Update on TPF-5(281)

"Steel Bridge Research, Inspection, Training, and Engineering Center"

(S-BRITE)

Prepared by

Robert J. Connor

Jason B. Lloyd

Purdue University

West Lafayette, IN 47907

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PURDUE
UNIVERSITY

JTRP

2014 has been a very active year for TPF-5(281) and the S-BRITE Center and as will be discussed, much has been accomplished. Short courses have been offered at Purdue, but also on-site at several of our partner's facilities. We have acquired several more specimens for the bridge component gallery and construction of the facility is about 95% completed. Research projects are proceeding on schedule and future projects and training are currently in the works. Lastly, S-BRITE has been recognized as an official Purdue University "Center".

This report provides details regarding progress on TPF-5(281) and the S-BRITE Center follow. Further, a teleconference is proposed for February 2015. A doodle pole will be sent soon to determine dates for the teleconference.

SHORT COURSES

Short courses have been offered at Purdue, Illinois, Iowa, Kansas, and South Dakota. Table 1 summarizes the courses taught to date. Two courses are currently planned to be held in Minnesota in January of 2015.

Location	Course	Dates	# Students
2013 Courses			
Purdue University	High Strength Structural Bolting	April	30
Purdue University	High Strength Structural Bolting	May	25
Purdue University	Inspecting Steel Bridges for Fatigue	June	25
Purdue University	Designing Steel Bridges for Fatigue	June	25
Purdue University	Inspecting Steel Bridges for Fatigue	August	30
2014 Courses			
Purdue University	High Strength Structural Bolting	February	31
South Dakota DOT	Designing Steel Bridges for Fatigue	March	21
Purdue University	Inspecting Steel Bridges for Fatigue	April	14
Kansas DOT	Inspecting Steel Bridge for Fatigue	April	23
Illinois DOT	Designing Steel Bridges for Fatigue	May	19
Iowa DOT	High Strength Structural Bolting	August	26
Purdue University	Inspecting Steel Bridges for Fatigue	September	12

Table 1 - Summary of courses taught to date

As can be seen in the table above, courses have been offered in each participating state with the exception of Minnesota. Over 280 professionals have successfully completed these courses. Feedback received to date has been excellent. In particular, students have indicated that they find having access to the full-scale specimens at the S-BRITE greatly beneficial to the short-courses as they are able to observe firsthand the type of details, cracks, and retrofits that are discussed in the PowerPoint presentations. Several photographs taken during recent courses follow.

Further, course attendees commented they greatly appreciated the specimens that are available in the classroom as they are effective for demonstrating fractures and fatigue cracking mechanics and retrofits. Lastly, the hands-on NDT demonstrations (Magnetic Particle Testing, Dye Penetrant, and UT) Minnesota was not able to schedule a course for 2014, but two bolting course are scheduled to be held in Minnesota in January of 2015.


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S-BRITE SPECIMEN ACQUISITION

Over the past 12 months, the team has spent considerable effort in coordinating the acquisition of specimens for the bridge component gallery at S-BRITE. We greatly appreciate the support of the pooled fund study partners who have worked with us in coordinating within their agencies to allow S-BRITE to obtain specimens and assisting with shipping. Additional specimens are always being sought after. The Research Team encourages the partners to contact us regarding any bridge or bridge component that is coming out of service that may be of interest to S-BRITE.

At present, the following specimens have been acquired:

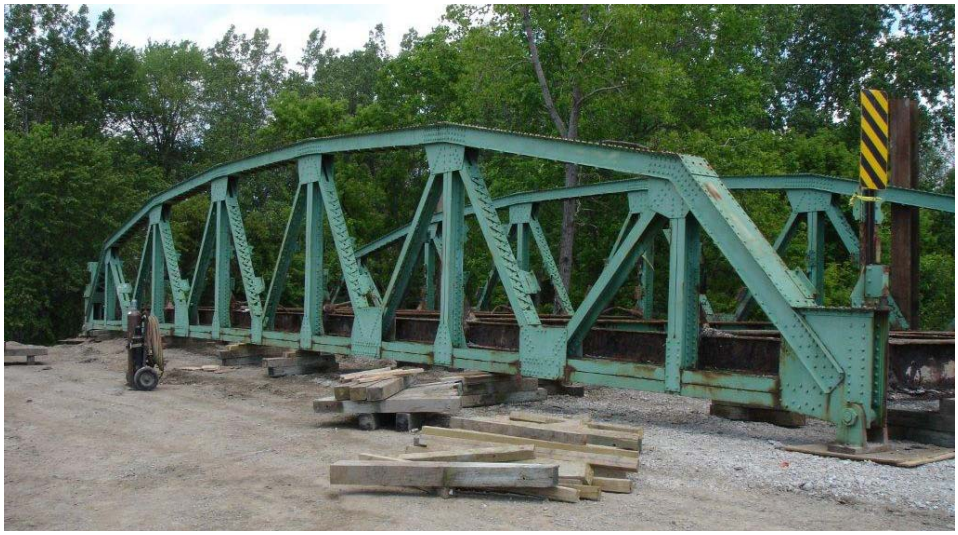
- Selected components from the I-35W Bridge, including a U10 and L11 joint (key joints in the failure of the bridge), large bearings, various joints, and members were provided my Minnesota DOT. The gusset plate joints are currently housed at the Bowen Laboratory to protect them from the weather. Long-term plans include the construction of a pole barn that can be used to keep these important components out of the weather. Other components, such as joints and miscellaneous members will be permitted to weather naturally outdoors.

- Two sections of 12 foot deep plate girder from the Lafayette Bridge in Minnesota have been erected. One of these girders contained a full depth fracture that occurred in the 1970s and is a "famous" fracture so to speak to fatigue and fracture researchers. In addition, a corresponding girder was also obtained that did not fracture, but was retrofit to prevent future fractures. These sections are extremely valuable for the short courses and for steel design courses.

