Report No. KS-04-4
FINAL REPORT

LATERAL DISTRIBUTION IN KANSAS DOT STEEL GIRDER BRIDGE WITH FRP DECK

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AUGUST 2005

KANSAS DEPARTMENT OF TRANSPORTATION

Division of Operations
Bureau of Materials and Research

1 Report No. KS-04-4	2 Government Accession No.	3 Recipient Catalog No.
4 Title and Subtitle LATERAL DISTRIBUTION IN KANSAS DOT STEEL GIRDER BRIDGE WITH FRP DECK		5 Report Date August 2005 6 Performing Organization Code
7 Author(s) John Schreiner and Michael Barker*, Ph.D., P.E.		8 Performing Organization Report No.
9 Performing Organization Name and Address University of Missouri – Columbia Columbia, MO 65211 *Current affiliation, University of Wyoming		10 Work Unit No. (TRAIS) 11 Contract or Grant No. C1022
12 Sponsoring Agency Name and Address Kansas Department of Transportation Bureau of Materials and Research 700 SW Harrison Street Topeka, Kansas 66603-3754		13 Type of Report and Period Covered Final Report August 1997 – October 2004 14 Sponsoring Agency Code RE-0132-01
15 Supplementary Notes For more information write to address in block 9.		

16 Abstract

The objective of this study is to compare the lateral load distribution (lateral stiffness) characteristics of a 14-girder bridge with corrugated metal decking with asphalt wearing surfaces to the same bridge after the original deck was replaced with a Fiber Reinforced Polymer (FRP) deck (polymer concrete wearing surface). These comparisons were developed by field testing the Crawford County Bridge 031 prior to and after the deck rehabilitation. Simple dynamic allowance tests were also conducted. The bridge 031 used in this experiment is located near Pittsburg Kansas on K-126.

All fourteen steel girders were instrumented with strain gages at mid-span along the longitudinal centerline of each girder and running diagnostic tests on the strain gages before truck loading. These wires were all connected to the data acquisition system onboard the University of Missouri's Civil Engineering Bridge Field Test Vehicle. Kansas DOT supplied a loaded truck for each deck test. Two types of tests were performed on the bridge systems: static and dynamic. The data was evaluated to determine when the bridge was experiencing maximum global stress. Lateral distribution of stress was computed, and a summary of maximum values has been provided.

The results of the study indicated that the simple dynamic tests are not to be used for decisions or conclusions for dynamic allowance. Testing also indicated very little change in the load distribution between the original deck system and the FRP deck system.

17 Key Words Bridge Deck, Fiber Reinforced Polymer, FRP, Girder, Steel and Strain Gage.		18 Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19 Security Classification (of this report) Unclassified	20 Security Classification (of this page) Unclassified	21 No. of pages 26	22 Price

Form DOT F 1700.7 (8-72)

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Final Report

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A Report on Research Sponsored By

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TOPEKA, KANSAS

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ABSTRACT

The objective of this study is to compare the lateral load distribution (lateral stiffness) characteristics of a 14-girder bridge with corrugated metal decking with asphalt wearing surfaces to the same bridge after the original deck was replaced with a Fiber Reinforced Polymer (FRP) deck (polymer concrete wearing surface). These comparisons were developed by field testing the Crawford County Bridge 031 prior to and after the deck rehabilitation. Simple dynamic allowance tests were also conducted. The bridge 031 used in this experiment is located near Pittsburg Kansas on K-126.

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INTRODUCTION

The objective of this project was to compare the lateral load distribution (lateral stiffness) characteristics of a 14-girder bridge with corrugated metal decking with 10 to 12 in. asphalt wearing surfaces to the same bridge after the original deck was replaced with a Fiber Reinforced Polymer (FRP) deck (total thickness 5 in. and 0.5 in. polymer concrete wearing surface). These comparisons were developed by field testing the bridge prior to and after the deck rehabilitation. In addition, simple dynamic allowance tests were also conducted. The Bridge used in this experiment was Crawford County Bridge 031. While the testing was performed on only bridge 031, bridge 035 is of identical design. The bridge design parameters for bridge 031 and 035 were as follows: the beams are W21 x 68, with a spacing of 27 in. The bridge deck before replacement was, basically, 45 ft long and 30 ft wide. The final replacement deck is 32 ft wide. Roadway width was increased from 28.5 ft to 30.5 ft. This change of bridge width was the only major change in the design dimensions of the bridge deck. Bridges 031 and 035 are located six and one miles west of K-7, respectively near Pittsburg Kansas on K-126.

TEST SETUP

Before the actual load tests could be performed, several steps had to be taken in preparation.

- Planning – Gage all girders so lateral distribution could be determined. This involved instrumenting all fourteen girders with strain gages at mid-span and running diagnostic tests on the strain gages before truck loading.
- Scaffolding – Various scaffolding systems were constructed below the bridge girders because they could not be reached from the ground surface. They consisted

of both a ladder and a hanging assembly (Figure 1), which was attached to the girder flanges.

- Grinding – The bottom of the bridge girders had to be prepared prior to application of the strain gages. Grinders were used on each girder at mid-span to remove paint and debris, obtaining a clean metal surface.

FIGURE 1: Scaffolding Used in January Test

- Gage Layout – Strain gages were positioned precisely at mid-span and along the longitudinal centerline of each girder. Measurements were made and marks were placed on each girder to allow for precise positioning.
- Gage Placement – Each weldable strain gage was attached to the flange face through the use of a weldable gage spot welder. Gages were welded with a pattern of ninety-six spot welds around their perimeter. The application of a strain gage is being performed in Figure 2 and a picture of the welded gage is shown in Figure 3.

FIGURE 2: Spot Welding of Strain Gage onto Flange

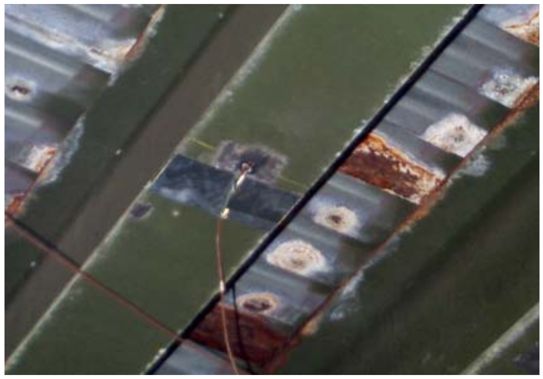

FIGURE 3: Welded Strain Gage

- Instrumentation Wires – Once the strain gages had been installed, wires were attached to each gage, taped to remove slack, and connected into a collector box. The instrumentation wires attached to the strain gage can be seen in Figure 4. These wires were all connected to the data acquisition system onboard the University of Missouri's Civil Engineering Bridge Field Test Vehicle (Figure 5).

