Connecticut Permanent Long-Term Bridge Monitoring Network Volume 6: Monitoring of a Continuous Plate Girder Bridge with Load Restrictions – Route 15 Over the Housatonic River in Stratford (Bridge #761)

Prepared by: Stephen Prusaczyk, Harinee Trivedi Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim

> August 18, 2014 Report Number CT-2256-7-13-8

> > SPR 2256

Connecticut Transportation Institute University of Connecticut

Prepared for: Connecticut Department of Transportation

James A. Fallon, P.E. Manager of Facilities and Transit Bureau of Engineering and Construction

Disclaimer

This report does not constitute a standard, specification or regulation. The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the views of the Connecticut Department of Transportation or the Federal Highway Administration.

Technical Report Documentation Page

monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages N/A	1.		port No. -2256-7-13-8	2. Governn	nent Accession No.	3. Reci	ipient's Catalog No.				
Volume 6: Monitoring of a Continuous Plate Girder Bridge with Load Restrictions – Route 15 over the Housatonic River in Stratford (Bridge #761) Rathor(s) Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim 10 Work Unit No. (TRAIS) University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 13. Type of Report and Period Covered 13. Type of Report and Period Covered 14. Sponsoring Agency Name and Address Final 1999 - 2013 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words		4.	4. Title and Subtitle			5. Report Date					
Volume 6: Monitoring of a Continuous Plate Girder Bridge with Load Restrictions – Route 15 over the Housatonic River in Stratford (Bridge #761) 7. Author(s) SPR-2256 SPR-2256 7. Author(s) Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim In Ower Work Unit No. (TRAIS) 9. Performing Organization Name and Address In Ower Work Unit No. (TRAIS) 10. Work Unit No. (TRAIS) 11. Contract or Grant No. SPR-2256 12. Sponsoring Agency Name and Address Final 1999 - 2013 13. Type of Report and Period Covered 1999 - 2013 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. In No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. In No. of Pages In Price Unclassified In No.					m Bridge Monitoring Network		•				
(Bridge #761) 7. Author(s) Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim 9. Performing Organization Name and Address University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Unclassified 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.						6. Perf					
7. Author(s) Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim 9. Performing Organization Name and Address University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 13. Type of Report and Period Covered Final 1999 - 2013 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Unclassified 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classified 10. No of Pages 11. No. of Pages 12. No. of Pages 12. No.				the Housatonic	River in Stratford		SPR-2256				
Stephen Prusaczyk, Harinee Trivedi, Richard E. Christenson, John T. DeWolf, Jeong-Ho Kim 9. Performing Organization Name and Address University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder Bridge monitoring, continuous, plate girder No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	7	<u> </u>				0 D C		D AN			
John T. DeWolf, Jeong-Ho Kim 9. Performing Organization Name and Address 10 Work Unit No. (TRAIS)	/.					8. Peri	orming Organization	Report No.			
9. Performing Organization Name and Address University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 11. Contract or Grant No. SPR-2256 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) 21. No. of Pages 21. Price Unclassified		<u>*</u>									
University of Connecticut Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder Bridge monitoring, continuous, plate girder Unclassified 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of this page) 21. No. of Pages 21. Price Unclassified 22. No. of Pages 21. Price N/A	0						ala I India Niga (TD A IC)				
Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge (Springfield, Virginia) 22161. 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	9.	Performing Organization Name and Address				10 WO	rk Unit No. (TRAIS)				
Connecticut Transportation Institute 270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge (Springfield, Virginia) 22161. 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.		Hn	iversity of Connecticut								
270 Middle Turnpike, U-202 Storrs, Connecticut 06269-5202 13. Type of Report and Period Covered				tituta	to		ntract or Grant No.				
Storrs, Connecticut 06269-5202 13. Type of Report and Period Covered				attute		11. Co.					
12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Unclassified 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) 21. No. of Pages 21. Price Unclassified				2			SI K-2250				
12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. Price Unclassified		Dio	113, Connecticut 00207 320	~		13 Tv	ne of Report and Perio	od Covered			
Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price N/A	12	Sne	ongoring Aganay Nama and	Addragg		[13. 1y]	pe of Report and Ferre	od Covered			
Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18.Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classifi. (of this page) Unclassified 21. No. of Pages 21. Price N/A	12.	Spo	disorning Agency Name and	Address			Final				
2800 Berlin Turnpike Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price N/A		Co	nnecticut Department of Tra	neportation							
Newington, CT 06111 14. Sponsoring Agency Code SPR-2256 15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge monitoring, continuous, plate girder bridge monitoring accontinuous, plate girder bridge have bridge having a security Classified to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classified 20. Security Classific (of this page) 21. No. of Pages 21. Price Unclassified Unclassified 12 N/A				insportation	ntation		2010				
15. Supplementary Notes This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages N/A	_										
This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price N/A		110	wington, C1 00111			SP	R-2256				
This study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price N/A	15.	Sur	plementary Notes			ı					
Administration. 16. Abstract This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price N/A				ation with the	U.S. Department of Tran	sportati	on, Federal Highway				
This report describes the instrumentation and data acquisition system for monitoring of a continuous span steel plate girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. Price N/A			•		•	•					
girder bridge with a composite concrete deck located on a limited access highway. The monitoring system was developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. Price N/A	16.	Ab	stract								
developed and installed on the bridge. The limited traffic loading on the bridge resulted in significant challenges to provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge 18.Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. Price N/A	Thi	s re	port describes the instrumer	itation and dat	ta acquisition system for n	nonitori	ing of a continuous sp	an steel plate			
provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Unclassified 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages N/A	giro	der l	oridge with a composite con	crete deck loc	ated on a limited access h	ighway	. The monitoring syste	em was			
monitoring installations in Connecticut and around the country and the world were considered here. Issues with low signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages N/A	dev	elop	ped and installed on the brid	ge. The limite	ed traffic loading on the br	idge re	sulted in significant cl	hallenges to			
signal-to-noise ratios and aliasing were subsequently identified as needing to be addressed prior to any data collection for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge Bridge monitoring, continuous, plate girder through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price N/A	pro	provide high fidelity measurements of the bridge response. Additionally, lessons learned from the other bridge									
for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a measurement of environmental conditions to correlate measured responses and potential calculated damage measures. 17. Key Words Bridge monitoring, continuous, plate girder bridge No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages N/A		monitoring installations in Connecticut and around the country and the world were considered here. Issues with low									
17. Key Words Bridge monitoring, continuous, plate girder bridge 19. Security Classif. (of report) Unclassified 18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 20. Security Classif. (of this page) Unclassified 21. No. of Pages Unclassified Virginia 12 Vivaliance											
17. Key Words Bridge monitoring, continuous, plate girder bridge No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages Unclassified N/A		for vibration-based monitoring of this bridge. Further, the inclusion of temperature sensors is identified to provide a									
Bridge monitoring, continuous, plate girder bridge No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages Vice N/A	me	asur	ement of environmental cor	ditions to cor	relate measured responses	and po	tential calculated dam	nage measures.			
Bridge monitoring, continuous, plate girder bridge No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages Vice N/A	17	Key	v Words		18 Distribution Statemen	t					
bridge through the National Technical Information Service, Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) Unclassified 21. No. of Pages 21. Price Unclassified 12 N/A	1,,	•		plate girder							
Springfield, Virginia 22161. 19. Security Classif. (of report) Unclassified Unclassified Unclassified Springfield, Virginia 22161. 21. No. of Pages Unclassified Virginia 22161.				Prace Street	•						
19. Security Classif. (of report) Unclassified 20. Security Classif. (of this page) 21. No. of Pages V/A			<i>O</i> -		_			- 7			
Unclassified Unclassified 12 N/A	19.	Sec	urity Classif. (of report)	20. Secur				21. Price			
	•		` <u> </u>				_				
rothi bot i 1700.7 (6-72) Reproduction of completed page authorized	For	rm l	DOT F 1700.7 (8-72)	Reproduc		ıthorize		<u> </u>			

