TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Oregon Department of Transportation

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 # TPF 5(259)	**Transportation Pooled Fund Program - Report Period:** X Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 1 – December 31)
Project Title: **Imaging Tools for Evaluation of Gusset Plate Connections in Steel Truss Bridges**	

Name of Project Manager(s): **Xiugang (Joe) Li**	**Phone Number:** **503-986-4115**	**E-Mail** Xiugang.Li@odot.state.or.us
Lead Agency Project ID: **TPF5259**	**Other Project ID (i.e., contract #):** **Agreement 17384** **Work Order 12-05**	**Project Start Date:** April 2012
Original Project End Date: **9/30/2014**	**Current Project End Date:** **9/30/2014**	**Number of Extensions:** 0

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
$440,000	$164,625.32	51

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	NA	80

Project Description:

The collapse of the I-35W Bridge in Minnesota has resulted in considerable interest in steel truss and gusset plate connection performance. The load paths in many truss bridges are non-redundant and thus failure of a truss member or connection may cause collapse of the structure. Periodic inspections and structural evaluations are crucial for these types of bridges.

The most common method of evaluation that has been used to assess the safety of highway bridges is load rating, an approach used to estimate the available strength and allowable load on a bridge. Although sophisticated bridge load rating computer programs are available, these programs do not explicitly consider the gusset plates connecting the truss members. Hence, after the initial design calculations are completed and checked, it is unlikely that recalculations for load rating purposes have been made for gusset plates. As an outcome of the investigation into the collapse of the I-35W Bridge, steel truss bridge connections are required to undergo review. This additional scrutiny requires development of new tools to efficiently and effectively evaluate the large numbers of steel truss bridge connections in the inventory.

Digital imaging techniques have been developed to enable rapid collection of field geometric data from in-service gusset plates. These tools are implemented in software that allows extraction of gusset plate dimensional information to facilitate ratings. The present tools provide a basic set of functionality such as image rectification and scaling and allow geometric data extraction such as length, perimeter, and angles. However, these basic functions need enhancement to take full advantage of the advancements available to bridge inspection and management with digital imaging. Enhancements such as automation of rectification tasks and identification of features within the images are proposed that will enable transportation agencies to efficiently and effectively collect geometric and condition data and use this data to evaluate and rate gusset plate connections.

There are four main objectives of this research:

1. Develop methods to collect dimensional gusset plate connection information including surface geometry and out-of-plane deformations on in-service gusset plates. The information to be collected includes the geometry of the connectors, members, and overall plate dimensions. It also includes out-of-plane distortions of the gusset plate.

2. Develop methods to automate identification and optimization of reference target points, and to automate identification and extraction of the gusset plate edges, fastener locations and their corresponding member affiliations, as well as member orientations. These dimensional data feed directly into the connection rating tasks.

3. Develop finite element modeling and analysis techniques to directly rate gusset plates using extracted digital image data as the input source.

4. Develop software tools to manage and organize images and image data to enhance bridge management and allow identification of condition changes over time.

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

Task 1: Literature Review
Schedule status: *On schedule*
Percent complete: 75%

Task status: *Literature being collected and synthesized as research progresses.*

Task 2: Software Development and Data Collection
Schedule status: *On schedule*
Percent complete: 80%

Task status: *Computer Science graduate students have continued to refine the software and graphical user interface. Navigation through process has been streamlined. Sample images have been developed for user testing.*

New image targets as well as old image targets are now an option to enable use of legacy images.

Task 3: Gusset Plate Analysis
Schedule status: *On schedule*
Percent complete: 10%

Task status: *Manual calculations of gusset plate components according to the latest AASHTO MBE provisions are now coded into the image processing module. The MBE calculations are done by combining automatic detection features and user selected data. Reporting features and outputs are complete.*

Task 4: Implementation Example
Schedule status: *On schedule*
Percent complete: 90%

Task status: *A gusset plate sample that has an image target has been developed. The analyses features, both AASHTO-MBE and finite element, have been performed.*

Task 5: Imaging Data Informatics for Bridge Management
Schedule status: *On schedule*
Percent complete: 20%

Task status: Additional development of an *ArcGIS model was performed but then halted after discussions with colleagues indicated that Revit would potentially be a more useful tool.(see Circumstance affecting project below).*

Task 6: Analysis Software
Schedule status: *On schedule*
Percent complete: 90%

Task status: *Additional validation was performed for the OpenSees formulation. Elastic and inelastic responses were well predicted for isolated tension, compression, buckling, bending (in and out-of-plane), and shear. The strength level needs to be established using a tangent or secant stiffness criteria. Correlation with full-size experimental test results showed good correlation using a tangent stiffness approach. An approach for including brace stiffness attributes for sway buckling is near final and expected to be complete before software release. Reporting features and graphical user interface have been enhanced.*

Anticipated work next quarter:

Task 1: Literature Review- *Continue review and synthesis*

Task 2: Software Development and Data Collection – *Release software to project participants on May 15, 2014 and solicit feedback. At same time, continue to revise and improve.*

Task 3: Gusset Plate Analysis – *Get user feedback and use to assess uncertainties in results. Conduct sensitivity studies to user/software detection errors.*

Task 4: Implementation Example - *None*

Task 5: Imaging Data Informatics for Bridge Management – *Solicit feedback from users for preferred GIS software tool.*

Task 6: Analysis Software – *Continue to refine GUI and reporting features based on user feedback. Finalize analysis approach with integral compression truss member stiffness properties for sway buckling analysis checks. Continue refinement of analysis output (stress outputs).*

Significant Results:

While results are preliminary, the following results are significant:

A revised set of image targets shows good rectification with significantly reduced cost and eliminates the need for standoff correction in the scaling.

The software application can now automate image processing of a general gusset plate. It requires refinement and further development by the research team.

The analysis tools can effectively rate the connection strength using either AASHTO-MBE or nonlinear FEA.

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).

No significant problems.

The software will be release to the TAC on May 15. A conference call will be held with the TAC during the week of May 19 to walk through the beta version.

The image processing requires the use of MatLab. We will try to create a stand-alone executable, but will develop contingencies to allow remote use of the license.

After beginning development of an ArcGIS model, discussions with colleagues indicated that Revit would potentially be a more useful tool. Development was suspended to hear from the TAC as to a preferred alternative.

Potential Implementation:

We will release a working version of the software to the TAC on May 15. Sample gusset plate images with image targets will be provided for users.