Load Testing a Temporary Railcar Bridge over Bee Tree Creek in Swannanoa, NC

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May 12, 2026

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RESEARCH & DEVELOPMENT

Condition and Behavior of Temporary Railcar Bridges: Load Testing a Temporary Railcar Bridge over Bee Tree Creek in Swannanoa, NC

FINAL REPORT

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16. Abstract

Extensive damage to the Western North Carolina road network caused by Hurricane Helene in September of 2024 necessitated the rapid installation of many temporary bridges constructed from flatbed railroad cars. As of late 2025, at least 33 temporary structures remained in North Carolina that rely on railcars as primary structural elements. Maintaining the safety and functionality of this collection of temporary structures is necessary as permanent bridge replacements will take significant time to implement. As such, detailed inspections, including numerical models, are required to facilitate decision-making about the load capacities of these railcar structures. Inspections and modeling will also inform decisions about whether specific repairs or upgrades are required to improve or maintain load carrying capacities. In addition, as railcars comprising these temporary structures are removed from service, NCDOT plans to catalog and store them in maintenance yards for possible future use. Thus, detailed information on the load capacity of each railcar is useful, both now and in the future.

This Technical Assistance Request (TAR) supported collection and analysis of the initial field data necessary to characterize the condition and behavior of existing temporary railcar bridges. The data are also useful for others developing a detailed three-dimensional finite element model (FEM) that will be used to load rate these types of bridges.

A physical load test was conducted on a railroad flatcar bridge in Swannanoa, NC to determine the global behavior and to measure strain in key components. Data collected from field testing will be used to improve rating techniques.

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EXECUTIVE SUMMARY

As a result of Hurricane Helene in late 2024, the spanning members of nearly three dozen temporary bridges in Western North Carolina (WNC) are currently comprised fully or partially of repurposed flatbed railroad cars. Many of these bridges will need to stay in operation for years before permanent replacements can be completed, necessitating a detailed study of these temporary structures, especially from the perspective of load rating. The bulk of published prior work by others on railroad flatcar (RRFC) bridges is generally focused on permanent structures with composite concrete decks, which the temporary structures in WNC do not have. Additionally, prior work on RRFC bridges that does comprise cars with non-composite steel or timber decks and/or non-composite asphalt wearing surfaces is generally focused on RRFCs of a somewhat different geometry and/or span than the RRFCs currently in use in WNC. To develop methods and tools to facilitate the reliable load rating of temporary railroad flatcar bridges of the type currently in widespread temporary service in Western North Carolina, this preliminary study examined the behavior of one typical railcar bridge. Static and dynamic load tests were conducted in the field in Swannanoa, NC. The effects of vehicle weight and position of load were investigated by using two different known vehicle weights and collecting data at different lane positions and distances along the bridge. The results demonstrated that the railcars act compositely when connected with welded plates and the members remained elastic with a vehicle weight of 40 kips. The methods used for load testing these bridges will be expanded in future work to load rate the wide range of RRFC bridges in Western North Carolina.

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Chapter 1. Introduction

Since Hurricane Helene in late 2024, at least 33 temporary bridges have been deployed in North Carolina that rely on flatbed railcars as their primary structural elements. Many of these structures remain in service as of the end of 2025. This report documents load tests conducted on one of these bridges to collect data for characterizing structural behavior and for validating finite element models being developed elsewhere.

1.1. Objective

The objective of the load testing program was to gather field data on temporary railcar bridges sufficient to characterize the fundamental behavior of the structure and to support the separate development of finite element models of these kinds of temporary structures.

1.2. Scope

On December 16th 2025, load tests were conducted in the field in Swannanoa, NC by the Constructed Facilities Laboratory at North Carolina State University. A single lane temporary bridge, NCDOT Buncombe County Structure 203, was tested. Six static load tests were conducted with two different vehicle weights and three different lane positions. For each test, a vehicle was driven eastward in 10 ft. increments along the length of the bridge. Additional data were collected with dynamic loads applied by traffic moving at speed. Dynamic data were recorded for the two known vehicle weights as well as for other traffic of unknown weights observed crossing the structure.

Chapter 2. Literature Review

The Departments of Transportation from several states including Arkansas, Iowa, and Indiana have completed significant studies on various aspects of railroad flatcar (RRFC) bridges, including permanent and temporary structures. Those three states in particular have significant numbers of RRFC bridges in their permanent inventories on rural low-volume roads. Key reports and studies from these states are listed in the References section, with significant work dating as early as 1991.

Examples of RRFC bridges in each of those states are reproduced in Figure 2 through Figure 4 below. In reviewing photographs of RRFC bridges in other states, it is important to note how different these bridges are from the RRFCs currently in service in WNC. Prior works on RRFCs, including rating methods, envision RRFC bridges much more similar to examples in the following photos than to the examples in WNC shown in Figure 1.

Figure 5 shows an experimental test conducted at Purdue University, reproduced from their 2015 final test report. This laboratory testing represents some of the most detailed and most recent work conducted on RRFC bridges, but considers structures that differ in significant ways from the temporary WNC bridges.

Figure 1. Temporary RRFC bridges in WNC in Swannanoa (left) and near Burnsville (right)

Figure 2. Permanent RRFC Bridge in Indiana Supported at Original Truck Supports (from TR-2-2013)

Note how the cross-section differs from the temporary WNC bridges.

Figure 3. Permanent RRFC Bridge with a Short Span, Timber Deck, and no Railings on an Unimproved Road in Iowa (reproduced from TR-421)

Note the short span, inset bearing locations, and different cross section relative to the WNC temporary RRFC bridges.

Figure 4. Permanent RRFC Bridge in Iowa Made from a 56’ Long V-Deck Flatcar (from TR-498)

Note the short span and different cross section relative to the WNC temporary RRFC bridges.

Figure 5. Significant Previous Experiments at Purdue University on Two Adjacent RRFCs, Prior to Adding a Composite Concrete Deck. Reproduced from the 2015 Purdue Phase III Final Report.

Note the 47’ support span, supports inset at the truck mounts, and lack of an integral deck.

In general, most prior studies envision railroad flatcars in permanent service supported on a span much less than 90 ft. Recent work recommends composite concrete decks and spans of 65 ft. or less. Existing, excellent works on load rating RRFC bridges do not exactly apply to the temporary bridges currently in service in WNC which have long spans, integrated steel plate flooring, bent-plate side sills, and non-composite wearing surfaces.

One challenge in investigating the temporary RRFC bridges in WNC is a lack of accurate engineering drawings for the older flatcars. Some historical technical drawings of RRFCs do exist (see Figure 6), however, details are generally lacking, and railcars as found in the field do not exactly match the details provided on a given drawing. Anecdotal discussions with individuals in the railroad industry have indicated that there are currently several manufacturers of RRFCs, there have been many more manufacturers historically, and there is not one standard flatcar design that applies to all railcars. Many types of RRFC exist, and while the general design of a given type is specified, many variants of each type exist with different structural design varying from batch to batch. As such, a “railcar” bridge has many different specific meanings from a structural standpoint, as confirmed by the figures of various RRFC bridges in other states presented above.

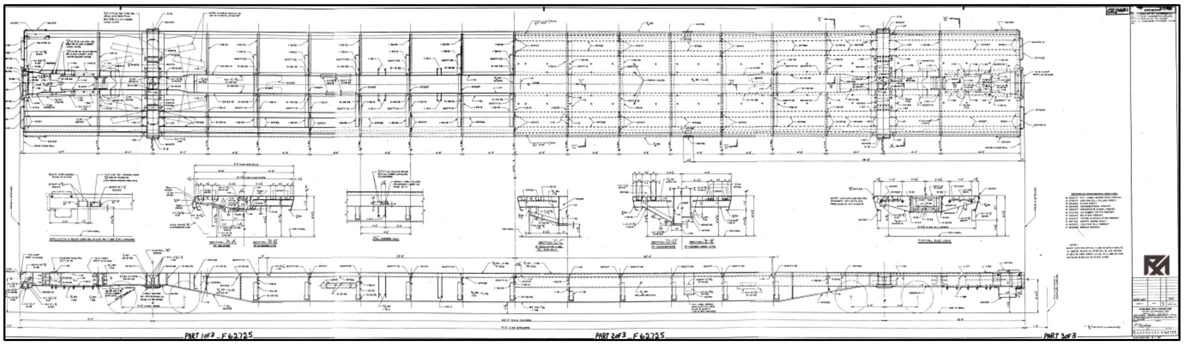

Figure 6. Example Engineering Drawing of an "FM" 90' Flatcar by Bethlehem Steel Corp.