	<u>·</u>	N METRIC) CONVERSION FACTORS								
Symbol	When You Know	DXIMATE CONVERSIONS TO SI UNITS Multiply By To Find	Symbol							
Зуппоот	Wileli Iou Kilow		Зуппоп							
		LENGTH								
in ft	inches feet	25.4 millimeters 0.305 meters	mm m							
yd	yards	0.914 meters	m							
mi	miles	1.61 kilometers	km							
		AREA								
in ²	square inches	645.2 square millimeters	mm^2							
ft ²	square feet	0.093 square meters	m ²							
yd ²	square yard	0.836 square meters	m^2							
ac	acres	0.405 hectares	ha							
mi ²	square miles	2.59 square kilometers	km ²							
		VOLUME								
fl oz	fluid ounces	29.57 milliliters	mL							
gal	gallons	3.785 liters	L m³							
ft ³	cubic feet	0.028 cubic meters 0.765 cubic meters	m² m³							
yd ³	cubic yards		m							
	NOTE: volumes greater than 1000 L shall be shown in m ³ MASS									
OZ	ounces	28.35 grams	a							
lb	pounds	0.454 kilograms	g kg							
T	short tons (2000 lb)	0.907 megagrams (or "metric ton")	Mg (or "t")							
·	0.10.1 10.10 (2000 12)	TEMPERATURE (exact degrees)	g (5. 1)							
°F	Fahrenheit	5 (F-32)/9 Celsius	°C							
•	T differment	or (F-32)/1.8	Ü							
		ILLUMINATION								
fc	foot-candles	10.76 lux	lx							
fl	foot-Lamberts	3.426 candela/m²	cd/m ²							
		FORCE and PRESSURE or STRESS								
lbf	poundforce	4.45 newtons	N							
lbf/in ²	poundforce per square in		kPa							
	APPROX	(IMATE CONVERSIONS FROM SI UNITS								
Symbol	When You Know	Multiply By To Find	Symbol							
		LENGTH								
mm	millimeters	0.039 inches								
m			in							
	meters	3.28 feet	in ft							
m		3.28 feet 1.09 yards	in ft yd							
	meters		ft							
m km	meters meters	1.09 yards	ft yd mi							
m km mm²	meters meters	1.09 yards 0.621 miles	ft yd mi in ²							
m km mm² m²	meters meters kilometers	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet	ft yd mi in ² ft ²							
m km mm² m² m²	meters meters kilometers square millimeters square meters square meters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards	ft yd mi in ² ft ² yd ²							
m km mm² m² m² ha	meters meters kilometers square millimeters square meters square meters hectares	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres	ft yd mi in ² ft ² yd ² ac							
m km mm² m² m²	meters meters kilometers square millimeters square meters square meters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles	ft yd mi in ² ft ² yd ²							
m km mm² m² m² ha km²	meters meters kilometers square millimeters square meters square meters hectares square kilometers	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME	ft yd mi in ² ft ² yd ² ac mi ²							
m km mm² m² m² ha km²	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces	ft yd mi in ² ft ² yd ² ac mi ² fl oz							
m km mm² m² m² ha km²	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons	ft yd mi in ² ft ² yd ² ac mi ² fl oz							
m km mm² m² m² ha km² mL L m³	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet	ft yd mi in ² ft ² yd ² ac mi ² fl oz gal ft ³							
m km mm² m² m² ha km²	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards	ft yd mi in ² ft ² yd ² ac mi ² fl oz							
m km mm² m² m² ha km² mL L m³ m³	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³							
m km mm² m² m² ha km² mL L m³	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards	ft yd mi in ² ft ² yd ² ac mi ² fl oz gal ft ³							
m km mm² m² m² ha km² mL L m³ m³	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz							
m km mm² m² m² ha km² mL L m³ m³ m³ g kg Mg (or "t")	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb T							
m km mm² m² m² ha km² mL L m³ m³ m³	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds short tons (2000 lb)	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb							
m km mm² m² m² ha km² mL L m³ m³ m³ g kg Mg (or "t")	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms megagrams (or "metric to	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds short tons (2000 lb) TEMPERATURE (exact degrees)	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb T							
m km mm² m² m² ha km² mL L m³ m³ m³ g kg (or "t") °C	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms megagrams (or "metric to	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds 5m") 1.103 short tons (2000 lb) TEMPERATURE (exact degrees) 1.8C+32 Fahrenheit	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb T							
m km mm² m² m² ha km² mL L m³ m³ m³ g kg Mg (or "t")	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms megagrams (or "metric to Celsius lux candela/m²	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds short tons (2000 lb) TEMPERATURE (exact degrees) 1.8C+32 Fahrenheit ILLUMINATION 0.0929 foot-candles 0.2919 foot-Lamberts	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb T							
m km mm² m² m² ha km² mL L m³ m³ m³ g kg (or "t") °C	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms megagrams (or "metric to Celsius lux candela/m²	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds short tons (2000 lb) TEMPERATURE (exact degrees) 1.8C+32 Fahrenheit ILLUMINATION 0.0929 foot-candles	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb T							
m km mm² m² m² ha km² mL L m³ m³ m³ g kg (or "t") °C	meters meters kilometers square millimeters square meters square meters hectares square kilometers milliliters liters cubic meters cubic meters grams kilograms megagrams (or "metric to Celsius lux candela/m²	1.09 yards 0.621 miles AREA 0.0016 square inches 10.764 square feet 1.195 square yards 2.47 acres 0.386 square miles VOLUME 0.034 fluid ounces 0.264 gallons 35.314 cubic feet 1.307 cubic yards MASS 0.035 ounces 2.202 pounds short tons (2000 lb) TEMPERATURE (exact degrees) 1.8C+32 Fahrenheit ILLUMINATION 0.0929 foot-candles 0.2919 foot-Lamberts	ft yd mi in² ft² yd² ac mi² fl oz gal ft³ yd³ oz lb T							