- An entire 65 foot span welded two-girder railroad bridge fabricated in the late 1950s was erected at S-BRITE in the fall of 2014. The bridge spent most of its life on the Pennsylvania railroad in New Jersey, but was retired and sent to the Transportation Technology Center Inc. in Pueblo to be placed on their test track. While in Pueblo, the bridge was subjected millions of tons of train loading. The bridge possesses details susceptible to Constraint Induced Fracture (CIF). While in Pueblo, two such fracture occurred; one was repaired while the other remains in the bridge. When TTCI was finished with the bridge, it was donated to S-BRITE and shipped to Lafayette via BNSF and CSX at no charge.

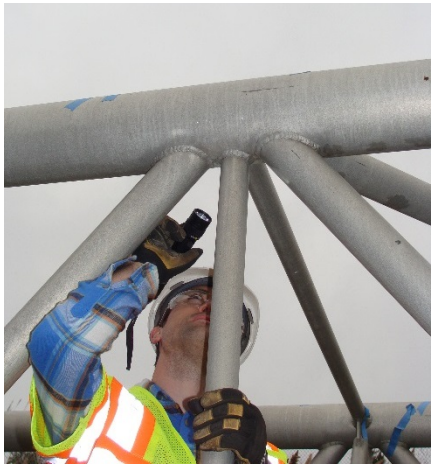
- A section of a ship-lap joint and tooth dam has been acquired. A ship-lap joint is one where one smaller girder is supported on a larger, deeper girder. The leaking joint caused considerable corrosion to the girders below as can be seen in the photographs below. The specimen was provided by the Minnesota DOT and is an excellent example of corrosion damage at a leaking joint that is useful in short courses and bridge design courses.

- A 91 foot span truss has been sold to S-BRITE for $1 by Calhoun County in Marshall, MI. The bridge is known as the Indian Trail Road Bridge and is a very nice example of a larger pony truss span. The bridge was dismantled into four large truss pieces and the floor system removed. All components were stored and will be shipped to S-BRITE in early 2015. The plan is to erect the bridge in the spring/summer 2015.



- Selected portions (about 200 feet in total) of large plate girders from the Virginia Avenue over I-65 were donated to S-BRITE by INDOT. The girders are six feet deep. These girders have been repeatedly struck by over-height vehicles. There is significant damage to the girders, including brittle fractures with bolted splices. Various nicks, gouges, and broken stiffener connections are also apparent. The girders will be erected at S-BRITE in the Spring/summer of 2015. It is anticipated a concrete deck may be added as part of other research on long-term concrete deck performance and inspection.

- Miscellaneous components from various bridges continue to be obtained. The specimens included those with corrosion, cracks, and other damage. Some specimens however have no damage and are useful for illustration of basic steel detailing. A few photographs of these specimens are below.

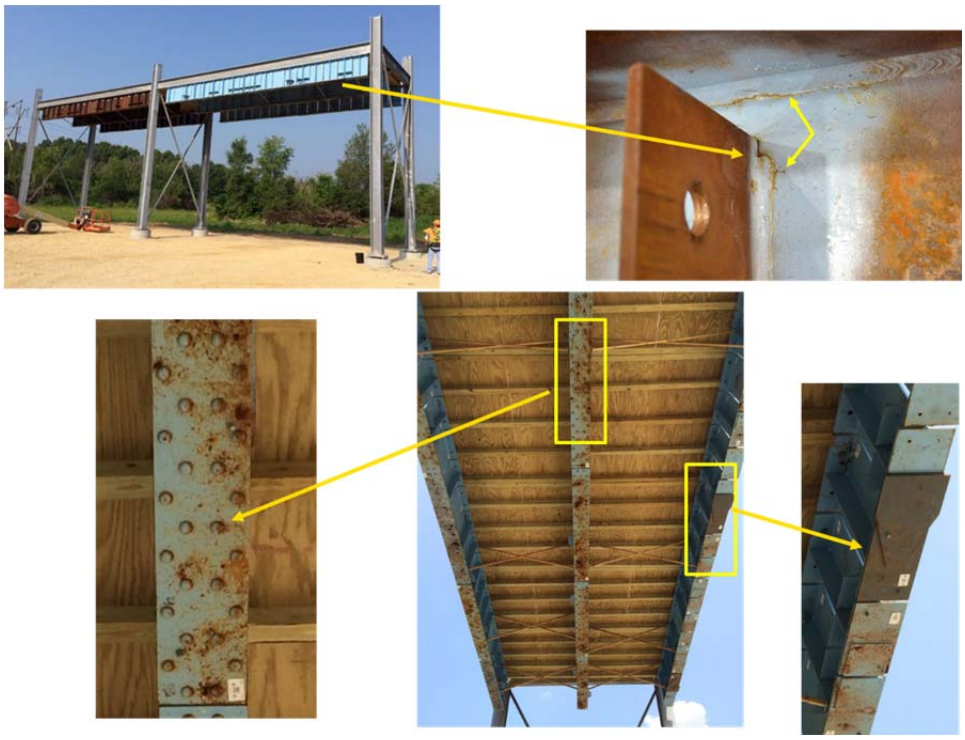


S-BRITE RESEARCH PROJECTS CURRENTLY UNDERWAY

Probability of Detection (POD) Study

The first "formal" S-BRITE research project is a Probability of Detection (POD) Study focused on crack detection in steel bridges. While the initial phase of the study is focused on cracking, other damage modes such as corrosion, distortion, missing fasteners etc. will also be considered. In short, a POD study quantifies the probability of a certain type of damage being detected by an inspector. In the case of cracking, the probability of detecting using normal visual inspection techniques will be established. This study is the first of its kind related to highway bridges that is being conducted in a controlled manner.