Analysis of RRFC bridges is made easier by the increased availability of high-end computational resources which make three-dimensional numerical analysis of full-scale structures and bridges increasingly feasible. The tools of 3D Finite Element (FE) modeling have been used in recent years to great success to gain new insights in bridge behavior. Three-dimensional FE models have been recently used to assess the accuracy of AASHTO's Conventional Load Rating procedure, which relies on 2D beam theory. A number of researchers have concluded that 3D modeling better-accounts for the three-dimensional effects of load distribution across the bridge width and leads to significantly higher load ratings (Sanayei et al. 2015). A comprehensive study of reinforced concrete flat-slab and T-beam bridges using 3D FE models (Ravazdezh et al., 2021) revealed that nonstructural members such as railings significantly affect stress distribution across the width, leading to lower demands and significantly higher load ratings for reinforced concrete bridges.

These findings on the utility of 3D FEM are implemented in a revised load rating procedure by the Indiana Department of Transportation. Given the non-traditional and relatively complex configuration of RRFC bridges, and particularly those in temporary service in WNC, 3D FE modeling provides detailed insights into demand distribution and load carrying capacity for these bridges under different loading conditions.

Chapter 3. Test Program

The field-testing program consisted of several load tests of the temporary rail car bridge on Warren Wilson Road in Swannanoa, NC that crosses Bee Tree Creek. This single-lane bridge, shown in Figure 7, consisted of two adjacent railcars spanning 82 feet. Both railcars were supported directly on the original concrete end bents with new concrete filling the original girder pockets. A welded steel jumper plate joined the decks of the two cars with a thin asphalt topping comprising the wearing surface. Steel barrier rails completed the structure which is currently posted at a weight limit of 15 tons. The two flatbed railcars comprising the spanning elements of the structure are identified in this report as the South Car and the North Car based on their positions relative to Warren Wilson Road, which runs generally east-west.

Figure 7. Temporary railcar bridge in Swannanoa, NC (Buncombe #203)

View looking west from below (left); View looking east along Warren Wilson Road (right)

3.1. Test Setup

The bridge was instrumented with string potentiometers to measure the vertical deflection of the structure at selected locations. To determine the displacement profile across the width of the bridge at midspan under different loading conditions, measurements were taken at the center (mid-width) and at each edge of each rail car, for a total of 6 string potentiometers located at the midspan of the bridge. An additional string potentiometer was placed towards the west end of the South Car at the mid-width of this car, where it tapers to a shallower section. Weldable strain gages were installed next to each string potentiometer to measure the longitudinal tensile strain in the extreme fiber at each location of interest. The typical instrumentation and instrumentation layout is shown in Figure 8 through Figure 10.

Figure 8. Strain gage (blue arrow) and string potentiometer (red arrow) at a typical measurement location

Figure 9. Measurement locations at the structure midspan (yellow circles and one yellow arrow)

Figure 10. Measurement location at the west end (yellow circle) and arrangement of the data acquisition system (yellow arrow)

Engine #61 of the Swannanoa Fire Department was used to apply the load. The firetruck was filled with 1500 gallons (12,500 lbs.) of water and had a total measured weight of 40,040 lbs., distributed as 10,060 lbs. on the front axle and 29,840 lbs. in the rear axle. All three weights were measured on a truck scale at a local quarry with the measured front and rear axle weights summing to within 150 lbs. of the total measured weight. The front steering axle measured 7’-7” in overall outer width and the single rear axle with dual tires measured 8’-6”. The center-to-center axle spacing was 16 ft.

Data were recorded continuously from all 14 instruments on an electronic data acquisition system at 5 Hz while the truck moved across the bridge from the west to the east on each run. While fully loaded, the truck crossed the bridge 3 times, stopping every 10 feet to ensure a static condition was achieved. At each stop, the truck was positioned such that the side mirror was aligned with the 10’ increment marker. Once the 8 stops across the span were completed, the truck would exit the bridge, turn around, cross the bridge from east to west at roadway speed, and reset on the west side of bridge for the subsequent run. Data measured during the dynamic loading while the truck crossed back from east to west at approximately 10 mph were recorded simultaneously on all sensors at 100 Hz. In all cases, positive deflections are vertically downward and positive strains are tension.

To assess the interaction between the two rail cars, the position of the truck relative to the single lane width varied with each run. For the first run, the truck drove centered down the mid-width of the bridge. For the second and third runs, the truck was driven as close as possible to the South and then North guard rails, respectively. The truck was then emptied of water to create a different loading condition (27,540 lbs. total weight) and the same process of three runs was repeated.

3.2. Test Results

The maximum deflection and strain measured at the midspan locations and in the end region location for each run with Engine #61 are summarized in Table 1.

Table 1. Maximum measured deflections and strains

Truck Weight (lbs.)	Driving Direction	Loading Condition	Lane Location	Maximum Vertical Deflection (in.)		Maximum Longitudinal Tension Strain (microstrain)		
				Midspan	End Region		Midspan	End Region
40,040	West to East	Static	Centered	1.15	0.52		180	158
			South	1.25	0.64		171	184
			North	1.21	0.45		194	132
	East to West	Dynamic	Centered	1.37	0.64		212	171
27,540	West to East	Static	Centered	0.80	0.34		127	102
			South	0.86	0.42		119	129
			North	0.86	0.30		136	90
	East to West	Dynamic	Centered	0.86	0.41		127	124

The variation in midspan deflection with each truck position is shown in Figure 11 for the centered run of the truck filled with water. The maximum measured midspan deflection was 1.15 inches as measured at the inside edge of the North Car. This deflection was recorded while the truck's side mirror was located at 50 ft and 60 ft. At these truck positions, the rear axle would have been slightly on each side of the midspan, as shown in Figure 12.

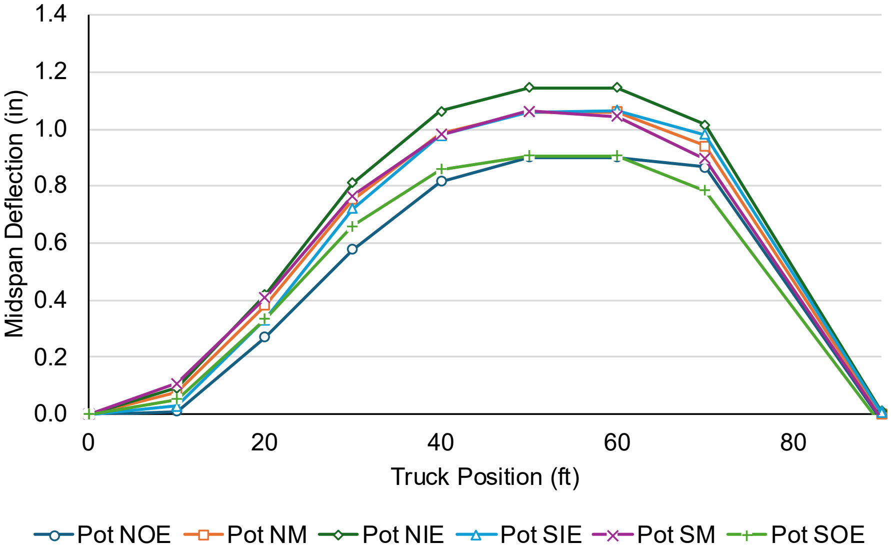

Figure 11. Midspan deflection vs. truck position for the centered run of the truck filled with water

Instrument Labeling Key:

Pot – String Potentiometer	NIE – North Car Inside Edge
NOE – North Car Outside Edge	NM – North Car Mid-width
SIE – South Car Inside Edge	SM – South Car Mid-width
SOE – South Car Outside Edge	

Figure 12. Truck positioned at the 50 ft marker

Figure 13 shows the displacement profile of the midspan bridge cross-section for the centered run of the truck filled with water (positive deflections are plotted downward on the y-axis to enable easy visualization of the profile). The x-axis plots the width of the bridge at the midspan with sensor locations identified as data points connected by straight lines. The outside edge of the North Car is located at 0 ft, and the outside edge of the South Car is located at 18.5 ft. The displacement profile for the centered run was fairly uniform, with the discontinuity at the mid-width (9.25 ft.) representing the difference in vertical deflection between cars that must be accommodated within the jumper plate.

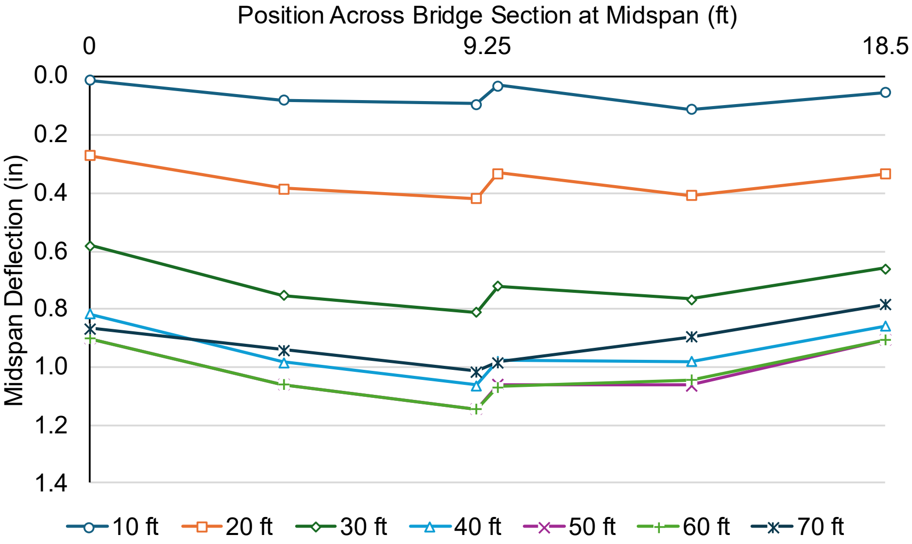

Figure 13. Displacement profile of the midspan bridge cross-section for the centered run of the truck filled with water

A comparison of the maximum displacement profiles for the three runs with the truck filled with water and positioned at 50 ft is shown in Figure 14. As expected, when the truck stayed close to the south guardrail, larger deflections were observed on the South Car. Similarly, when the truck stayed close to the north guardrail, larger deflections were observed on the North Car. The maximum measured deflection in the South run was 1.25 inches, measured at the outside edge of the South Car. For the North run, the maximum measured deflection was 1.22 inches, measured on the outside edge of the North Car.

