT) proposes the methods shown in Table 1. The list was developed to include those methods are that are most commonly used in both the shop and field. Other more experimental or non-field oriented methods will not be included but they are listed for completeness.

Method	Include YES/NO	Comment
Visual Inspection (VI)	YES	real in-person data but may also consider visual examination of collected images (i.e., from UAS). Task to detect damage, identify the appropriate CS and quantity of damage, and assess the quality of results.
PAUT/UT	YES	surface and internal, cracks, thickness, internal defects, etc.
Dye Penetrant (DP)	YES	Surface-breaking cracks
Magnetic Particle (MP)	YES	Surface-breaking cracks
Ultrasonic thickness measurements	YES	Assessment of section loss on steel members
Total Focusing Method – Full Matrix Capture UT (TFM-FMC)	NO	Very early stages of application and no codified acceptance/rejection criteria exist
Radiographic Testing (RT)	NO	Existing technician criteria appear adequate and it is not an approach that is commonly used in the field
Eddy Current	NO	No commonly used in the shop or field

Task 4 - Develop Testing Procedures and Identify Test Specimens

Task 4 is one of the primary tasks associated with the project. It includes both the development of the actual procedures to be used for a given test (e.g., how to evaluate an inspector's ability to measure and quantify section loss) but also identifying the number and type of specimens to use for evaluating performance. The RT has considerable experience in developing standard procedures for such tests and has developed procedures for previous studies evaluating performance for UT, MT, and visual inspections. Thus, this task, though large, is well understood.

At present, it is envisioned that a majority of the specimens already located at the S-BRITE site will provide a strong starting point. There are a wide range of specimen types including various levels of damage, from those with no measurable damage too those with severe damage. However, the RT will very likely need to fabricate, or in some way obtain other specimens with known internal flaws for UT/PAUT testing. Fortunately, the RT has experience fabricating specimens with internal defects (e.g., slag, porosity, etc.). Such specimens have been fabricated for performance testing of UT and PAUT inspectors. The previous work conducted by the RT has resulted in procedures that result in specimens in which the defect type, size, and location are highly controlled. Specifically, additional specimens with CJP welds will be fabricated.

Other damage modes, such as corrosion and impact damage are included on a variety of the specimens at S-BRITE and it is not envisioning that additional specimens will be needed. This includes specimens in which the coating is in various stages of deterioration.

Lastly, from previous POD studies, there are many specimens with real fatigue cracks of know location and length at S-BRITE. It is anticipated that the cracks will need to be "freshened" so to speak since they have been located out doors for a number of years. This will be accomplished by simply cycling the specimens in the fixture used to initially create them in order to ensure the cracks appear active and are not unrealistically difficult to find.

The procedures for conducting the performance testing will also be developed during this task. The procedures will include the details of how the evaluation is to be conducted, timing of inspection tasks, tools and equipment to be used, and other activities to ensure consistent implementation of the performance tests. Methods of analyzing the results in terms of variability in detection and characterization of damage will also be developed to ensure the test procedure yields results that can be quantitatively assessed and compared. These procedures for analyzing data and assessing outcomes will be further developed in Task 6 as described below.

Task 5 – Conduct Beta Performance Testing

During this task, a handful of inspectors will be brought to S-BRITE in order to “beta” test the inspection procedures, evaluate the realism of the specimens, and perform an overall evaluation of the approach. Such trial runs have been found to be critical in ensuring the testing is both reasonable and meaningful. The RT will call upon S-BRITE partner states to provide some inspectors for this task so that representative input is received.

Based on the results from the initial Beta testing, the procedures, specimens etc. will be revised as needed to develop the final approach.

Task 6 – Develop Methodology for Evaluating Performance

This task will focus on the development of acceptable scoring approach as well as an acceptable “passing” score. As is well known, there are no established criteria for evaluating the performance of a bridge inspector. In other words, how does an inspector get “scored” and what constitutes acceptable performance. Further, questions arise as to what factors should be considered in the scoring calculations? For example, while it is important to identify and quantify damage, it is also important that the individual identifies the most appropriate condition rating and/or element level condition state. During the literature review, the RT will examine what other industries in the context of performance testing and in particular scoring or establishing a passing score.

As stated, one thing to keep in mind is that the performance testing may not need to be completed by ALL bridge inspectors. Thus, if only an “elite” team of inspectors (e.g., Steel Team 6) are to be certified through the performance testing, it would seem that a rather high bar should be set in order to achieve a passing score.

Task 7 – Document the Procedure in a Final Project Report

During Task 7 a Final Report for the Project will be submitted. It will also include the recommended test procedures and scoring methodologies for the evaluating the capability of inspectors.

Task 8 – Conduct Performance Testing and Certifications for Inspectors from Partner States

Task 8 envisions an ongoing activity to provide performance testing and certifications to the participating states based on the results of the research. This will allow a broader group of states to utilize the performance testing procedures and associated samples to qualify inspectors according to their needs.

REFERENCES

1. Washer, G., et al., *Guidelines to Improve the Quality of Element-Level Bridge Inspection Data*. 2018, NCHRP: Washington, D.C.