The photograph below is of the "POD" bridge which includes about 108 individual specimens. Each girder line in the bridge (there are 3) is 80 feet (2 spans @ 40 feet). Since the details are placed closely together, the equivalent total length is about 250 feet per span, or 500 feet total. Details include welded cover plate terminations, riveted members, and details susceptible to out-of-plane distortion cracks. Eleven INDOT inspectors have gone through the test and the inspection results are being reviewed. The research team would like to invite partner states to participate in this study. Details of how partner states can participate will be discussed during the proposed February teleconference.

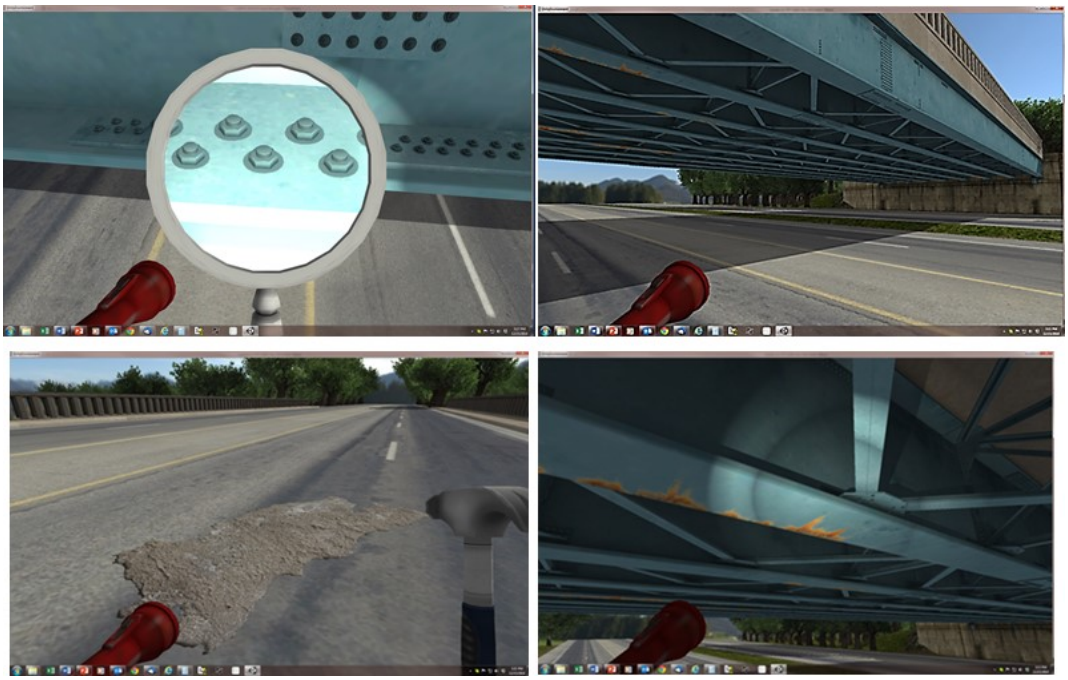


Virtual Bridge Inspection Pilot Study

During the various S-BRITE short courses related to bridge inspection and through discussion with various DOTs, it has become apparent that there is a need for improved training tools for bridge inspectors. Specifically, as related to defect detection and where to look for defects. As a result, a pilot study was initiated to evaluate the potential for developing a "virtual" bridge inspection training module that could be made available to partner states. During this pilot study, a basic bridge inspection simulation was developed to create life-like, virtual models of bridges and various bridge components. The objective is to develop a web-based or PC-based tool that will allow owners, managers, inspectors, designers, and students to conduct complete virtual bridge inspections using state-of-the-art simulations with the goal of improving the quality and quantity of the training, as well as the safety and reliability of bridge inspection.

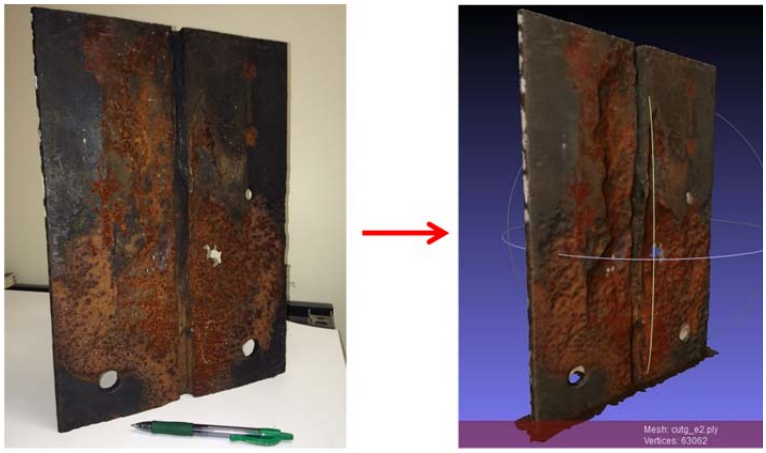
An NCHRP IDEAS proposal was submitted, but not funded. However, feedback from the IDEAS review committee indicates that several states were interested in pursuing this concept as a pooled fund study. Hence, the S-BRITE Research Team will be developing a full proposal that will allow states to contribute to the existing TPF-5(281) study. As originally developed, TPF-5(281) is intended to have multiple tasks that continue and evolve over time. Hence, there is no need to initiate a new or separate study, greatly decreasing the time and effort to begin the work, should there be sufficient interest. A few screen capture images from the virtual model are shown below. In the "virtual" bridge, there are several tools, as shown above such as a flashlight, magnifying glass, hammer (with sound), a tape measure, and marking tool to "mark" delamination, corrosion, or cracks. Work continues on the model.

More regarding this study will be presented during the update meeting to be held this spring.



