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 #):** **KAN00063732**	**Project Start Date:** 08/31/2008
Original Project End Date: **08/31/2011**	**Current Project End Date:** **08/31/2013**	**Number of Extensions:** **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
$1,060,000.00	$1,060,000.00	100%

Quarterly Project Statistics:

Total Project Expenses	Total Amount of Funds	Percentage of Work Completed

This Quarter	Expended This Quarter	This Quarter
$0	$0	

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
Weekly research group meetings have continued to take place this quarter.

Contract Status
The contract ended on August 31, 2013. The project work is complete, and the researchers are in the final stages of preparing the final report.

The final report is being structured such that the first portion of the report provides a summary of the work performed and overall findings and recommendations of TPF-5(189). The remainder of the report provides detailed information and findings for the different aspects of the project in three Appendices. The intent of this approach is so that readers can quickly obtain a summary of the project outcomes, while being referred to more detailed discussions of each of the research focuses. An outline of the draft final report is provided here:

1. Introduction
2. Background
3. Methodology
4. Results
5. Discussion
6. Conclusions and Recommendations
7. References

(Appendix A: Development of the Angles-with-Plate Repair Technique)

8. Repairing Distortion-Induced Fatigue Cracks in Steel Bridge Girders using Angles-with-Plate Retrofit Technique, Part 1: Physical Simulations
9. Repairing Distortion-Induced Fatigue Cracks in Steel Bridge Girders using Angles-with-Plate Retrofit Technique, Part II: Computer Simulations
10. Experimental Investigation of Distortion-Induced Fatigue Repair in 9.1m (30ft) Test System
11. Parametric Retrofit Analysis for Distortion-Induced Fatigue in a 9.1m (30 ft) Test Bridge

(Appendix B: Development of PICK Technology)

12. Development of a Technique to Improve Fatigue Lives of Crack-Stop Holes in Steel Bridges
13. Design, Modeling, and Testing of Piezoelectric Impact Compressive Kinetic (PICK) Tool for Crack-Stop Hole Treatment
14. Improving the Fatigue Performance of Drilled Holes in Steel Bridges through Use of Mechanical Treatments

(Appendix C: FRP Retrofit Techniques)

15. Use of CFRP Overlays to Repair Fatigue Damage in Steel Plates under Tension Loading
16. Use of CFRP Overlays to Strengthen Welded Connections under Fatigue Loading
17. Fatigue Enhancement of Welded Details in Steel Bridges using CFRP Overlay Elements

(Appendix D: Skewed Bridge Analytical Investigation)

18. Parametric Analysis of Cross-Frame Layout on Distortion-Induced Fatigue in Skewed Steel Bridges
19. Effects of Lateral Bracing Placement and Skew on Distortion-Induced Fatigue in Steel Bridges

Technical Updates

- None

Anticipated work next quarter:

The final report will be submitted.

Significant Results:

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.

Simmons, G., Bennett, C., Matamoros, A., Barrett-Gonzalez, R., and Rolfe, S. (2014). "Improving the Fatigue Performance of Drilled Holes in Steel Bridges through Use of Mechanical Treatments," *Proc. Annual Transportation Research Board Meeting*, Transportation Research Board, Washington, D.C.

Hartman, A., Bennett, C., Matamoros, A., and Rolfe, S. (2013). "Innovative Retrofit Technique for Distortion-Induced Fatigue Cracks in Steel Girder Web Gaps," *Journal of Bridge Structures*, IOS Press, (9), 57-71.

Alemdar, F., Overman, T., Matamoros, A., Bennett, C., and Rolfe, S. (2013). "Repairing Distortion-Induced Fatigue Cracks in Steel Bridge Girders using Angles-with-Plate Retrofit Techniques, Part I: Physical Simulations." Accepted for publication in the ASCE *Journal of Structural Engineering*, American Society of Civil Engineers (ASCE). In Press.

Alemdar, F., Nagati, D., Matamoros, A., Bennett, C., and Rolfe, S. (2013). "Repairing Distortion-Induced Fatigue Cracks in Steel Bridge Girders using Angles-with-Plate Retrofit Techniques, Part II: Computer Simulations." Accepted for publication in the ASCE *Journal of Structural Engineering*, American Society of Civil Engineers (ASCE). In Press.

Alemdar, F., Gangel, R., Matamoros, A., Bennett, C., Barrett-Gonzalez, R., Rolfe, S., and Liu, H. (2013). "Use of CFRP Overlays to Repair Fatigue Damage in Steel Plates under Tension Loading," Accepted for publication in the ASCE *Journal of Composites for Construction*, American Society of Civil Engineers (ASCE).

Hassel, H., Bennett, C., Matamoros, A., and Rolfe, S. (2013). "Parametric Analysis of Cross-Frame Layout on Distortion-Induced Fatigue in Skewed Steel Bridges," *Journal of Bridge Engineering*, American Society of Civil Engineers (ASCE), 18(7), 601-611.

Simmons, G., Bennett, C., Barrett-Gonzalez, R., Matamoros, A., and Rolfe, S. (2013). "Design, Modeling, and Testing of a Piezoelectric Impact Compressive Kinetic (PICK) Tool for Crack-Stop Hole Treatment, Proceedings of the SPIE Smart Structures / NDE Conference, SPIE, San Diego, CA, March 10-14, 2013.

Richardson, T., Alemdar, F., Bennett, C., Matamoros, A., and Rolfe, S. "Evaluation of the Performance of Retrofit Measures for Distortion-Induced Fatigue Using Finite Element Analysis," National Steel Bridge Alliance (NSBA) World Steel Bridge Symposium (WSBS) 2012 Proceedings, April 18-20, 2012.

Richardson, T., Alemdar, F., Bennett, C., Matamoros, A., and Rolfe, S. (2012). "Retrofit Measures for Distortion-Induced Fatigue," *Modern Steel Construction*, American Institute of Steel Construction (AISC), 52 (4), 32-34.

Alemdar, F., Matamoros, A., Bennett, C., Barrett-Gonzalez, R., and Rolfe, S. (2012). "Use of CFRP Overlays to Strengthen Welded Connections under Fatigue Loading," *Journal of Bridge Engineering*, American Society of Civil Engineers (ASCE), 17(3), 420-431.

Kaan, B., Alemdar, F., Bennett, C., Matamoros, A., Barrett-Gonzalez, R., and Rolfe, S. (2012). "Fatigue Enhancement of Welded Details in Steel Bridges Using CFRP Overlay Elements," *Journal of Composites for Construction*,

American Society of Civil Engineers (ASCE), 16(2) 138-149.

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 American Society of Civil Engineers (ASCE) / Structural Engineering Institute (SEI) Structures Congress, Las Vegas, NV, April 14-16, 2011.

Hartman, A., Hassel, H., Adams, C., Bennett, C., Matamoros, A., and Rolfe, S. (2010). "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, Dec, 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, Dec, 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 American Society of Civil Engineers (ASCE) / Structural Engineering Institute (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 American Society of Civil Engineers (ASCE) / Structural Engineering Institute (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).