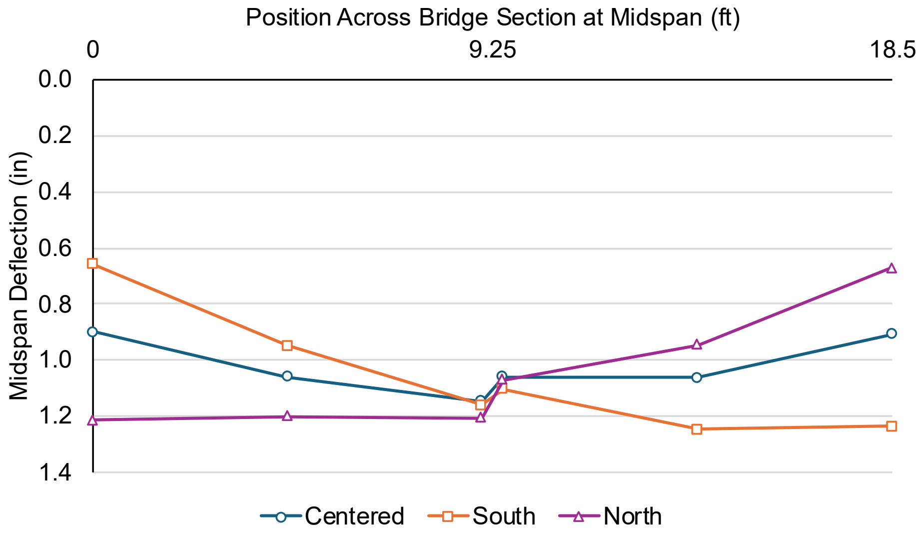

Figure 14. Displacement profiles of the midspan bridge cross-section for three runs with the truck filled with water and located at 50 ft

The maximum strain profiles of the bridge midspan cross-section for three runs with the truck filled with water and positioned at 50 ft is shown in Figure 15. The plotted data reveal that the largest tension strains were measured at the mid-width of each railcar, in the main girder with the strain gage located at the deepest point. The maximum strain was around 200 microstrain, indicating that the steel remains elastic at a level equal to approximately 10% of the estimated yield strain. Tension strain levels in the extreme fibers of the edge beams (or “bent plate side sills”) were roughly an order of magnitude lower, indicating that the main central beam is doing the bulk of the work in resisting the tension generated by global flexure.

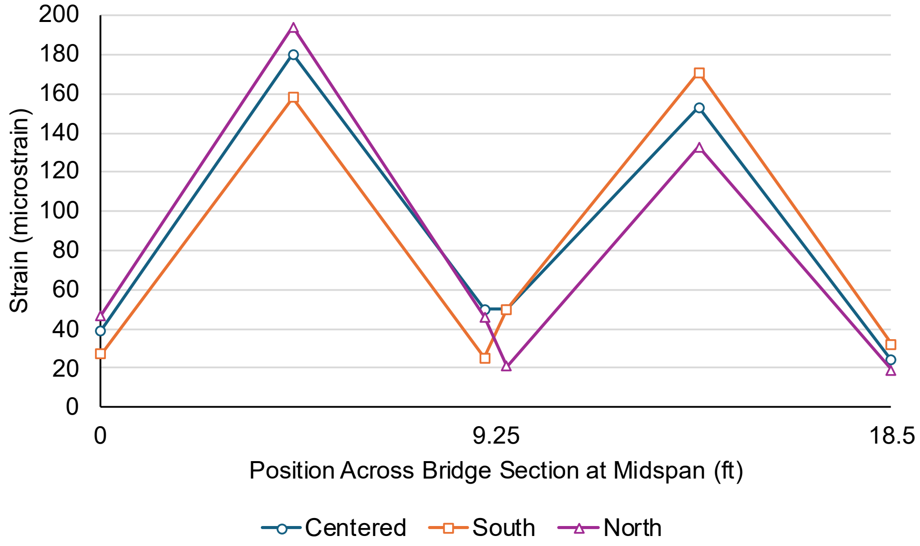

Figure 15. Strain profile for the truck filled with water at 50 ft for all runs

The maximum midspan deflection and strain profiles for the three runs with the empty truck are shown in Figure 16 and Figure 17. The maximum deflection was reduced to 0.86 inches and the maximum strain was reduced to approximately 140 microstrain, both reductions roughly in proportion with the reduction in vehicle weight, confirming a nominally linear response.

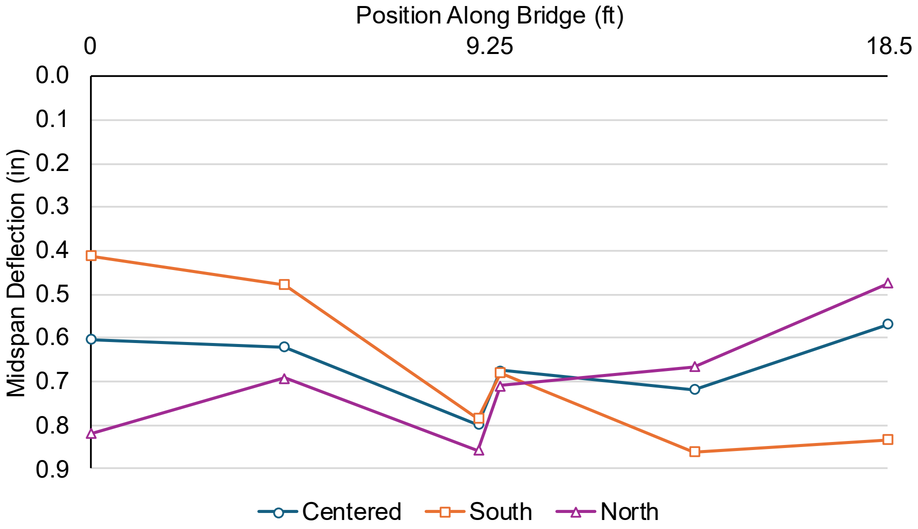

Figure 16. Displacement profiles of the midspan bridge cross-section for three runs with the empty truck located at 50 ft

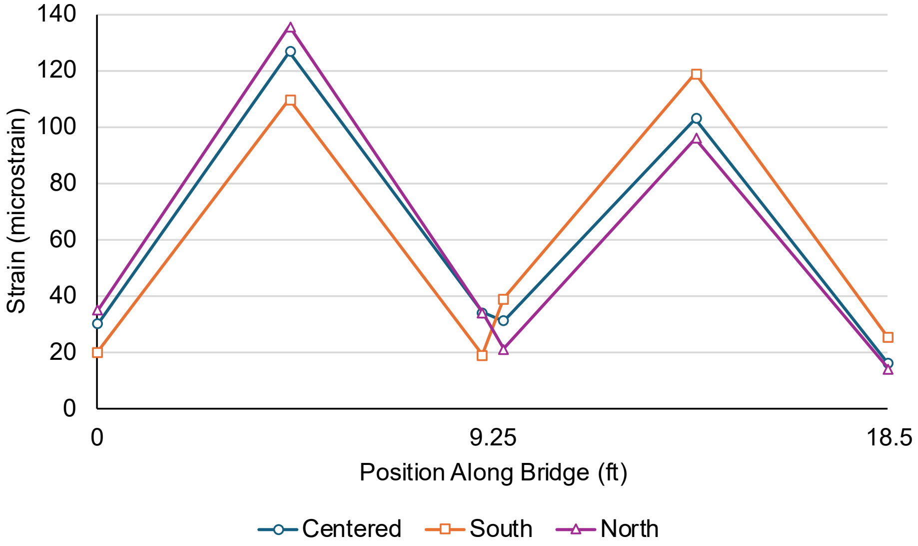

Figure 17. Strain profile for the empty truck at 50 ft for all runs

At both ends of each railcar, the main beam tapers to a shallower section. A string potentiometer and strain gage were placed approximately 6 inches from the edge of the taper on the western end of the South Car at the mid-width. These measurements are compared to the mid-width, mid-span South Car instruments in Figure 18 and Figure 19 for the centered run of the truck filled with water. The deflection measured at the reduced section was always less than the maximum deflection measured at the midspan for each truck location. The strain at the end location reached a maximum value slightly higher than the maximum strain measured at the midspan location for the truck positions that caused maximum effect at each of those instrument locations. The midspan strain reached its maximum when the rear axle was near the midspan, and the reduced section reached its maximum when the rear axle was above the taper. The position of the truck when the reduced section reaches maximum strain is shown in Figure 20.