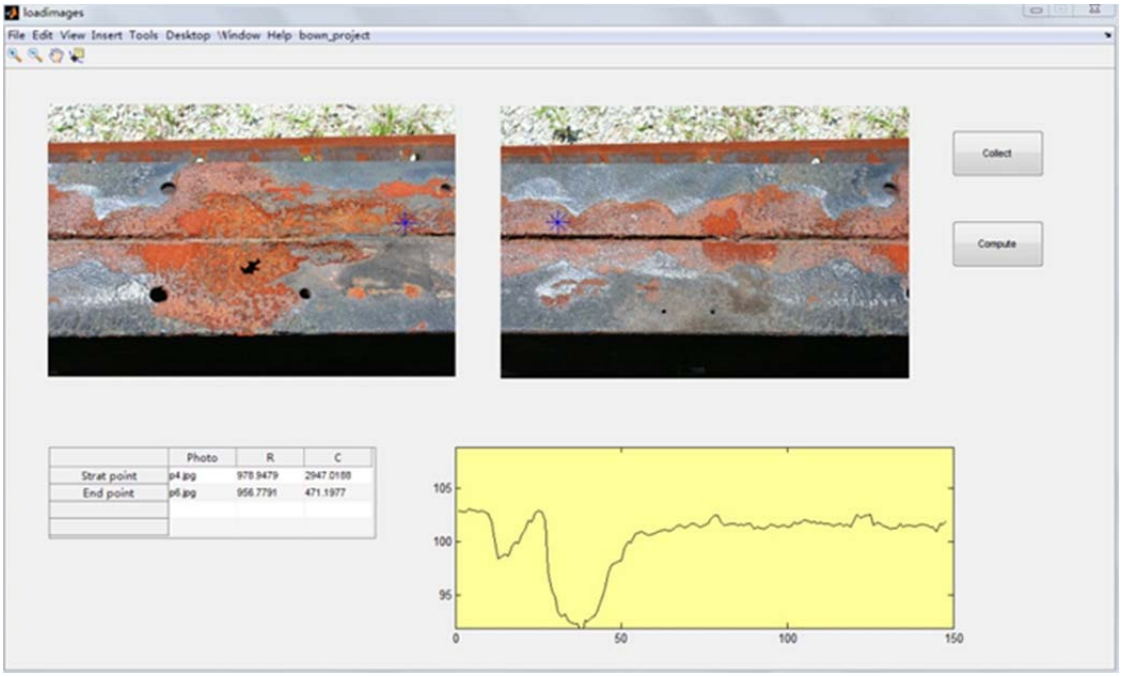
Corrosion and Damage Measurement using 3D Imaging

During the portions of the POD study that are focused on measuring corrosion, it became clear to the Research Team that challenges exist in measured section loss in a timely and accurate fashion. Further, establishing the "real" section loss can be a challenge over a widespread area. After discussions with researchers in Purdue's Geomatics group, it was determined that by using off-the-shelf cameras the images could be processed using photogrammetry techniques to yield the surface point clouds. The concept uses recent advances in Photogrammetry and Computer Vision to generate dense and accurate 3D point clouds of the surfaces of bridge structural members at critical locations. An example of this technique is shown below. The image on the left is simply a 2D photograph of a member with significant corrosion. On the right is the 3D point cloud generated from a series of pictures of the specimen on the left.



2D Photograph 3D Point Cloud

This digital surface representation can be used to detect areas where material has corroded, and, by inference, to determine the depth of the remaining material or even remaining cross sectional area. Today, inspectors have to make time consuming and tedious discrete measurements of corrosion, damage due to impact, or other defects. Further, these measurement have been shown to be highly variable from inspector to inspector and no permanent record exists. The objective is to develop a user friendly and automated tool to measure geometric imperfections due to impact damage, corrosion, or any other cause and quantify this damage. To date, a simple tool has been developed which can be used to measure actual section loss of complex geometry as shown in the figure below. The software has been shown to be able to be used to accurately measure section loss due to corrosion, using off-shelf-cameras.



A proposal will be developed focused on further development of this tool as an added S-BRITE task through TPF-5(281) using the mechanism discussed above. The S-BRITE Research Team will share the proposal with state DOTS. Initial conversations with a few state DOTS have indicated that there is interest in supporting the effort and it is anticipated the study could be launched in the spring of 2015. More regarding this study will be presented during the proposed February teleconference.