FIGURE 4: Instrumentation Lines Attached to Gages

FIGURE 5: University of Missouri's Civil Engineering Bridge Field Test Vehicle

- Load Pattern Layout – A series of lines were painted on the surface of the bridge deck spaced at two-foot intervals (Figure 6). The first of these lines was positioned so the right front tire of the loaded truck would travel directly across the centerline of the first interior girder. Adjacent lines were then spaced laterally across the

FIGURE 6: Load Pattern Layout on Bridge Deck

bridge deck using the first line as a datum and allowing enough room for ten load passes. The layout for the load passes can be seen in Figure 7.

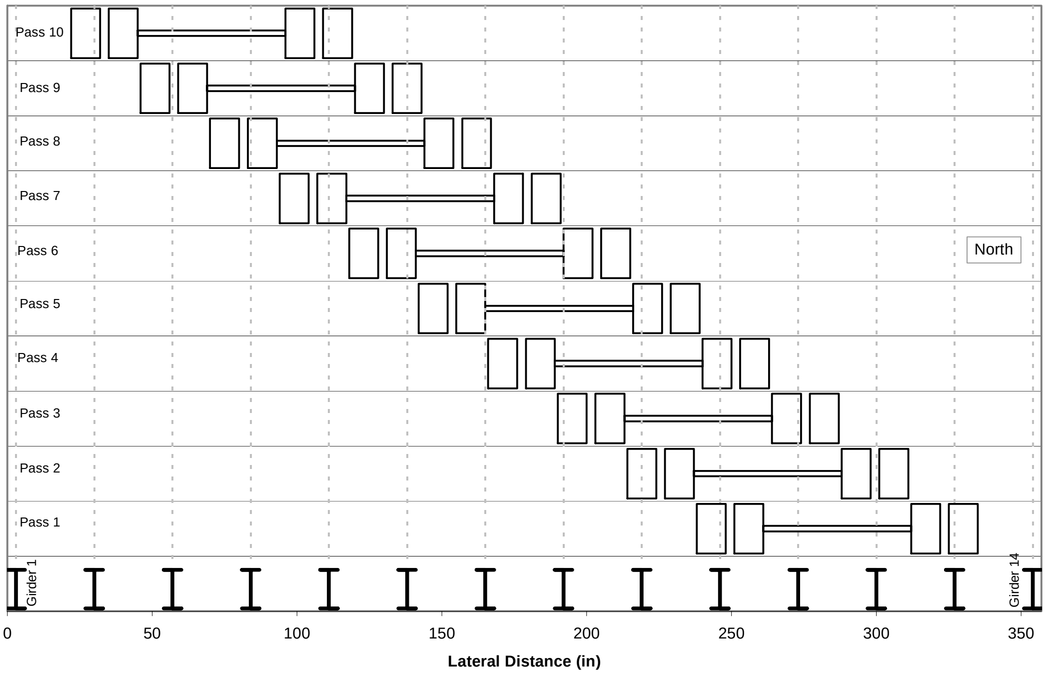

FIGURE 7: Lateral Load Position Layout

- Test Vehicles – Kansas DOT supplied a loaded truck for each deck test. Upon arrival, trucks were weighed with portable digital scales. Figures 8 shows the truck used in the first original deck test. Figure 9 shows the truck used in the second FRP deck test being weighed.

FIGURE 8: Test Load for Original Deck Approximately 78,400 lbs

FIGURE 9: Test Load for FRP Deck Approximately 47,800 lbs

TEST PROCEDURE

Two types of tests were performed on the bridge systems: static and dynamic. The static tests consisted of driving the loaded vehicle across the bridge at crawl speed, following the longitudinally painted lines with the left front tire. Crawl speed was as slow as the truck could travel without applying the brakes. Ten passes were made and ten sets of data were recorded for each deck configuration. The dynamic load tests consisted of driving the loaded vehicle across the bridge at crawl speed, 25 mph, and 50 mph. The driver was to position the vehicle in the center of the driving lane as the truck passed across the bridge (maximizing stresses in Girders 9, 10, & 11 ~ Pass 4 in Figure 7). Illustrations of the loading tests in progress are shown in Figures 10 and 11. Tests on the original deck were performed on September 11, 1999, and tests on the FRP deck on January 4, 2000.

FIGURE 10: Test in Progress on Original Deck

FIGURE 11: Test in Progress on FRP Deck

RESULTS

From the static load tests, ten graphs (Figures 12-21) have been created that illustrate the lateral stress distribution at maximum loading across the girders for each truck pass. Both data from the original deck and the FRP deck are shown for comparison. Each graph illustrates the transverse location of the rear axle line. The tests were run so the right front tire of the truck was positioned directly over Girder 13 on the first pass. Figure 7 displays the lateral position of all ten truck passes on the deck.

An illustration of data for one static test run can be seen in Figure 22. These values are the calculated stresses recorded at mid-span of each girder during pass 2 on the original deck. Stresses were calculated by taking the strain reading minus the average of the first few strain readings, multiplied by a strain gage factor and by the modulus of elasticity. Subtracting the initial readings yields the live load stresses from the vehicle.

$$\sigma = (\varepsilon - \text{average}(\varepsilon_{\text{initial}})) \times (\text{gage factor}) \times (E) \qquad \text{(Equation 1)}$$

Stress values for each time increment were then added to find when the bridge was experiencing maximum global stress. Figure 22 shows, with a vertical line, where this occurred. This maximum global stress position was used to develop the lateral stress distribution plots. The lateral distribution (DF) values plotted are equal to the actual stress on a particular girder divided by the sum of the stresses on all the girders.

$$DF_i = (\sigma_{girder\ i}) / (\Sigma\ \sigma_{girder\ 1\text{-}14}) \qquad \text{(Equation 2)}$$

From the dynamic load tests, six graphs (Figures 23-28) have been provided that show the actual stress experienced by girders 9, 10, and 11. Figure titles denote deck material and speed for the plotted data. Stresses were calculated in the same manner as those for the static tests.

SUMMARY

Bridge testing on concrete and FRP decking materials was performed. Fourteen steel girders were instrumented with strain gages and data from static and dynamic load testing were recorded. Lateral distribution of stress was computed and the results are plotted in Figures 12-21 and Figures 23-28. A summary of maximum values has been provided in Table 1. Testing also indicated very little change in the load distribution between the original deck system and the FRP deck system. The simple dynamic tests are not to be used for decisions or conclusions for dynamic allowance.