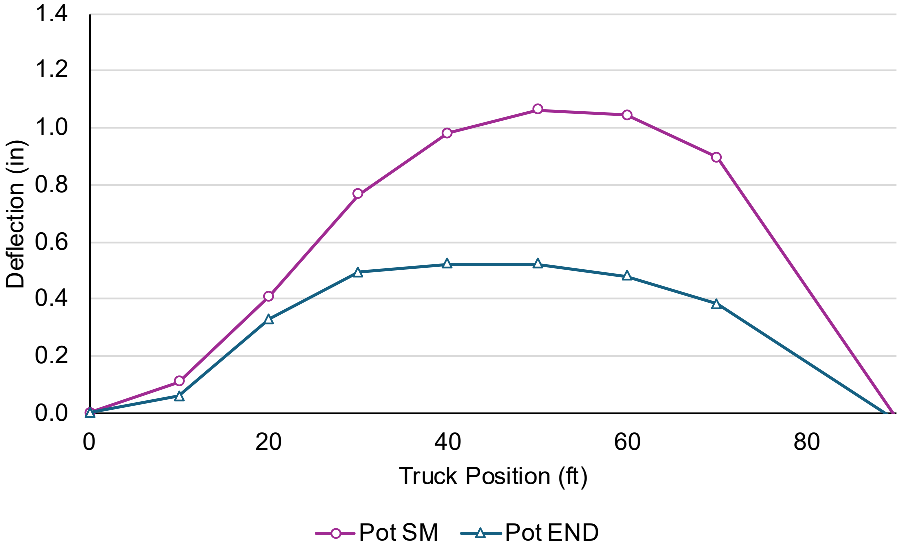

Figure 18. Deflection at midspan and in the reduced section at mid-width on the South Car

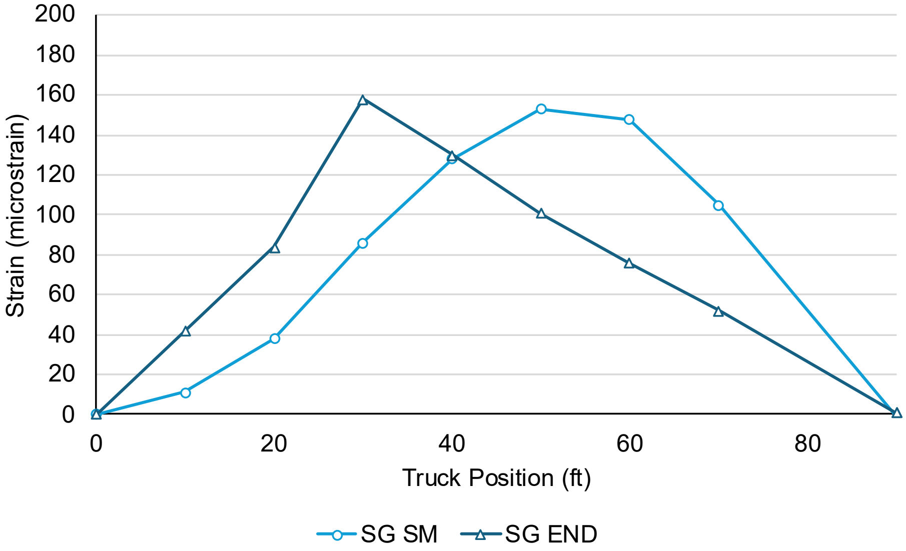

Figure 19. Strain at midspan and in the reduced section at mid-width on the South Car

Instrument Labeling Key:

SG – Strain Gage	END – Location at the West End (Reduced Section after Taper)
SM – South Car Mid-width	Pot – String Potentiometer

Figure 20. Truck positioned at the 30 ft marker creates maximum strain at the tapered section

Figure 21 shows the midspan deflection data recorded as the truck filled with water crossed the bridge from east to west at approximately 10 mph, without stopping at the 10’ increment markers. The maximum deflection was amplified to 1.37 inches compared with the maximum 1.25 inches measured in the static runs.

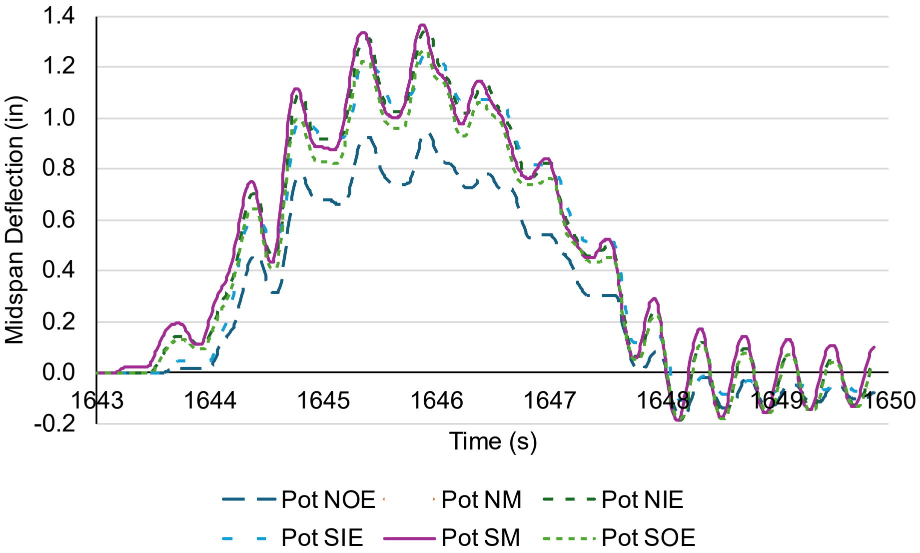

Figure 21. Deflection vs. time for the dynamic run of the truck filled with water

Instrument Labeling Key:

Pot – String Potentiometer
NOE – North Car Outside Edge
NM – North Car Mid-width
NIE – North Car Inside Edge
SIE – South Car Inside Edge
SM – South Car Mid-width
SOE – South Car Outside Edge

Chapter 4. Recommendations

The load tests confirm that the railcars comprising the bridge on Warren Wilson Road in Swannanoa, NC that crosses Bee Tree Creek remain elastic under loads from regular traffic and vehicles at or below the posted load limit. Both the midspan strains and strains at the critical reduced section remained well below the elastic limit. The authors recommend maintaining the posted load limit to ensure elastic behavior of the railcar bridges.

The displacement profiles indicate that the connector plate between the adjacent railcars was effective in sharing load between the two railcars. Further study of this connector plate detail through finite element analyses planned elsewhere is recommended before future implementation of similar bridges.

Chapter 5. Implementation and Technology Transfer Plan

The results of this preliminary study were used to confirm the validity of the existing load posting of the railcar bridge on Warren Wilson Road in Swannanoa, NC that crosses Bee Tree Creek. All data collected from these tests have been made available to the NCDOT and are included in the Appendix of this report. Data are being used by other researchers to validate finite element models of this railcar structure for additional studies of its details and capacity. The results of this preliminary work are also implemented in into the research plan of an upcoming NCDOT-funded research project which has the goal of developing more specific design guidance that will be broadly applicable to temporary railcar structures without composite decks.