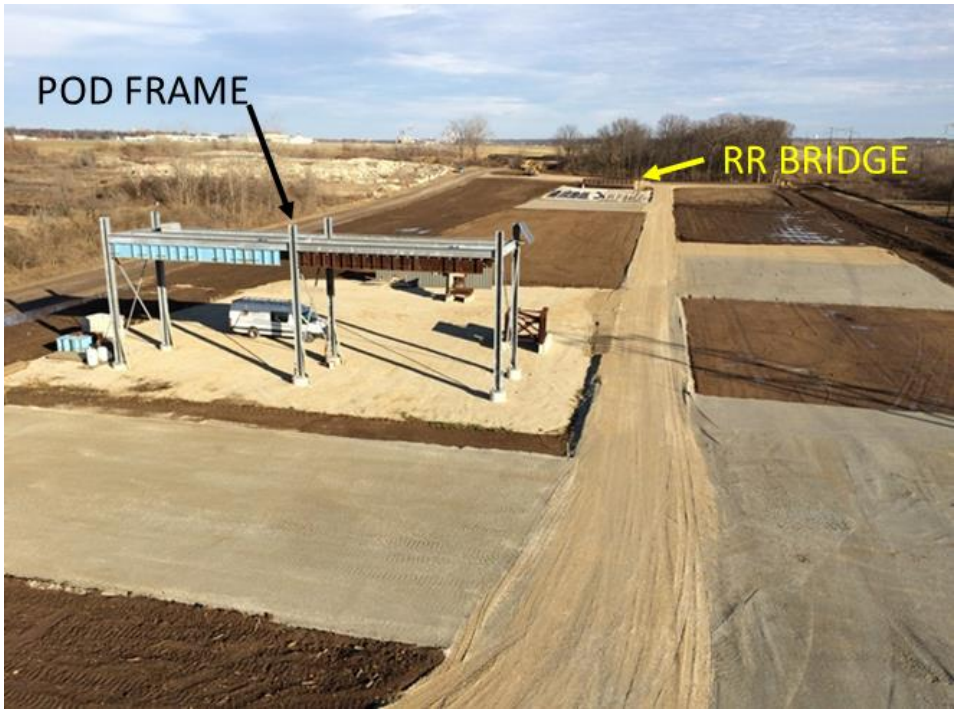
Steel Property Material Archive

A common problem that engineers face is related to establishing material properties for older grades of steel. Using a small of amount of funding provided by FHWA, S-BRITE was able to leverage existing database software developed by Purdue Universities' NEES hub Research Center program and create a searchable web-based interface to obtain such data. The website is populated with data from older bridges where material testing had been performed and available to the research team through a literature search. Over the summer, the data were collected and uploaded to the website.

The prototype of the website has been completed along with a simple user interface. Data include tensile, CVN, and steel chemistry. In addition, other media such as photographs and plans can also be uploaded. The database is searchable by steel grade, year, location, highway, etc. Data will continue to be added by S-BRITE staff as they become available. Any files or reports that contain such material property data that the project partners possess and are willing to add to the site are requested. In the near future, the site will be set up such that users can register and add their data themselves. The website can be viewed here: https://datacenterhub.org/resources/67. Users should click on the "Dataview" tab in the upper right. More clear directions on how to use the site are currently in preparation. However, holding one's mouse pointer over a data entry box results in a text box appearing with directions on how to input query terms.

S-BRITE/CAI SITE CONSTRUCTION

Construction of the S-BRITE/Center for Aging Infrastructure (CAI) facility began in October of 2014 and is approximately 95% complete. Construction work has ended due to winter weather for 2014, but will be completed in the spring of 2015. It is planned that all site work will be completed by April 2015. The figure below is a photograph taken in early December, 2014. The POD frame is in foreground and the 65 foot span RR bridge can be seen in the distance. The true scale of the facility is very apparent in this photograph. Some smaller specimens previously placed on the research POD research pad have been removed to facilitate the efforts of the construction work by the contractor.



The "empty" research pads shown in the photograph will house future specimens, such as those described above and those yet to be obtained. In addition, the areas that are presently covered with soil are available for future research pads that have not been constructed to date due to funding limitations.

Presently, the construction is on-time and within budget. Purdue University requires that contingency funds be set aside for unforeseen construction problems. Presently, no such problems exist and it is anticipated that the funds will be able to be used to bring power to the site and/or add more research pads. A website has been set up to monitor construction progress. Please visit the two sites below to see photographs of construction progress and live images from the site (updated every 10 minutes)

- Time lapse images - https://engineering.purdue.edu/CAI/SBRITE/Facilities
- Live video and weather - http://bigboy.ecn.purdue.edu/S-BRITE-Weather/index.html

DISTRIBUTED EXPERTISE NETWORK (DEN)

The DEN has been up and running over the past twelve months. Partner states are encouraged to utilize this feature of S-BRITE. To date there have only been about five questions come into the DEN, 4 of which were from INDOT. It is assumed that most partners forget that the DEN is available to them as partners in TPF-5(281).

A prototype website that summarizes some of the questions posed through the DEN is also available. Specifically, selected questions that have been placed to the DEN have been documented along with a summary of the response. Participants may find this useful as issues arise. The prototype site can be accessed at:

https://engineering.purdue.edu/CAI/SBRITE/DEN/secure/QA

The temporary username and password that partners can use to see the prototype site are as follows:

Username: "**sbrite-den"**

Password: **"boilerup14"**

PLEASE DO NOT SHARE THIS INFORMATION WIDELY AT THIS TIME.

In the next few weeks, each state will be receiving a unique username and password to allow them access to the site. Various resources will also be made available on the DEN Q&A site, including selected reports and papers. Further, more Q&As will be regularly added as questions arise.

PROPOSED PROJECTS/TRAINING FOR 2015

Implementing Effective Retrofits in Selected Steel Bridge Details

The objective of this project is to provide specialized training and certification for INDOT personnel, consultants, and contractors who select, design, and perform retrofitting of steel bridge details. The certifications would provide INDOT confidence that individuals; 1) understand the objective of various retrofit options; 2), recognize the urgency for specific retrofit; and 3) can properly install the retrofit so that it performs as intended.

Specifically, the following are proposed:

1. Development of a two-day short course that includes both classroom and "field" exercises (at S-BRITE) which includes the following:
    a. Case study examinations and discussion;
    b. Guidance on retrofit selection – (do's and don'ts);
    c. Objectives of specific retrofits;
    d. How to determine urgency for repairs;
    e. Hands-on examination of specimens that included effective, ineffective, and incorrect retrofits;
    f. Installation/execution of selected retrofit methods by the student, such as hole-drilling, grinding, plasma cutting, peening, etc.;
    g. Guidance on inspecting retrofit details after they are installed to confirm the retrofit is properly implemented and free of unacceptable defects.

2. Upon completion of the course, each professional would be required to successfully complete both a practical (hands-on) and written test. The professional will be required to achieve an acceptable score (e.g., 80%). The exact score will be determined during the project.

3. Professionals successfully completing the course will receive a certificate indicating they have demonstrated skills in retrofitting common steel bridge details.

The specimens would be housed at the S-BRITE Center and hands-on practical exams would be performed outdoors. (*During inclement weather, testing could be conducted at Bowen Laboratory*). The classroom training would be held at Bowen Laboratory. The program will build upon the existing investments in the S-BRITE Center at Purdue University.