TABLE 1: Maximum Values from Load Tests

	Original Deck	FRP Deck
Maximum DF for Interior Girder	0.238	0.226
Maximum DF for Exterior Girder	0.153	0.141
Maximum IMP	< 1.0	1.08

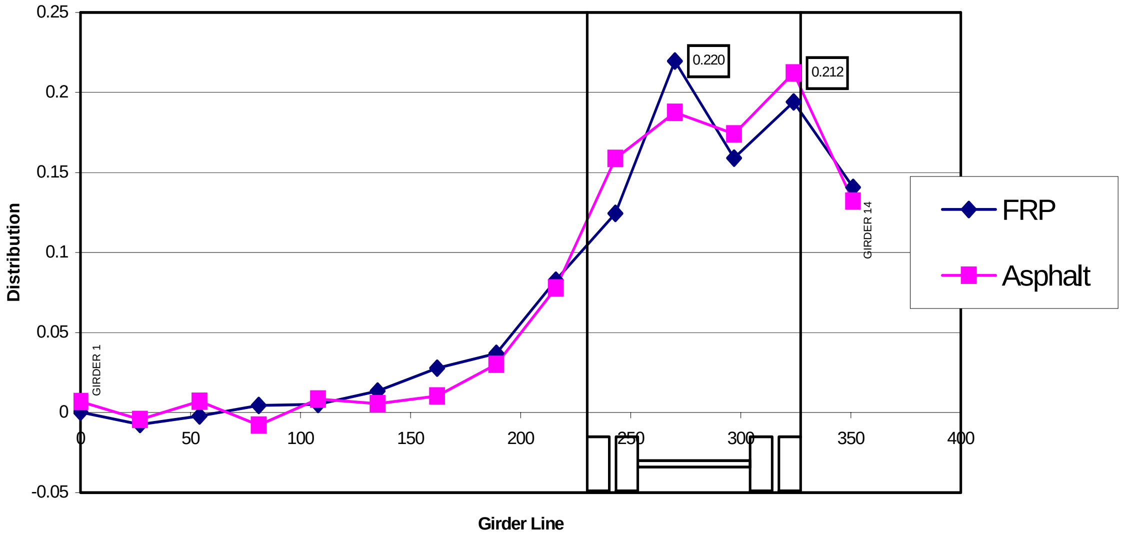

FIGURE 12: Lateral Distribution Load Position 1