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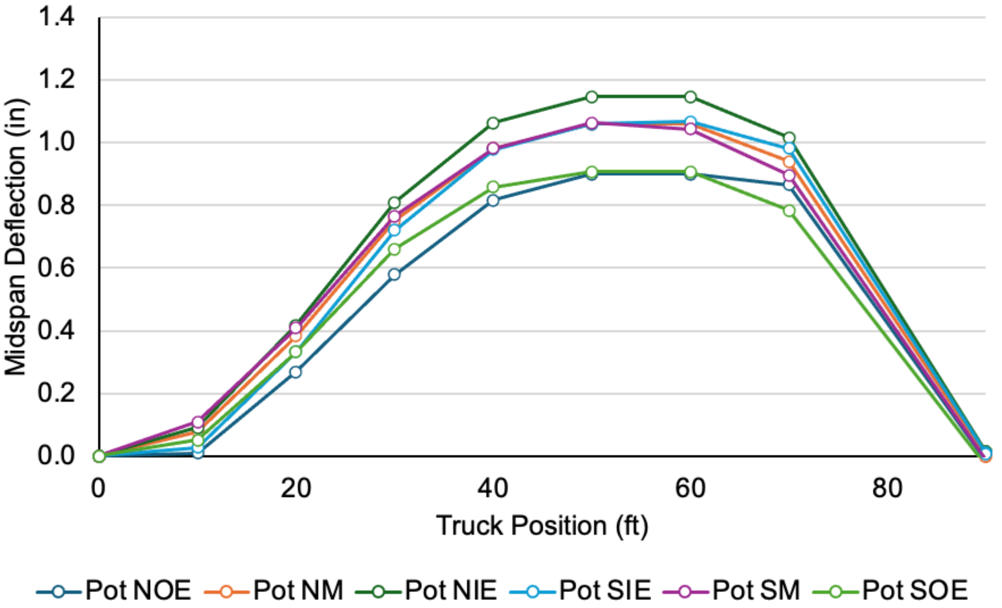
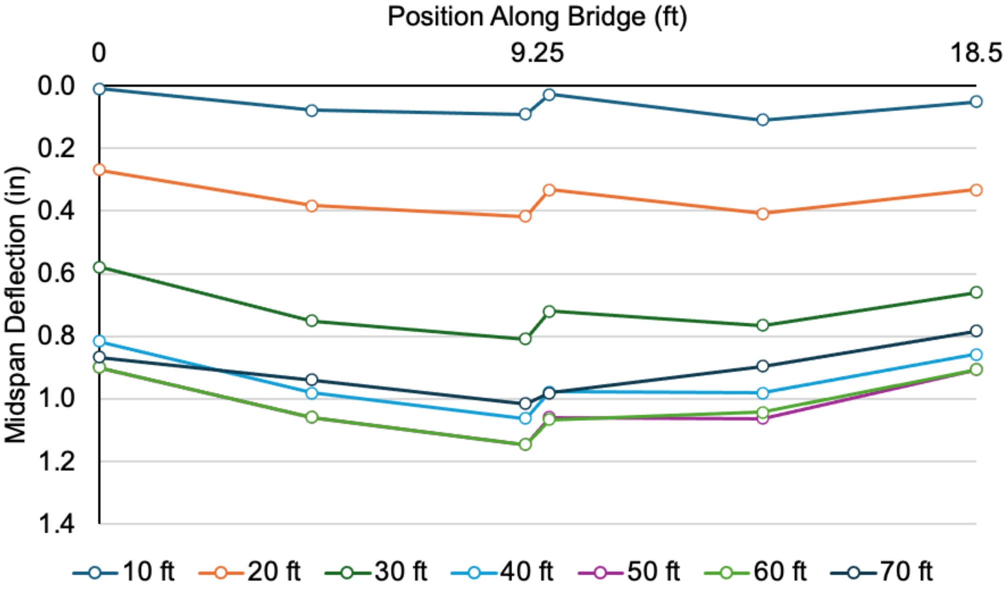
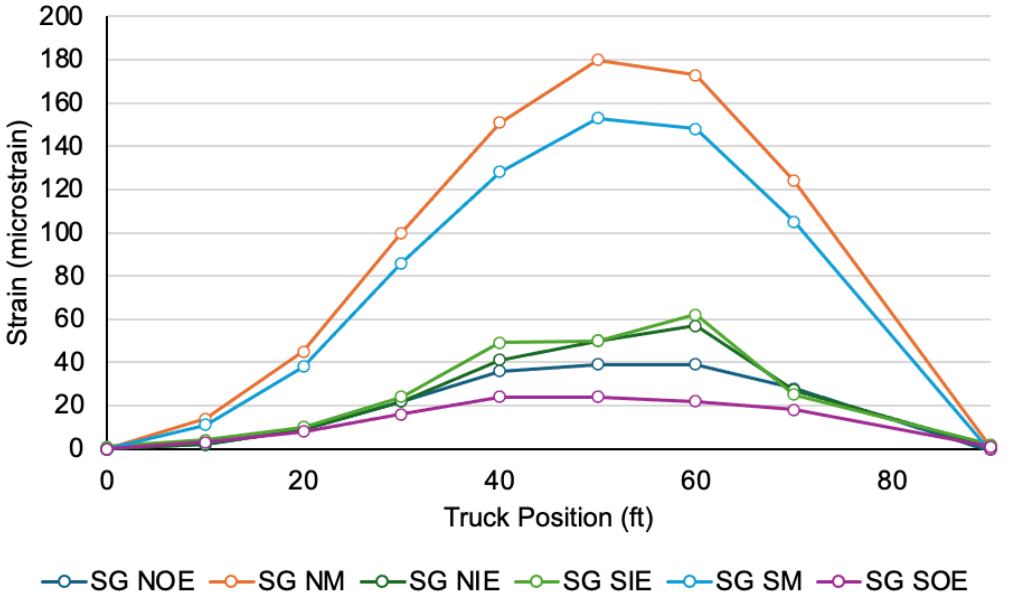
Appendix A. Detailed Data

All recorded data from all runs are presented in this Appendix.

A.1. Truck Filled with Water, Centered Alignment






Strain (microstrain)
200
180
160
140
120
100
80
60
40
20
0
0
20
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Truck Position (ft)
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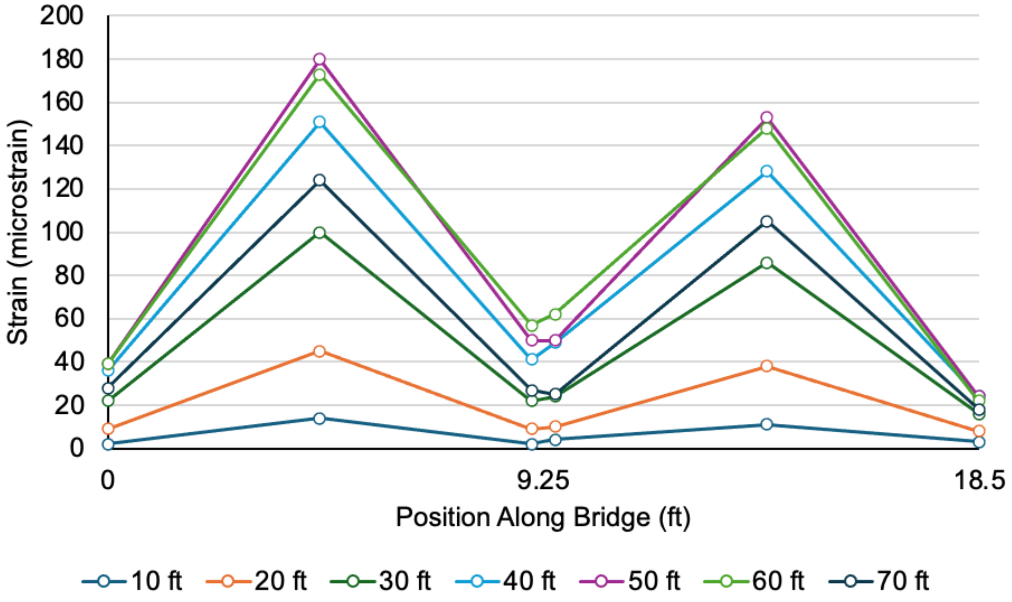
SG NM
SG NIE
SG SIE
SG SM
SG SOE


