TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Kansas 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 # *TPF-5(189)*	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) XQuarter 4 (October 4 – December 31)

Project Title:
"***Enhancement of Welded Steel Bridge Girders Susceptible to Distortion-Induced Fatigue***"

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Lead Agency Project ID:	Other Project ID (i.e., contract #):	Project Start Date:
	KAN00063732	08/31/2008
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
08/31/2011	**08/31/2013**	**1**

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Total Percentage of Work Completed
$1,045,000.00	$861,173.68	73%

Quarterly Project Statistics:

Total Project Expenses This Quarter	Total Amount of Funds Expended This Quarter	Percentage of Work Completed This Quarter
$49,113.07	$49,113.07	5%

Project Description:

A large number of steel bridges within the national inventory are affected by distortion-induced fatigue cracks. Repairs for this type of failure can be very costly, both in terms of direct construction costs and indirect costs due to disruption of traffic. Furthermore, physical constraints inherent to connection repairs conducted in the field sometimes limit the type of technique that may be employed. The goal of the proposed research is to investigate the relative merit of novel repair techniques for distortion-induced fatigue cracks.

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

Project Meetings

On October 12, 2011, the Kansas DOT (KDOT) coordinated a visit with Drs. Rolfe, Matamoros, and Bennett in Topeka, KS to discuss transfer of the technology developed under TPF-5(189) to a bridge in Wichita, KS that is need of repair for distortion-induced fatigue. Development of specific repair geometry and field testing are contracted separately with KDOT, but the extension of the connection stiffener-to-web steel angle repair that has been reported previously in TPF-5(189) progress report to the field should be of interest to all participants in this pooled fund study.

Weekly TPF-5(189) research meetings have continued to be held with all investigators attending regularly. The research meetings serve to define and assign tasks for TPF-5(189). The weekly meetings also serve to analyze new results and discuss recent findings. The weekly research meetings are in addition to nearly daily meetings with graduate students working on TPF-5(189) and laboratory technicians.

As reported in the previous progress report, a date for the TPF-5(189) participant's meeting has been set for **Friday, March, 16, 2012.** Funds are budgeted in the project to support travel costs (airfare and one night hotel stay) for one representative from each participating state DOT. The meeting will be held in Lawrence, KS, at the University of Kansas so that laboratory tests may be viewed.

Contract Status

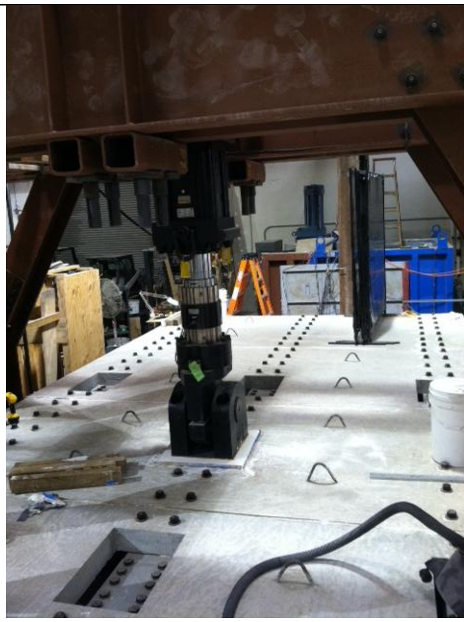
As reported in September, 2011, the contract for TPF-5(189) has been extended to August 31, 2013. To-date, Kansas, Tennessee, Illinois, New York, Pennsylvania, and Louisiana have each committed to contributing additional funds through the project extension. The KU Transportation Research Institute (KU TRI) will provide a 50% match to these contributions. As described in the June 21, 2011 letter sent to participating State DOTs and in the June 30, 2011 progress report, the request for one additional $35K commitment was made: to close the original funding shortfall, to fund student personnel while testing is completed, and to allow for an expansion in project scope.

Technical Updates

1. 30 ft. Three-Girder Specimens

Work this quarter has focused heavily on readying the 30-ft. bridge specimen for cycling. A number of final preparations were made:

1. A load-distributing steel plate was placed under the actuator, on top of the composite concrete bridge deck. The plate was leveled using HYDRO-STONE®, and is intended to ensure that loads applied by the actuator are evenly distributed to the concrete deck, centered over the middle girder in the bridge test set-up.
2. LVDTs were received and installed. Steel posts were manufactured with bases cast in concrete to serve as supports for the LVDTs measuring transverse displacements on the exterior girders. Specialized clamps were manufactured to attach the LVDTs to the steel posts.
3. Bridge Diagnostics Inc. (BDI) strain transducers were attached to the steel girders to measure longitudinal strains in the bottom flanges. Foil strain gages intended to measure stresses in the web gap regions had been attached previously.
4. A routine for the National Instruments data acquisition system was written in LabView.