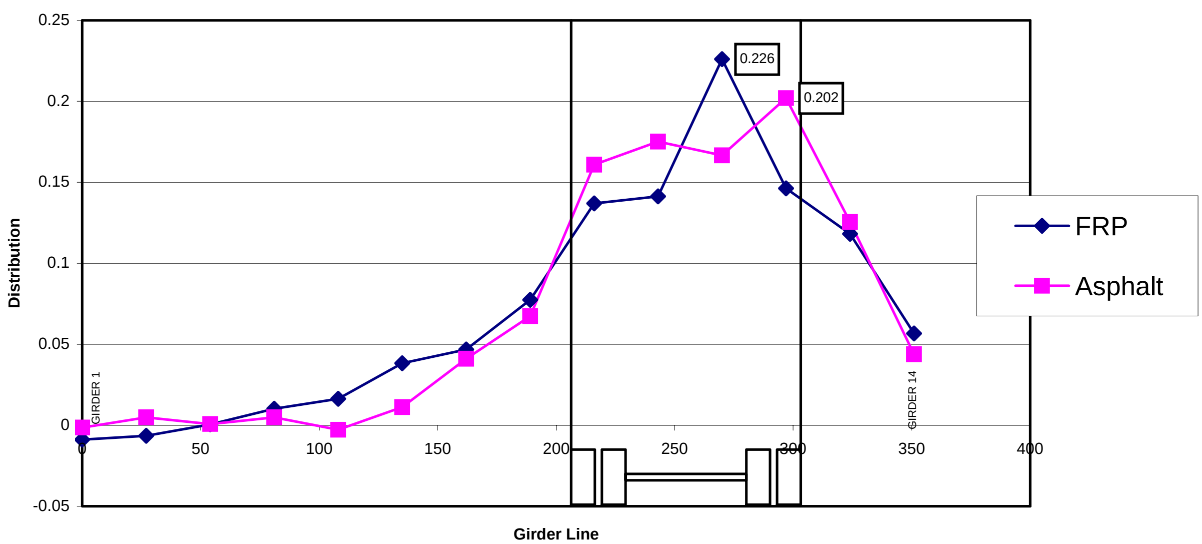

FIGURE 13: Lateral Distribution Load Position 2

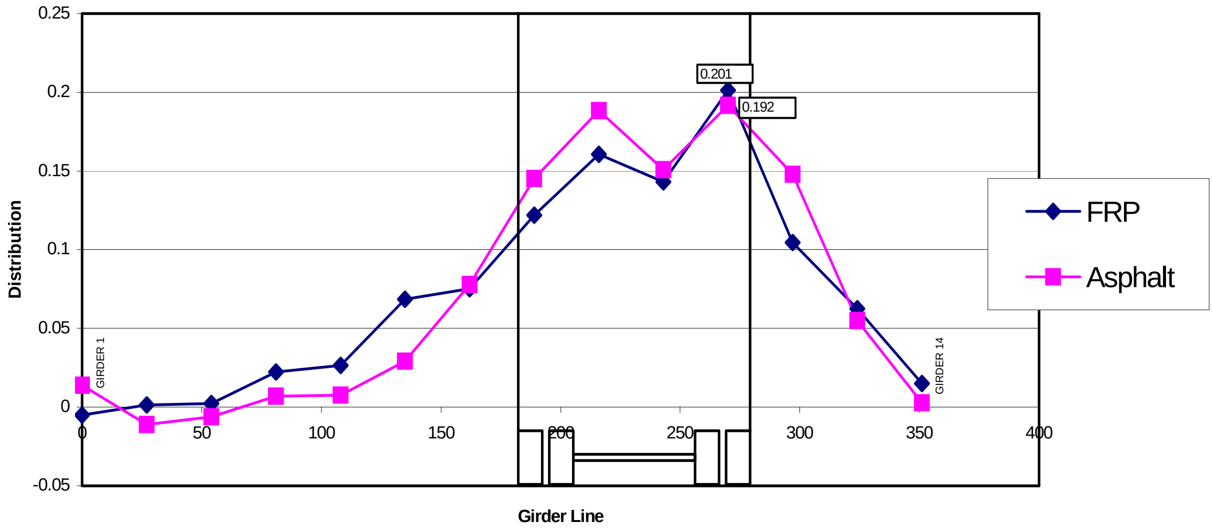

FIGURE 14: Lateral Distribution Load Position 3

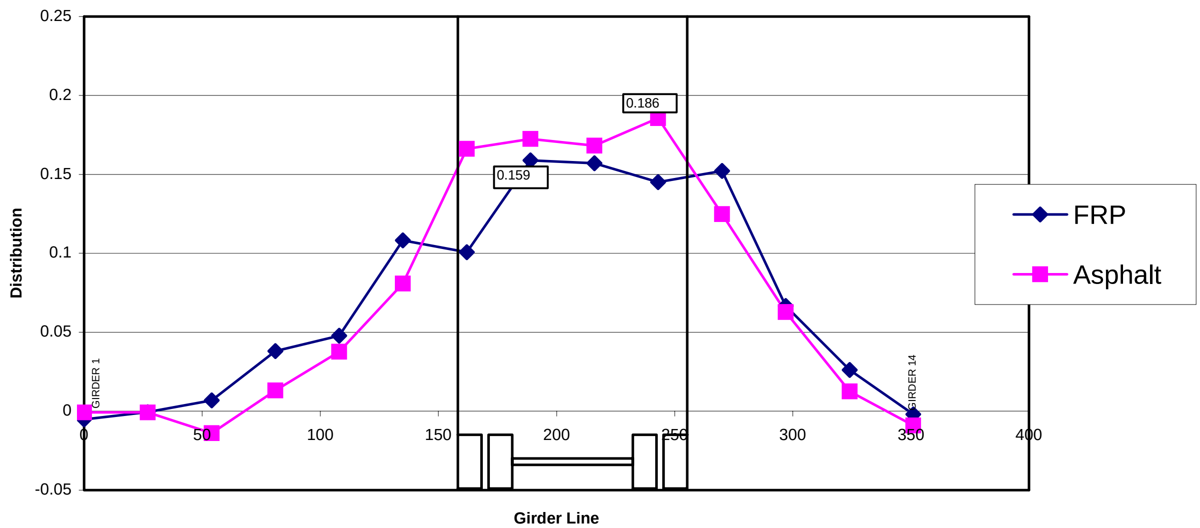

FIGURE 15: Lateral Distribution Load Position 4

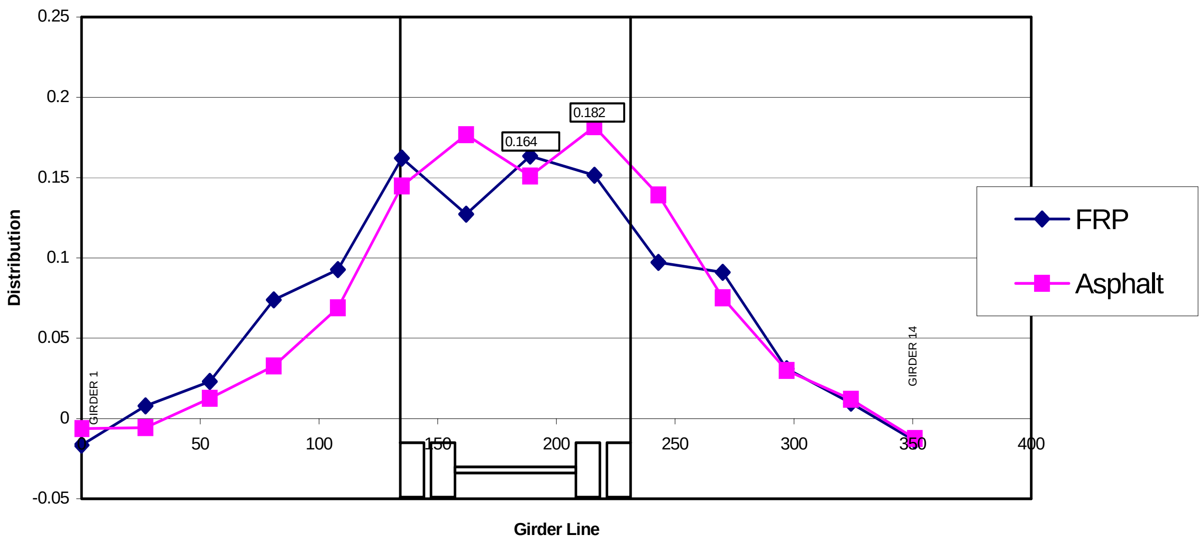