INDOT has committed funding for this project and work is in the initial stages. It is anticipated the first training will take place the 3rd quarter of 2015. Any TPF partner that is interested in obtaining these specialized training courses and supporting this project is encouraged to contact Dr. Connor. Based on the hands-on nature of the course, it would be best for participants to travel to S-BRITE. However, during the development of the course, the possibility of including specimens that can be shipped to a partner's location will all be explored. The full proposal and scope of work is included as Appendix A of this report to provide more information.

Phase II of Probability of Detection (POD) Study

The first phase of the POD study discussed above is nearing completion. This initial phase focused on the detection of cracks in steel girder details using only visual inspection techniques. Future phase(s) will examine POD related to other damage modes, such as corrosion, damage, and other defects (i.e., missing or loose bolts).

Phase I has revealed that there is quite a bit of room for improvement regarding POD associated with crack detection however. It must be recognize however that Phase I was not intended to find fault, but to identify areas where improvements could be made either through training, improved inspection procedures, and/or by providing specific equipment to improve the POD associated with visual inspection for cracks in steel details. Hence, a major component of these later phases will be to develop procedures that are intended to improve fatigue crack detection as well as other damage.

The procedures are currently in development and will be evaluated in the spring of 2015 by evaluating a second round of inspectors who have been trained and equipped based on the results of Phase I. It is desired to obtain more data from inspectors from other states however to improve the statistical models for inspectors using "traditional" procedures as well as those to be developed in the spring of 2015. Further, additional specimens will be needed to ensure that the inspectors are not biased by examining the same specimens multiple times.

A proposal will be developed for discussion during the teleconference to be held in February 2015 with the partner states that will outline more specifics of the proposed research.

Virtual Bridge Inspection Pilot Study

The S-BRITE Research Team will be working to further develop the virtual bridge inspection training tool described above. A full proposal that will allow states to contribute to the existing TPF-5(281) study will be sent out to existing partners as well as other states in the spring of 2015. As stated, TPF-5(281) is intended to have multiple tasks that continue and evolve over time. Hence, there is no need to initiate a new or separate study, greatly decreasing the time and effort to begin the work should there be sufficient interest.

Proposal for Adding S-BRITE Task to Develop Tools for Corrosion and Damage Measurement using 3D Imaging

As stated, a proposal will be developed focused on further development of this tool as an added S-BRITE task through TPF-5(281) using the mechanism discussed above without initiating a new separate pooled fund study. The S-BRITE Research Team will share the proposal with states DOTS. Initial conversations with a few state DOTS have indicated that there is interest in supporting the effort and it is anticipated the study could be launched in the spring of 2015. More regarding this study will be presented during the proposed February teleconference.

Proposed Training Schedule and Proposed Dates for 2015

Courses scheduled for MNDOT @ MNDOT:

- High Strength Structural Bolting – January 12, 2015
- High Strength Structural Bolting – January 13, 2015

Courses proposed for any DOT @ S-BRITE:

- Inspecting Steel Bridge for Fatigue – May 12-13, 2015
- Design of Steel Bridges for Fatigue & Fracture – June 16-18, 2015
- Implementing Effective Retrofits on Steel Bridge Details – August/September 2015

SUMMARY

2014 has been a very active year for the S-BRITE Center and more progress is planned in 2015. It is proposed to conduct a status meeting in February 2015 for the pooled fund partners to provide further updates and answer any questions that exist. At present, the Research Team is proposing the meeting be held via teleconference sometime the week of February 9th or 16th. A "Doodle" poll will be sent out in the next week or so to identify a suitable date for everyone.

Items S-BRITE needs input on include:

- Partner training requests for 2015
- Research topics for 2015 including interest in and discussion about the Virtual Bridge Inspection Program and the Bridge Damage Modeling Using 3D Imaging
- Future funding commitments from existing partners
- Outreach support from partner states to garner additional DOT partnerships

APPENDIX A

Proposal

for

Implementing Effective Retrofits in Selected Steel Bridge Details

Proposal
for
Implementing Effective Retrofits in
Selected Steel Bridge Details
by

Robert J. Connor
Jason Lloyd

School of Civil Engineering

Joint Transportation Research Program

Project No.:_____

File No.:_____

SPR-3915

Proposed as an SPR Study in Cooperation

with

The Indiana Department of Transportation
Federal Highway Administration
U.S. Department of Transportation

Lyles School of Civil Engineering
Purdue University
550 Stadium Mall Drive
West Lafayette, Indiana 47907-1284

July 25, 2014
Revised August 28, 2014

Background & Problem Statement:
Development and implementation of effective retrofits is an essential part of INDOT's asset management program associated with extending the life of the aging steel bridge inventory. Unfortunately, INDOT has first-hand experience where ineffective retrofits have been implemented on a steel bridge leading to costly repairs. In other cases, incorrect retrofit selection or execution has also been known to result in worse conditions than had the retrofit not been attempted. However, there also ample examples where retrofits have been effectively implemented and have extended the safe life of the structures. Further, based on the latest research and national experience, some improved retrofit methods have been developed for retrofitting common problems in steel bridges that many engineers may not be readily familiar with, especially younger, less "seasoned" individuals.

It is the objective of this research to develop classroom and hands-on training to educate bridge engineers and other stakeholders so that the most effective, efficient, and safe retrofit strategies are employed on INDOTs aging steel bridge inventory.

Proposed Scope of Work:
The objective of this project is to provide specialized training and certification for INDOT personnel, consultants, and contractors who select, design, and perform retrofitting of steel bridge details. The certifications would provide INDOT confidence that individuals; 1) understands the objective of various retrofit options; 2), recognizes the urgency for specific retrofit; and 3) can properly install the retrofit so that it performs as intended.