Strain (microstrain)
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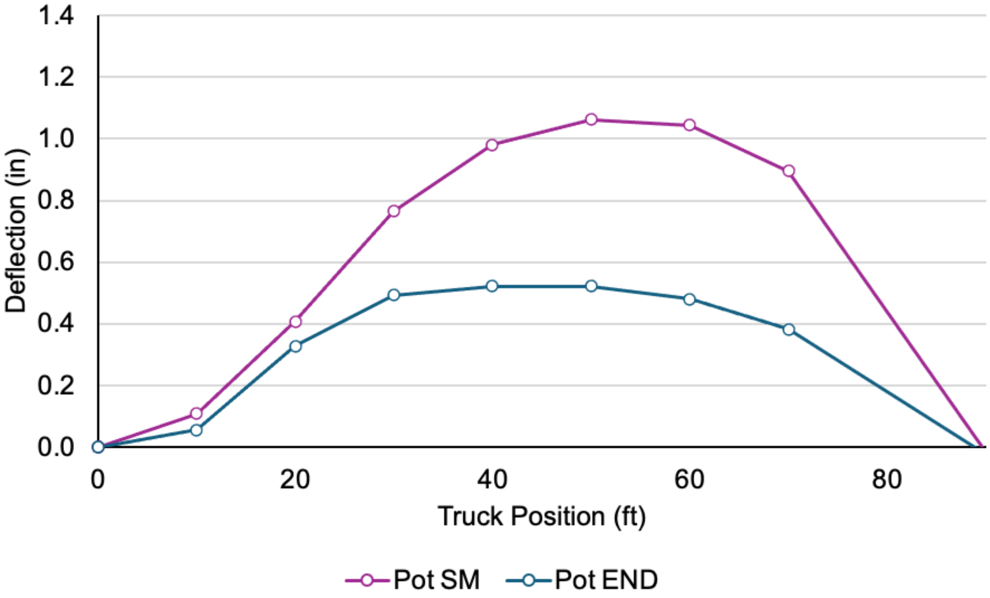
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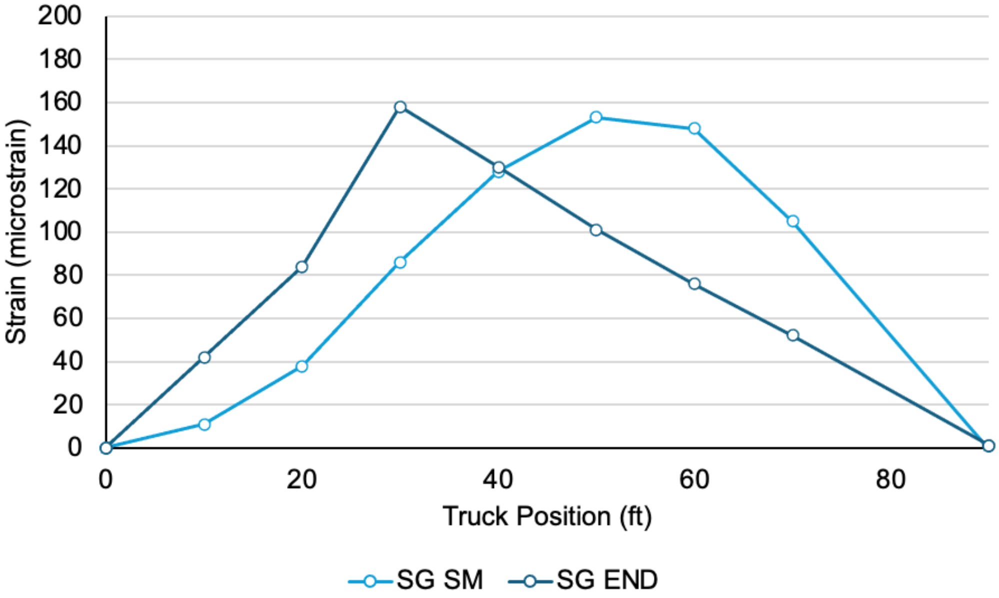
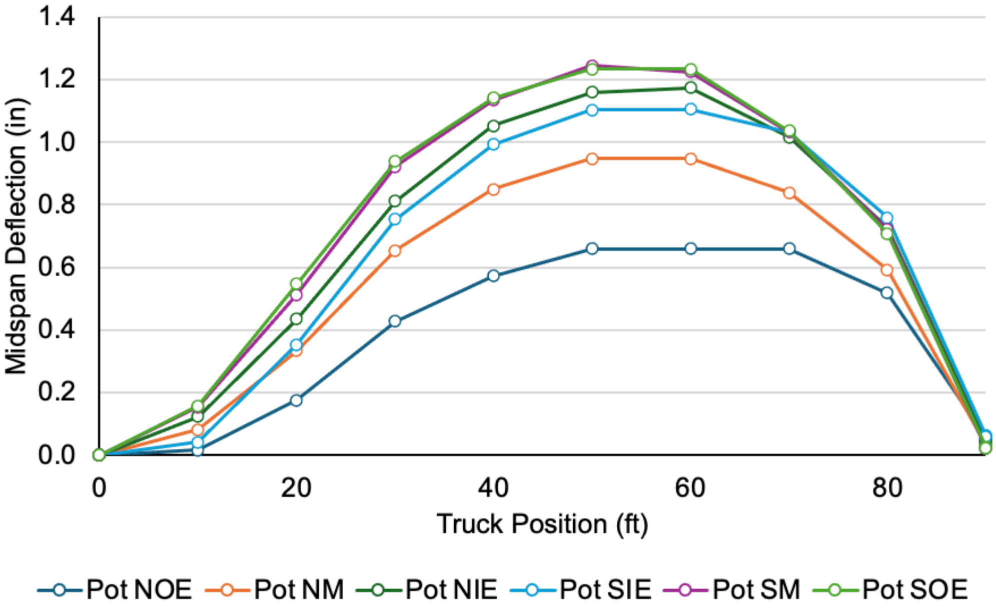
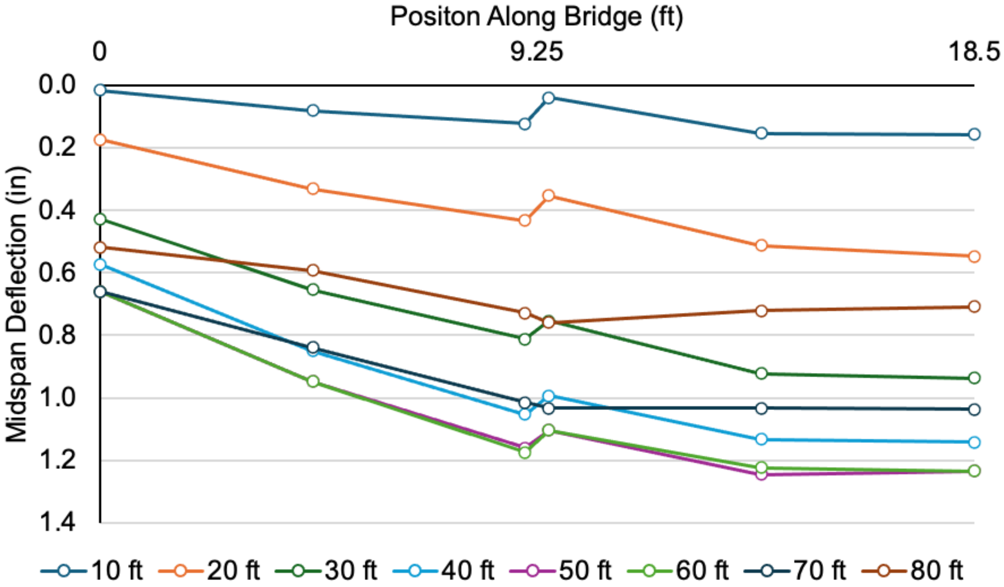
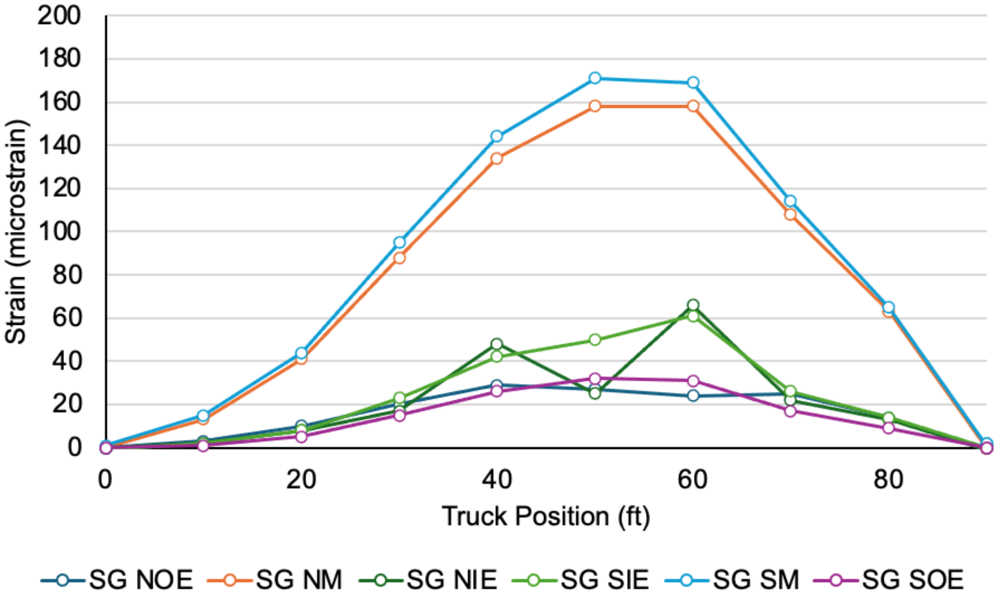
0.8
0.6
0.4
0.2
0.0
Deflection (in)
0
20
40
60
80
Truck Position (ft)
Pot SM
Pot END