FIGURE 16: Lateral Distribution Load Position 5

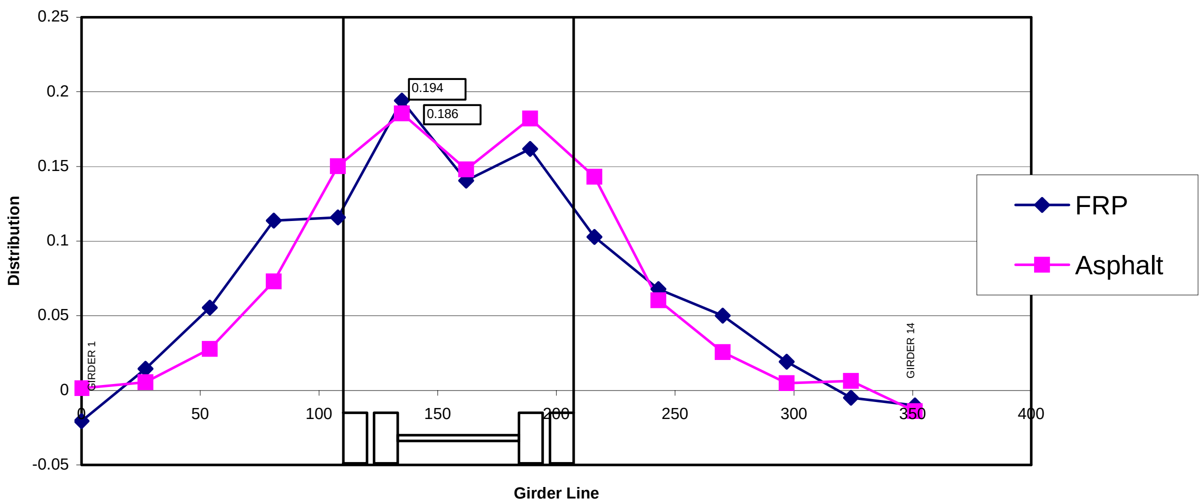

FIGURE 17: Lateral Distribution Load Position 6

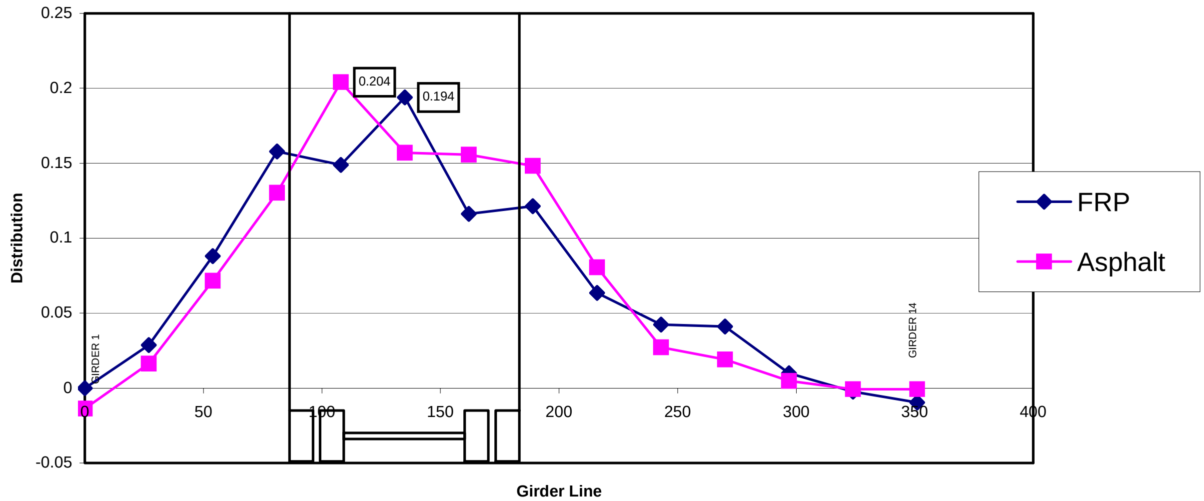

FIGURE 18: Lateral Distribution Load Position 7

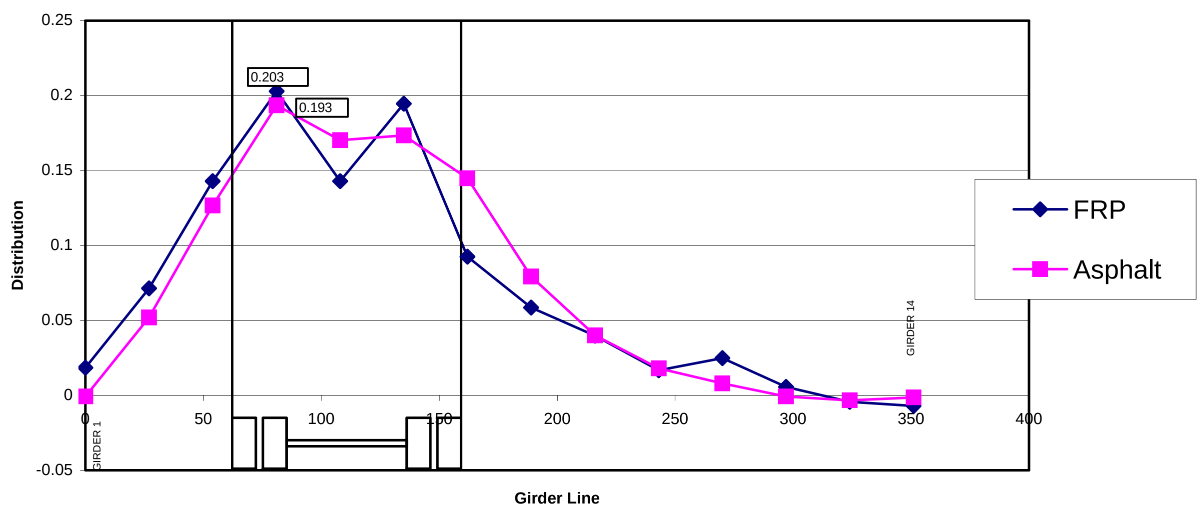