Specifically, the following are proposed:

1. Development of a two-day short course that includes both classroom and "field" exercises (at S-BRITE) which includes the following:
    a. Case study examinations and discussion;
    b. Guidance on retrofit selection – (do's and don'ts);
    c. Objectives of specific retrofits;
    d. How to determine urgency for repairs;
    e. Hands-on examination of specimens that included effective, ineffective, and incorrect retrofits;
    f. Installation/execution of selected retrofit methods by the student, such as hole-drilling, grinding, plasma cutting, peening, etc.;
    g. Guidance on inspecting retrofit details after they are installed to confirm the retrofit is properly implemented and free of unacceptable defects.

2. Upon completion of the course, each student would be required to successfully complete both a practical (hands-on) and written test. Students will be required to achieve an acceptable score (e.g., 80%). The exact score will be determined during the project.

3. Student successfully completing the course will receive a certificate indicating they have demonstrated skills in retrofitting common steel bridge details.

The specimens would be housed at the S-BRITE Center and hands-on practical exams would be performed outdoors. (*During inclement weather, testing could be conducted at Bowen Laboratory*). The classroom training would be held at Bowen Laboratory. The program would build upon INDOT's existing

investments in the S-BRITE Center at Purdue University. It is likely that pooled fund participants would also be interested in this training.

Retrofit Concepts to be Included

Out-of-plane distortion cracking

By far, one of the most common types of cracking that has been observed on highway bridges throughout the US is out of plane distortion cracking. A typical crack is shown in Figure 1. Various retrofit strategies have been developed for these details, including hold drilling, rigidly attaching the stiffener to the flange via welding or bolting, cutting back the stiffener, and combinations thereof. In addition, cracking is also observed at gusset plate/stiffener intersections. However, incorrectly selecting or implementing any one of these types of retrofits has also been observed to be ineffective, for example a common mistake is drilling holes that are too small. Further, challenges exist when the cracking is adjacent to a top flange that is embedded in concrete due to limited access if a bolted retrofit is selected.

Figure 1 – Photograph of typical out-of-plane crack at transverse connection plate

Table 1 – Proposed specimen matrix for out-of-plane distortion crack retrofits

Type of Detail	Include @ S-BRITE	Hands-on Retrofit Demonstrations	Specimen Details	# Required to illustrate damage or for hands-on repair
Cracked unretrofit detail	Yes	N/A	Welded Plate Girder Section	1-2[1]
Retrofits to be Considered				
Cutting/Grinding Stiffener/Gusset Back	Yes	Yes	Welded Plate Girder Section	1[2]
HS Bolted with Angles	Yes	No	Welded Plate Girder Section	1[2]
TBA[3]	Yes	Yes	Welded Plate Girder Section	1[2]

Notes

1. Several specimens with out of plane distortion cracks exist at s-BRITE, hence only 1 or 2 may need to fabricated for this project.
2. Each specimen will contain multiple details to repair, but no less than 40. However, only 1 specimen Specimens used for CIF retrofit will also be included in this matrix.
3. This specimen is intended to be used for more recently developed retrofits, such as using threaded studs to attached angles to top flanges or composite boding agents.

Table 1 includes a proposed matrix of specimens including both damaged and those to be used to illustrate retrofit details. There are several specimens currently at S-BRITE which have various states of out-of-plane distortion cracks which will be available to illustrate this type of cracking. However, 1 or 2 additional specimens may be needed. This will be determined during the research. At this time, the Research Team is proposing that girders approximately 15 or 20 feet long be fabricated which include multiple details that students can then retrofit. For example, a single specimen could have over 80 transvers stiffeners locations (e.g., both web faces, plus top and bottom flange) that could be retrofit simply by adding lots of stiffeners. This is shown schematically in Figure 2. Crossframe interference can be simulated by building a single wooded cross frame (of the same geometry as a typical crossframe) and moving from location to location.

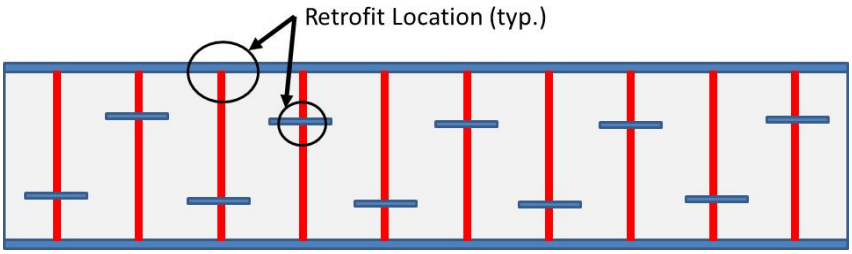


Figure 2 – Specimen illustrating multiple locations for students to perform retrofits for out of plane distortion cracking

CIF (Hoan) Type Retrofits

Details susceptible to constraint induced fracture (CIF), more commonly known as “Hoan Bridge” details will also be included. These details are covered extensively in the existing S-BRITE training courses for inspectors and engineers. Further, Dr. Connor has several fractured specimens that are excellent examples to illustrate these details after they fracture. In addition, the 65 foot span RR Bridge at S-BRITE includes several gusset details that have not been retrofit that can be used for training. Longitudinal stiffener details susceptible to CIF also exist at S-BRITE and can be used for this research.

Hence, the only specimens needed are for training of individuals who must actually perform these retrofits in the field. There are several methods which exist to effectively retrofit these details, ranging from more complex hole drilling using specialized machine tools to simply increasing the web gap through grinding. These are summarized in Table 2. It is noted that these specimens will serve dual purpose and be available to be used for implementation of out-of-plane distortion retrofitting since the vertical stiffeners need not be welded to the flanges.