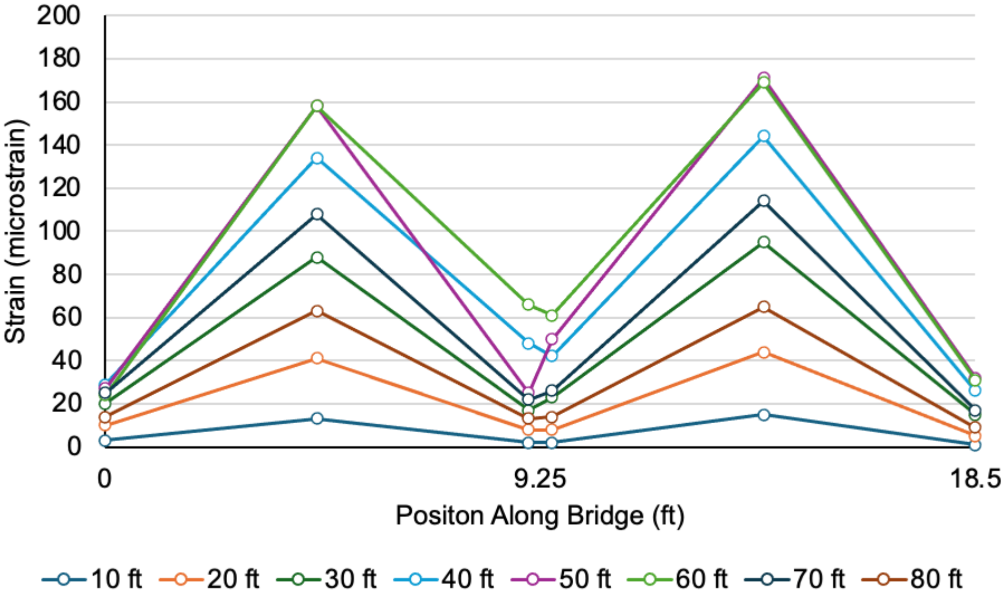

200
180
160
140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG SM
SG END

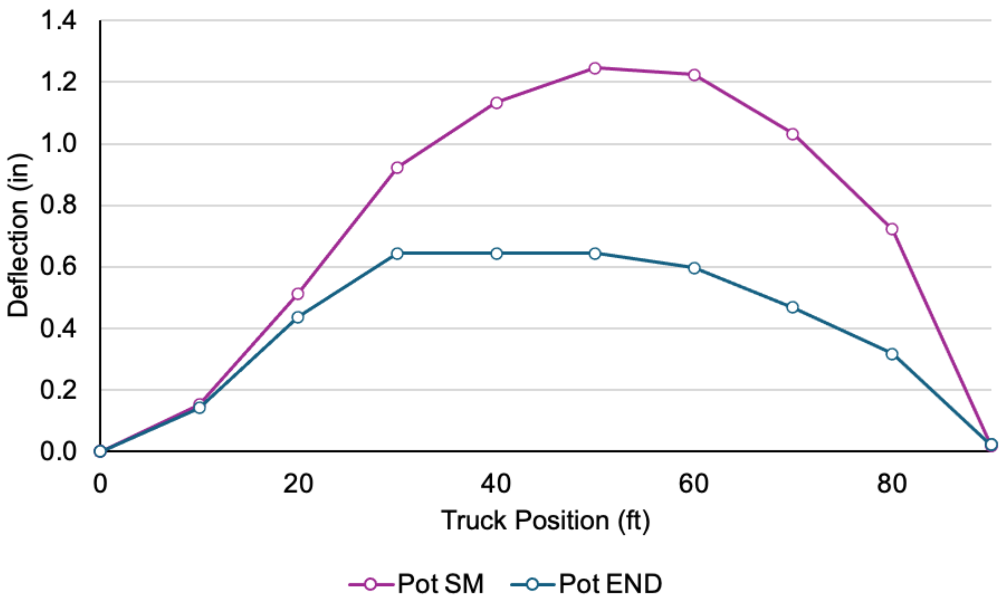
A.2. Truck Filled with Water, South Rail Alignment



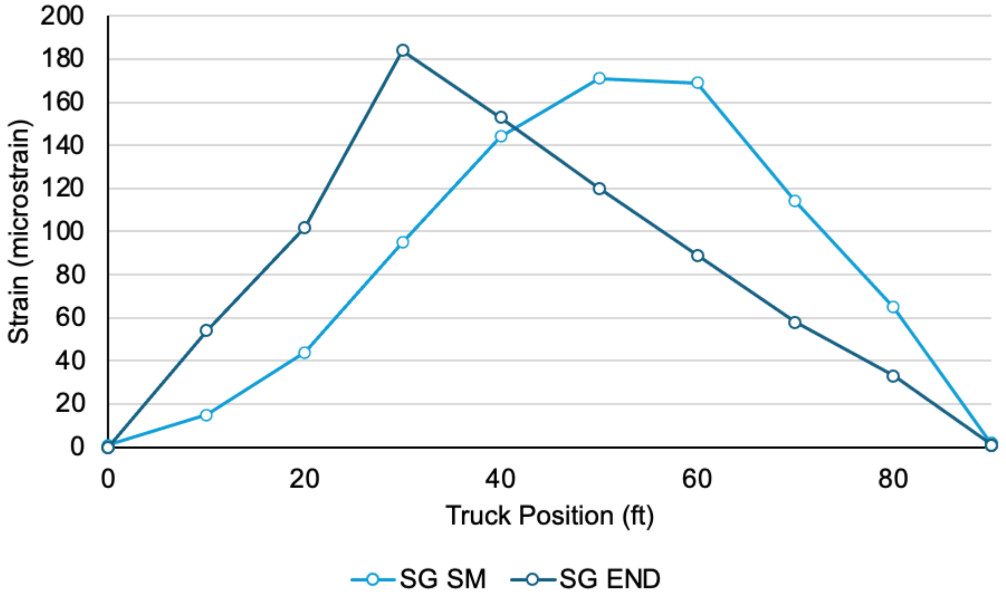



Strain (microstrain)
200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
Truck Position (ft)
SG NOE
SG NM
SG NIE
SG SIE
SG SM
SG SOE


Strain (microstrain)
200
180
160
140
120
100
80
60
40
20
0
0
9.25
18.5
Positon Along Bridge (ft)
10 ft
20 ft
30 ft
40 ft
50 ft
60 ft
70 ft
80 ft

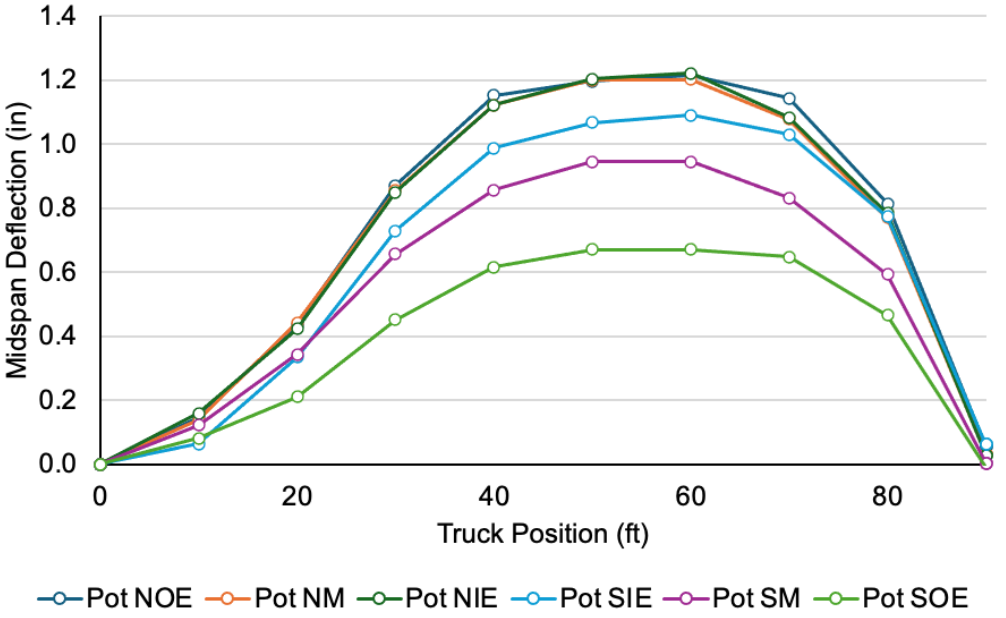


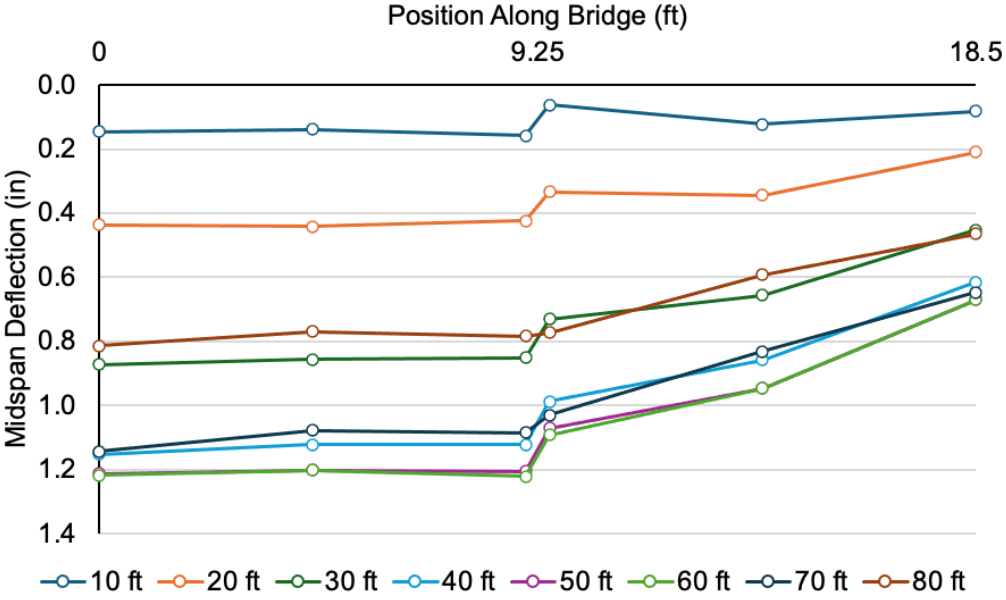
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Deflection (in)
0
20
40
60
80
Truck Position (ft)
Pot SM
Pot END