FIGURE 19: Lateral Distribution Load Position 8

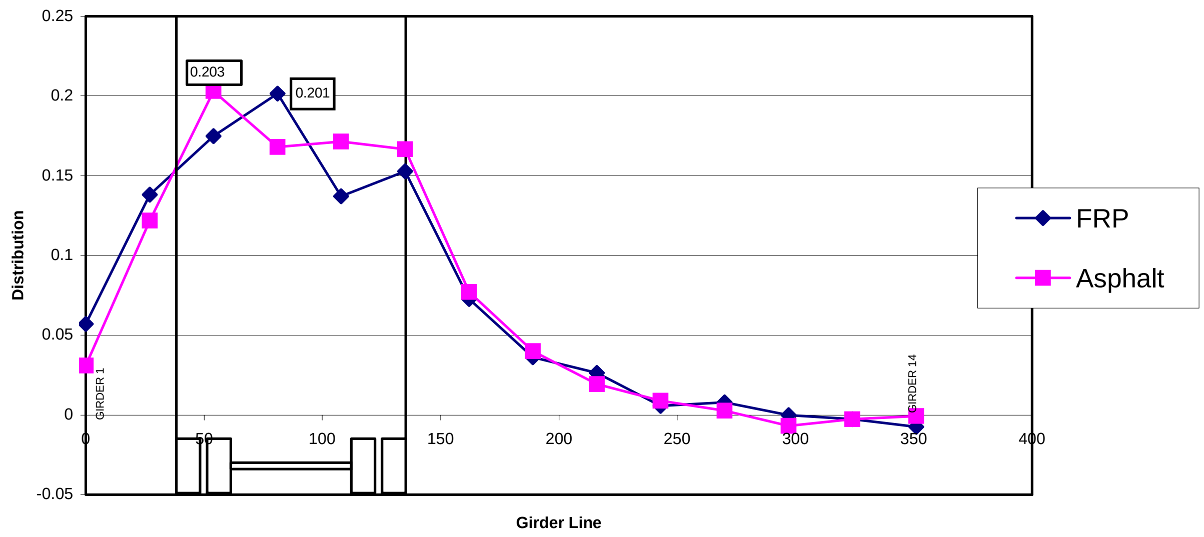

FIGURE 20: Lateral Distribution Load Position 9

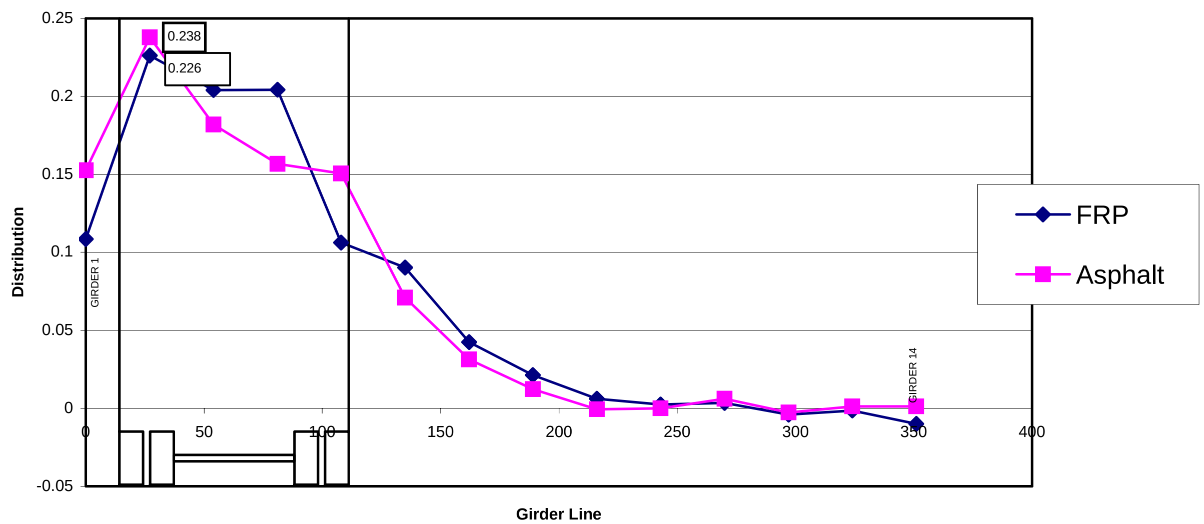

FIGURE 21: Lateral Distribution Load Position 10

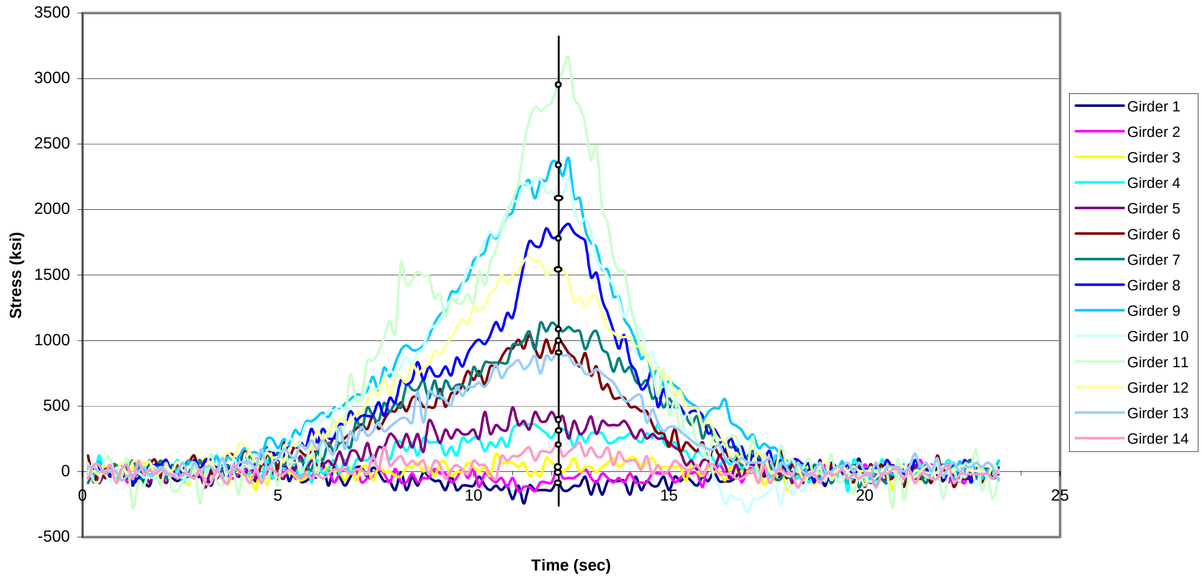