Table 2 – Proposed specimen matrix for CIF retrofits

Type of Detail	Include @ S-BRITE	Hands-on Retrofit Demonstrations	Specimen Details	# Required to illustrate damage or for hands-on repair
Unretrofit detail	Yes	N/A	Welded Plate Girder Section	N/A[1]
Retrofits to be Considered				
Cutting/Grinding Longit. Stiffener / Gusset Back	Yes	Yes	Welded Plate Girder Section	2[2]
Hole Drilling of Gusset	Yes	Yes	Welded Plate Girder Section	2[2]
Ball End Mill through Web	Yes	No	Welded Plate Girder Section	1[3]
Hole Drilling through Web	Yes	Yes	Welded Plate Girder Section	2[2]

Notes

1. Specimens with CIF details already exist at S-BRITE and can be used for this project.
2. Each specimen will contain multiple details to repair, but no less than 40.
3. A single specimen will be fabricated to illustrate the single-hole ball-end mill type retrofit as this requires specialized equipment that may not be available at S-BRITE / Bowen Laboratory

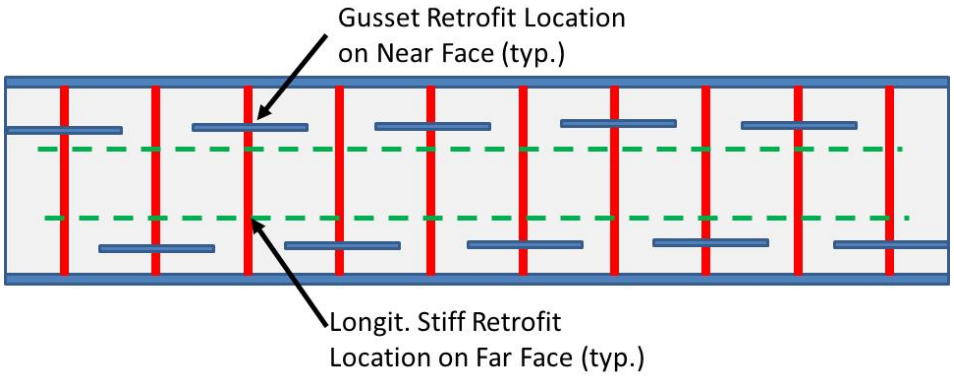


Figure 3 – Specimen illustrating multiple locations for students to Perform CIF retrofits

Weld Toe Peening

Weld toe improvement techniques using air hammer peening has been shown to increase the fatigue resistance of details with low fatigue resistance. Most commonly the details include E or E' terminations on gusset plates, longitudinal stiffeners, and cover plates. Since the specimens using for the out-of-plane and CIF details will have well over 100 such details, it is very cost effective to include air hammer peening on these specimens. For a very small cost, short cover plates can be added to the flanges (say 6 inch long) plates. Since the objective is to train individuals how to treat a weld toe, ALL weld toes of ALL attachments can be used for training. This will result in hundreds of feet of fillet weld available for training. However, some short cover plates will still be added to each specimen to require working overhead and to illustrate the challenges with access.

Estimated Number of Students in Class

It is estimated that based on the funding available to fabricated the specimens, 20 to 40 students should be able to be put through the course. Each course will be limited to 10 students since there will be significant time spent one-on-one with each student during the actual hands-on training. The course would be limited to INDOT employees at this time. Others can be added, but would have to pay a fee. At this time the cost for the course has not be developed, but would likely be between $1000 to $2000 to help compensate for the specimens the students would need to be certified. Funds are budgeted for meals/breaks, and handouts for the training, as well as development of the course.

Facilities and Personnel

The principal investigator for this project is Professor Robert J. Connor of the School of Civil Engineering at Purdue University. Dr. Connor has over 20 years of experience in the area of instrumentation, data acquisition, field monitoring, and the performance of steel bridge structural behavior, retrofitting, and performance. Adequate facilities exist to support this effort. Jason Lloyd, PE, Research Engineer will serve as Co-PI on the project. Either a grad student or post doc will also assist in the work.

Implementation Potential

The work is highly implementable as the project deliverable is to provide needed training in the area of steel bridge retrofitting guidance. Implementation of the work (i.e., training) will be performed by the research team through the offering of the short courses. The results will be implemented immediately following development of the courses by offering the training to the INDOT and the consultant community. This is also the project deliverable.

In order to implement the deliverables, INDOT must budget for the time and travel associated with bring INDOT employees to the Purdue University for the training. It is hoped that INDOT would require certification for some contractors performing retrofit work (design and implementation) on their steel bridge inventory. The course would be made available to consultants and contractors at a fee to be specified, thereby generating some revenue to assist in continually offering and improving the course.

Business Case

The business case for this project can be easily made by reviewing costs associated with funds spent on repairs to bridges that have already been repaired with *ineffective* retrofits. For example, CIF retrofits on the Cannleton Bridge were implemented incorrectly and performed on details that did not need to be retrofit. Deputy Commissioner Jay Wasson indicated the required repairs on the Cannelton Bridge needed as a result of the poorly installed initial retrofits are on the order of $2 million. Such obvious examples are rare of course, but there are several examples in the state where fatigue retrofits have been introduced and have been shown to be ineffective, such as drilling holes that are too small.

Since an objective of the project is to require certifications for contractors, engineers, and inspectors, it is believe that the overall quality of future retrofitting will improve thereby greatly reducing or eliminating the likelihood of events as occurred on the Cannelton Bridge.

Installation of effective retrofits at the proper time will extend the safe and useful life of the aging steel bridge inventory, thereby allowing resources to allocated more effectively. The project deliverables (training materials and courses) will also continue to place INDOT on the leading edge of steel bridge life extension in the US. It is envisioned that other state DOTs will desire to enroll in these classes providing revenue to help S-BRITE become more sustainable in the near future. It is envision that external

participant (i.e., non-INDOT employees) will be charge a fee of $1000-$2000 for the two-day training. This is an increase over the original estimated cost of $750-$1,000.

Proposed Schedule

The following is the proposed schedule for this project.

	2014	2015				2016				2017		
Task	4	1	2	3	4	1	2	3	4	1	2	3
Design Specimens												
Fabricate Specimens												
Develop Short Course Material												
Offer Courses												