^{*}SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

Table of Contents

Title Page	i
Disclaimer	
Technical Report Documentation Page	iii
Metric Conversion Factors	iv
Table of Contents	v
Introduction	1
Objectives and Scope of Study	2
Instrumentation and Data Acquisition	3
Analysis of Monitoring System	
Conclusions	
Acknowledgements	5
References	
LIST OF FIGURES	
Figure 1. Aerial View of the Sikorsky Bridge	
Figure 2. Sensor Locations along the Sikorsky Bridge	3

Monitoring of a Continuous Plate Girder Bridge with Load Restrictions – Route 15 over the Housatonic River in Stratford (Bridge #761)

INTRODUCTION

The Sikorsky Bridge (NBI # 761), located in the towns of Stratford & Milford, Connecticut is so named because of its proximity to the Sikorsky aircraft plant in Stratford, Connecticut. It carries Route 15 over the Housatonic River. Figure 1 shows the aerial view of the bridge. A project to replace the existing structure began in 2000, and the new bridge was opened to traffic in 2003. The total length of this bridge is 548.6 m (1800 ft), which is divided into five continuous spans, supported by structural steel plate girders with a composite concrete deck. The girders are 3.5 m (11 ft. 6 in.) deep except near the piers where they have haunches and are at a maximum depth of 4.8 m (15 ft. 9 in.). The substructure is made up of post-tensioned pier caps, concrete columns (2 columns per pier cap), and concrete footings resting on six-foot diameter drilled shafts which are embedded in rock sockets. The width of a typical span is 40.09 m (131 ft. 6 in.). There are six lanes having left and right shoulders along with a 3 m pedestrian walkway/bikeway. The bridge has a concrete deck with an asphaltic wearing surface.



Figure 1. Aerial View of the Sikorsky Bridge

Route 15 travelling over the bridge is classified as a limited access highway. Commercial vehicles, trailers, towed vehicles, busses, any vehicle that exceeds 7500 pounds, and any vehicle that exceeds twenty-four feet in length, seven feet six inches in width, and/or eight feet in height are prohibited from Route 15 (Connecticut DOT). Thus, traffic excitation on the Sikorsky Bridge is mainly due to cars.

OBJECTIVES AND SCOPE OF STUDY

The objective of this study was to use the initial bridge monitoring system developed for this load restricted bridge to expand the knowledge of the development and implementation of structural health monitoring systems on a series of bridges in Connecticut. The experiences from this particular bridge lead to the development of a set of specifications for highway bridge

structural health monitoring data (Trivedi, 2009; Trivedi and Christenson, 2009; Prusaczyk, et al., 2011; Prusaczyk, 2011). This report describes the bridge monitoring system installed and provides an analysis of the data provided by this monitoring system.

INSTRUMENTATION AND DATA ACQUISITION

The bridge monitoring system was installed in 2007. The long term monitoring system consists of 4 LVDTs (linear variable differential transformers) as displacement transducers, 22 accelerometers, 6 tilt-meters and 16 strain gages to measure expansion joint movement, bridge accelerations, pier tilts and beam strains, respectively. These sensors are located along the length of the bridge as indicated in Figure 2.

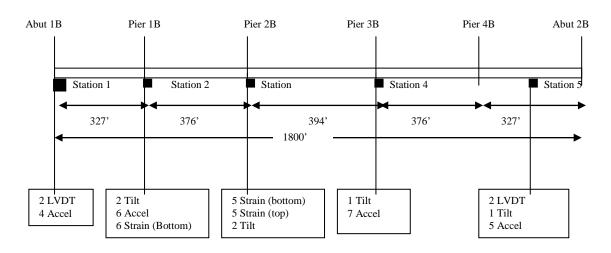


Figure 2. Sensor Locations along the Sikorsky Bridge

The accelerometers installed are PCB Inc. model 392c, which are integrated circuit piezoelectric (ICP), seismic, and uniaxial. Their measurement range is 2.5 g peak with a bandwidth of 0.01 Hz to 1200 Hz. The full bridge strain gages are manufactured by Hitec Corporation and have a

350 Ohm gage resistance. The LVDTs have a measurement range of 7.11 cm (2.8 inches) and are intended for static measurements. They are manufactured by Unimeasure. The uniaxial tilt meters have a measurement range of \pm 3 degrees and are also intended for static measurements. Applied Geomechanics manufactures these tilt meters.