FIGURE 22: Values for Stress Distribution Plots

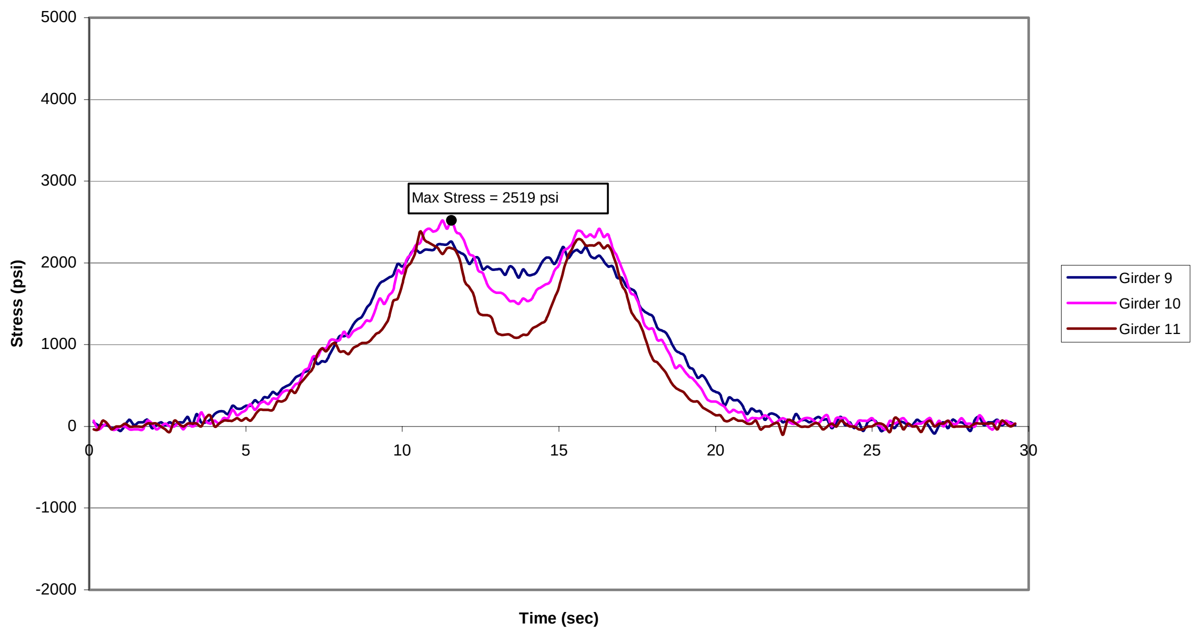

FIGURE 23: Stress for Original Deck, Crawl Speed

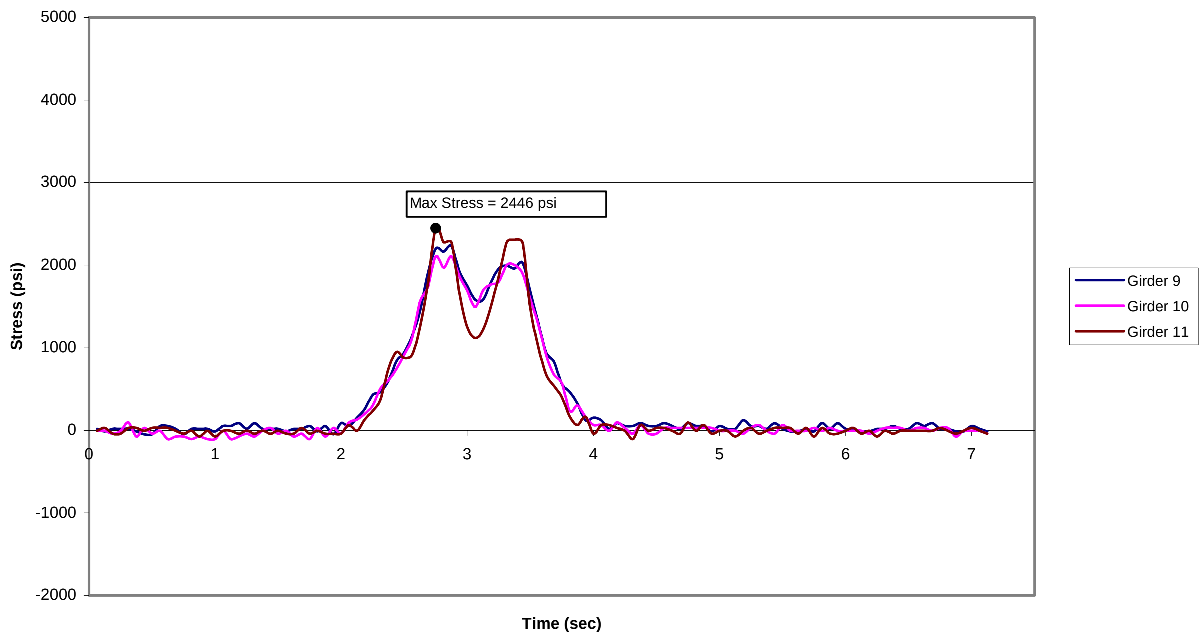

FIGURE 24: Stress for Original Deck, 25 mph

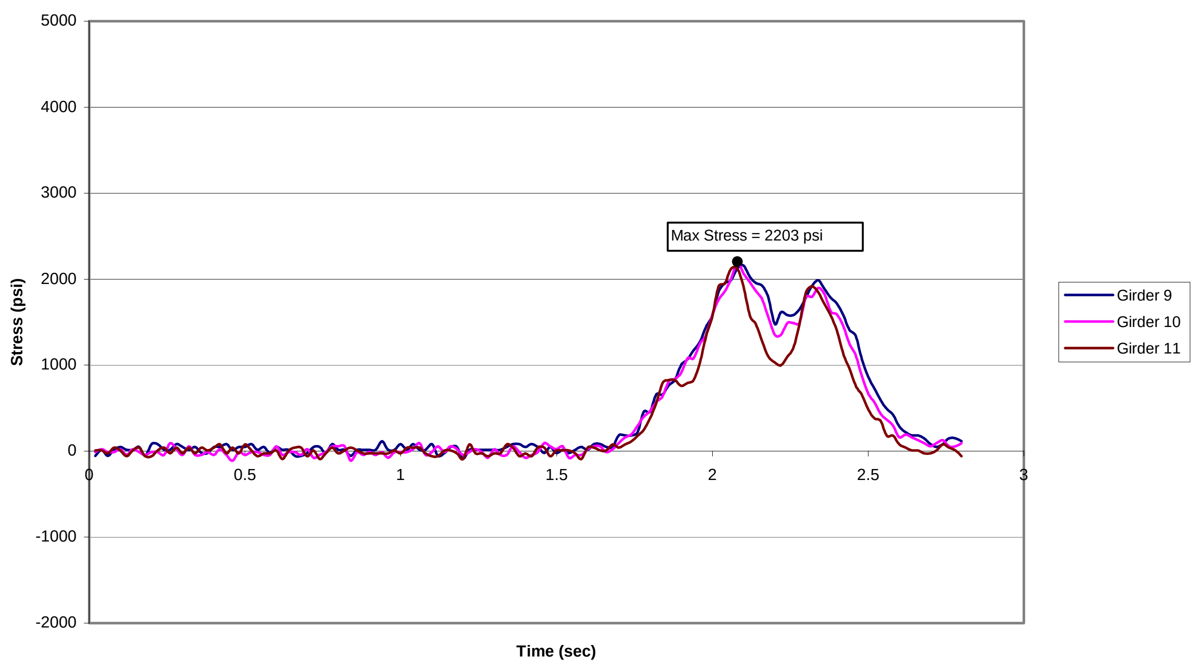