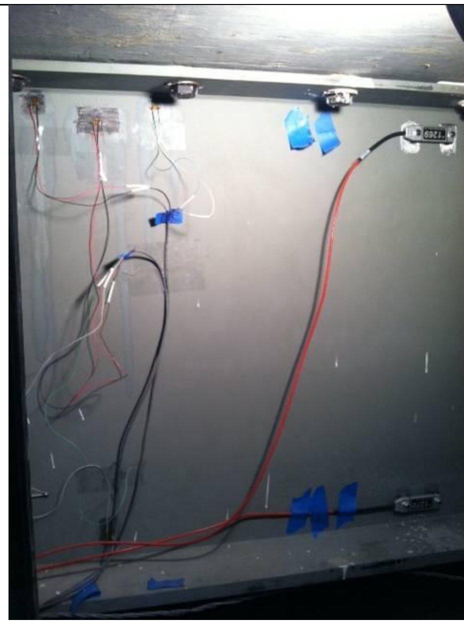


Fig. 1 View of top of bridge with actuator resting on load distribution plate

Fig. 2 View of instrumented exterior girder

2. 9 ft. Girder Specimens

Two 9-ft. girder specimens have been tested, and the third is in progress. The purpose of the Specimen 3 test has been two-fold: to provide repeatability to the test performed on Specimen 2, and to examine the performance of the steel angle and backing plate retrofit when applied over cracks of various lengths. As reported in the September, 2011 progress report, Specimen 2 included a test of the effectiveness of this retrofit technique when applied over very long horizontal (8 in.) and horseshoe-shaped (4 in.) cracks.

The current test, Specimen 3, has exhibited cracks in two locations: a horizontal crack at the weld toe between the bottom flange and web and a horseshoe-shaped crack at the intersection between the stiffener plate and the web. The first crack was observed at 73,000 cycles in the stiffener weld at a length of 3/8 in. A horizontal crack 1/16-in. long was first observed at 250,000 cycles. The horizontal crack was allowed to grow to approximately 2 in. (281,000 cycles), at which point the horseshoe crack had grown to 1-3/4 in. and 2 in. on either side of the stiffener. Each horseshoe-shaped crack also exhibited spider cracks 1/2-in. long. The retrofit shown in Figs. 3 and 4 was implemented when cracking in Specimen 3 had reached these levels.

Two angles were attached to either side of the stiffener plate and a plate was connected to the back side of the stiffener. The plate was periodically removed and the cracks were inspected. After 1.2 million additional cycles with the retrofit, the horizontal crack had grown by an additional 1/4 in. and there was no growth in the horseshoe-shaped crack.

Next, the angle/plate retrofit was removed and the horizontal crack was allowed to propagate to a 4-in. crack (71,700 additional cycles). The horseshoe crack was 2-in. long on either side and the spider cracks had reached lengths of 3/4 in. each. Also, a through-web crack 1-3/8-in. long was present directly behind the initiation point of the horseshoe crack. At this point, the retrofit was reapplied to the specimen and is currently being loaded for another 1.2 million cycles to examine the effectiveness of the retrofit for varying crack sizes.

Fig. 3 View of backing plate on fascia side of girder web on Specimen 3

Fig. 4 View of angles bolted to the connection stiffener and girder web on the interior of Specimen 3

Anticipated work next quarter:

- Fatigue testing the first 30-ft. bridge test set-up.
- Fatigue testing Specimen 3 and Specimen 4 in the 9-ft. girder test set-ups.
- Recommendations for scaling up the PICK tool will be completed.

Significant Results:

The angle retrofit described in the June 2011 and September 2011 reports has performed excellently under fatigue testing. This retrofit technique has a great deal of promise for practical field application, as it avoids complications that arise with connecting to a top flange.

A list of in-print publications produced by the project team in direct relation to TPF-5(189) is presented here, for the reader interested in further analysis of results to-date.

Alemdar, F., Matamoros, A., Bennett, C., Barrett-Gonzalez, R., and Rolfe, S. (2011). "Use of CFRP Overlays to Strengthen Welded Connections under Fatigue Loading," Accepted for publication in the *Journal of Bridge Engineering*, ASCE.

Kaan, B[‡], Alemdar, F.[‡], Bennett, C., Matamoros, A., Barrett-Gonzalez, R., and Rolfe, S. (2011). "Fatigue Enhancement of Welded Details in Steel Bridges Using CFRP Overlay Elements," Accepted for publication in the *Journal of Composites for Construction*, ASCE

Alemdar, F., Matamoros, A., Bennett, C., Barrett-Gonzalez, R., and Rolfe, S. (2011). "Improved Method for Bonding CFRP Overlays to Steel for Fatigue Repair," Proceedings of the ASCE/SEI Structures Congress, Las Vegas, NV, April 14-16, 2011.

Hartman, A., Hassel, H., Adams, C., Bennett, C., Matamoros, A., and Rolfe, S. "Effects of lateral bracing placement and skew on distortion-induced fatigue in steel bridges," *Transportation Research Record: The Journal of the Transportation Research Board,* No. 2200, 62-68.

Crain, J., Simmons, G., Bennett, C., Barrett-Gonzalez, R., Matamoros, A., and Rolfe, S. (2010). "Development of a technique to improve fatigue lives of crack-stop holes in steel bridges," *Transportation Research Record: The Journal of the Transportation Research Board,* No. 2200, 69-77.

Hassel, H., Hartman, A., Bennett, C., Matamoros, A., and Rolfe, S. "Distortion-induced fatigue in steel bridges: causes, parameters, and fixes," Proceedings of the ASCE/SEI Structures Congress, Orlando, FL, May 12-15, 2010.

Alemdar, F., Kaan., B., Bennett, C., Matamoros, A., Barrett-Gonzalez, R., and Rolfe, S. "Parameters Affecting Behavior of CFRP Overlay Elements as Retrofit Measures for Fatigue Vulnerable Steel Bridge Girders," Proceedings of the Fatigue and Fracture in the Infrastructure Conference, Philadelphia, PA, July 26-29, 2009.

Kaan, B., Barrett, R., Bennett, C., Matamoros, A., and Rolfe, S. "Fatigue enhancement of welded coverplates using carbon-fiber composites," Proceedings of the ASCE / SEI Structures Congress, Vancouver, BC, April 24-26, 2008.

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).