There are five data acquisition boxes located along the length of the bridge collecting signals from a number of sensor channels post any signal conditioning of these sensors. The signal conditioners are DI-75B 5B module expanders manufactured by DATAQ. No anti-aliasing (AA) filters are present, and gain settings are in steps of 10, 5, 2.5 & 1.25 V. The 14-bit data acquisition units (DI-720 by DATAQ) digitize the analog signals. The data acquisition units are connected to the main computer through Ethernet Data and are accessed and analyzed remotely.

ANALYSIS OF MONITORING SYSTEM

Prior to monitoring of the bridge, an analysis of the bridge monitoring system was conducted. It was identified that the as-built system has various issues needing to be addressed. These are summarized below.

Anti-aliasing filters are not present on any of the accelerometers' measurements. Aliasing
is observed on these measurements. As a result, the acceleration data is corrupted and
not useful for any monitoring purposes. Anti-aliasing filters should be installed prior to
digitizing the acceleration signals.

- All measurements are characterized by low signal-to-noise ratios. This is a result of the long cable lengths required prior to digitizing the sensor signals, coupled with small measured responses and a 14-bit analog-to-digital converter in the data acquisition module. Multiple data acquisition modules were initially used to minimize the cable lengths as best as possible, and this cannot likely be further improved from the original design. The sensors, in particular accelerometers, can potentially be switched out for more sensitive accelerometers, with a smaller range. Additionally, the 14-bit analog-to-digital converter could be upgraded to a 16-bit or 24-bit converter.
- Temperature measurements on the bridge are not available. While the full-bridge strain sensors have temperature compensation, the displacement measurements of the abutment would be further enhanced with a temperature measurement. Further, it has been shown that environmental conditions, mainly temperature, can affect various calculated damage measurements in bridge health monitoring. Surface mounted temperature transducers are suggested to enhance the existing monitoring system.

CONCLUSIONS

A bridge monitoring system was successfully installed on a continuous span steel plate girder bridge with a composite deck and load restrictions. An analysis of the bridge monitoring system identified issues with aliasing, low signal-to-noise ratios and no temperature measurements. Prior to monitoring the performance and structural health of the bridge, these issues will need to be resolved.

ACKNOWLEDGEMENTS

This report was prepared by the University of Connecticut, in cooperation with the Connecticut Department of Transportation and the United States Department of Transportation, Federal Highway Administration. The opinions, findings and conclusions expressed in the publication are those of the authors and not necessarily those of the Connecticut Department of Transportation or the Federal Highway Administration. This publication is based upon publicly supported research and is copyrighted. It may be reproduced in part or in full, but it is requested that there be customary crediting of the source.

The support of the Connecticut Transportation Institute, University of Connecticut, is gratefully acknowledged. The authors gratefully acknowledge the Federal Highway Administration and the Connecticut Department of Transportation for funding of this project through the State Planning and Research (SPR) program, project SPR 2256. The authors would like to express our gratitude for outstanding work by Connecticut Department of Transportation employees to make this work possible. The authors are grateful for the work of the other graduate students who have been involved in the full monitoring project. Some have made contributions to the monitoring of this specific bridge.

The U.S. Government and the Connecticut Department of Transportation do not endorse products or manufacturers.

REFERENCES

Prusaczyk, S., Christenson, R. E., DeWolf, J. and Jamalipour, A. "Proposed Data Specifications for Bridge Structural Health Monitoring Sensor Data," Structures Congress & Exposition, Las Vegas, NV, May 2011.

Prusaczyk, S. (2011). "Data Qualification for the Connecticut Bridge Monitoring Network," thesis presented to the Graduate School, University of Connecticut, Storrs, Connecticut, in partially fulfillment of the requirements for the Master of Science Degree.

Trivedi, H. (2009). "Development of a Data Qualification and Error Quantification Procedure for Bridge Monitoring Systems in Connecticut," thesis presented to the Graduate School, University of Connecticut, Storrs, Connecticut, in partially fulfillment of the requirements for the Master of Science Degree.

Trivedi, H. and Christenson, R. E. "Data Qualification and Error Quantification for Bridge Monitoring Systems in Connecticut," International Workshop on Structural Health Monitoring, Stanford University, Stanford, CA, September 2009.