FIGURE 25: Stress for Original Deck, 50 mph

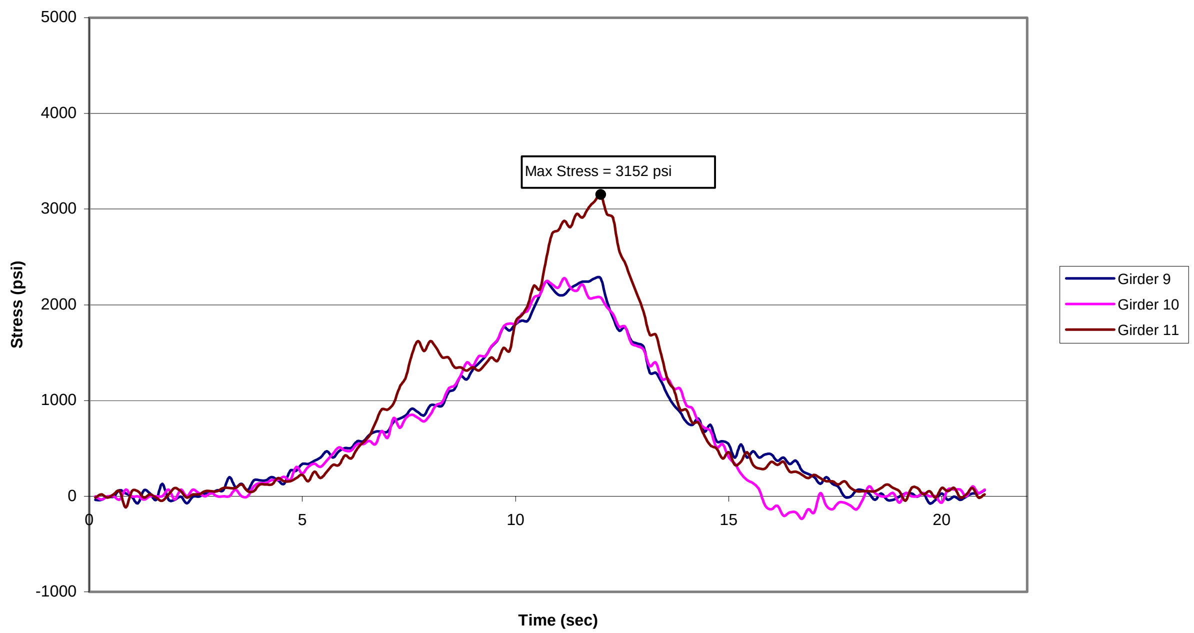

FIGURE 26: Stress for FRP Deck, Crawl Speed

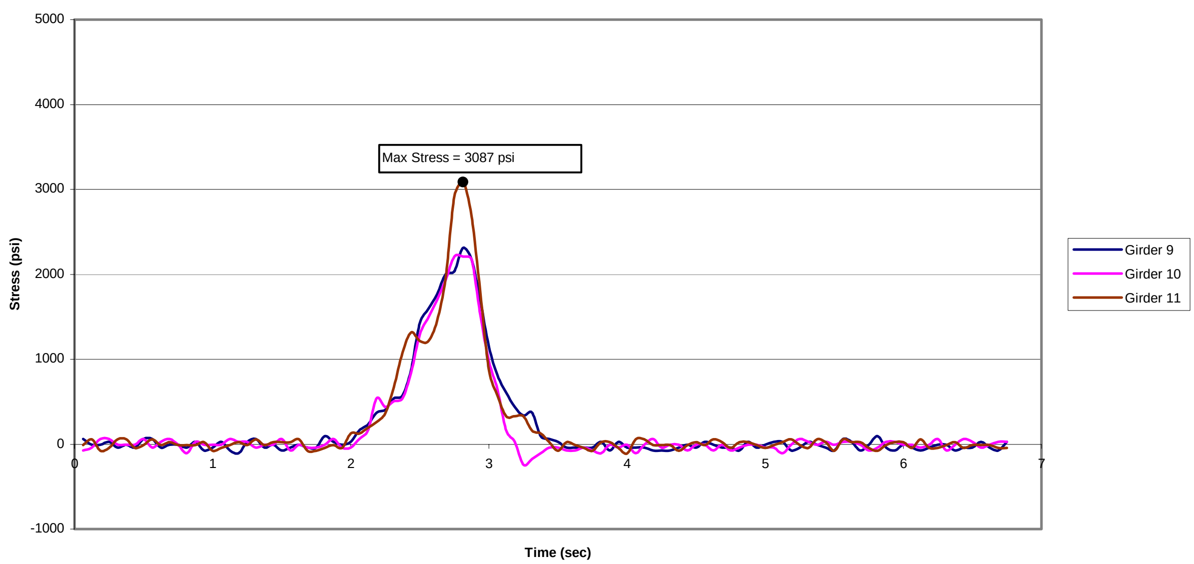

FIGURE 27: Stress for FRP Deck, 25 mph

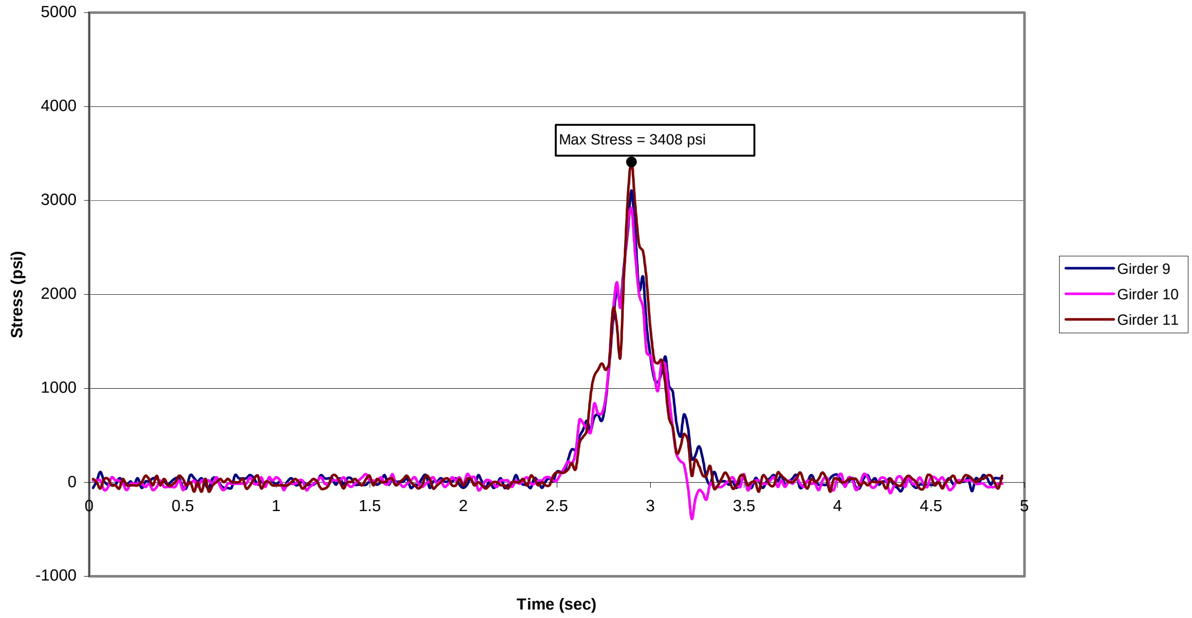

FIGURE 28: Stress for FRP Deck, 50 mph