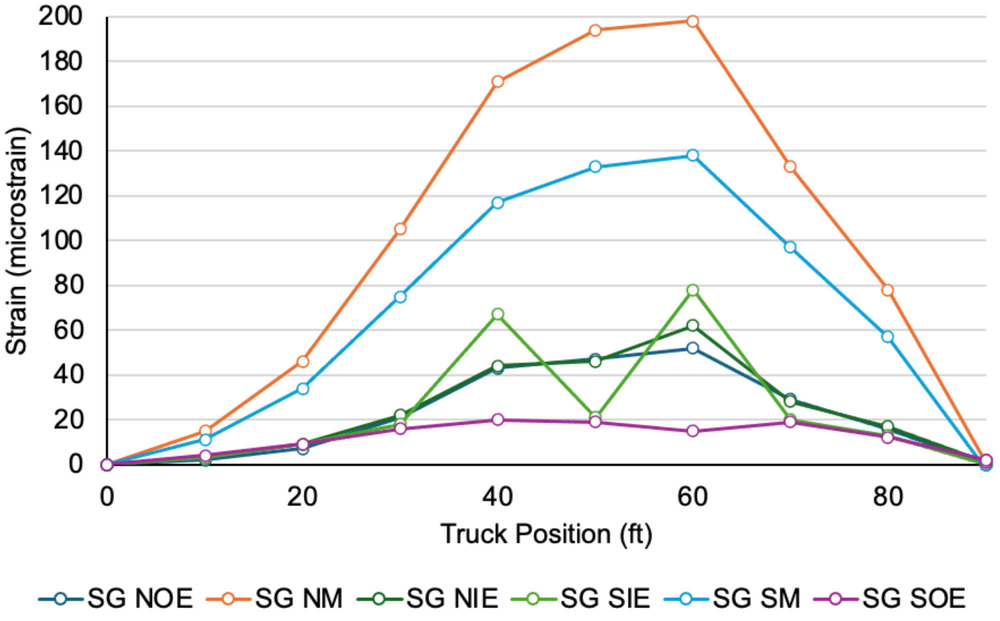


200
180
160
140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG SM
SG END

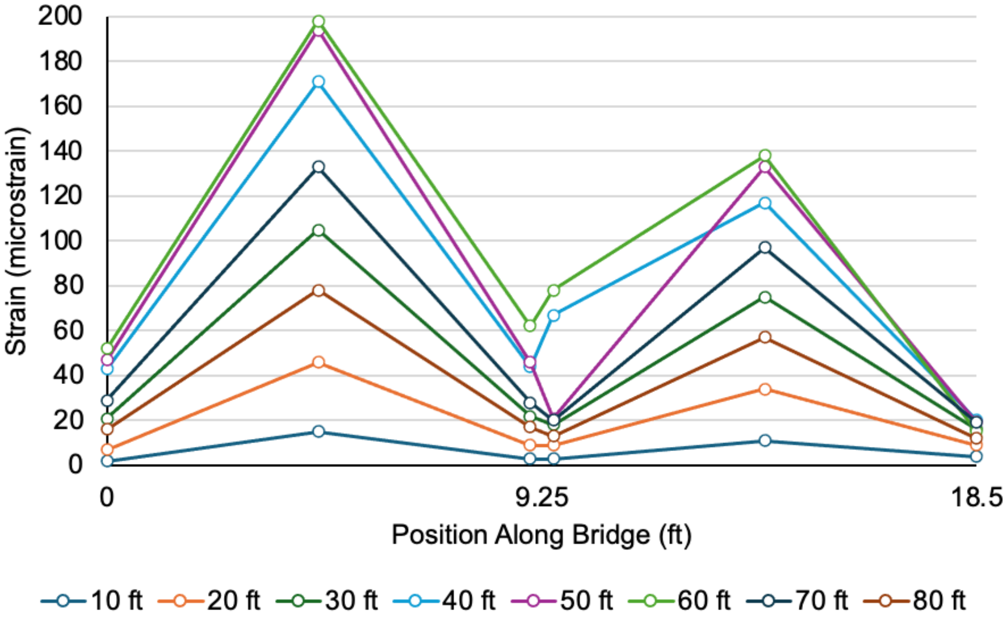
A.3. Truck Filled with Water, North Rail Alignment



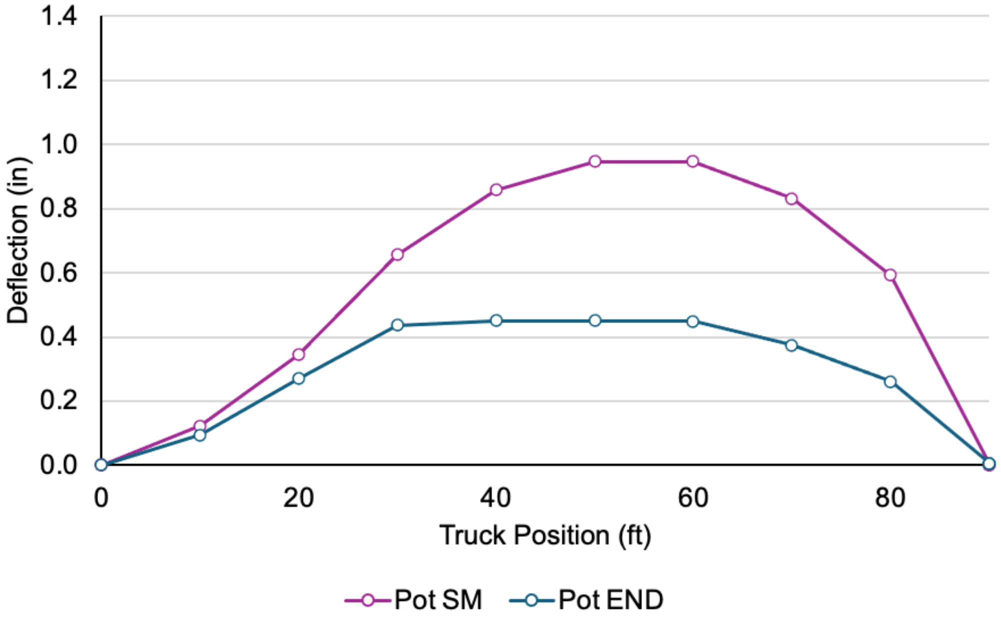




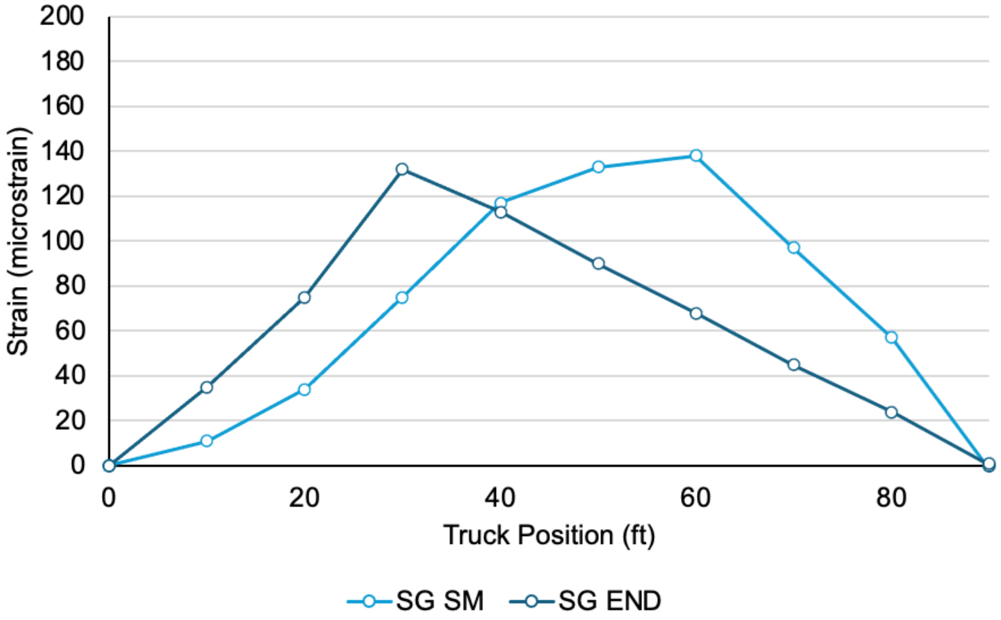
Strain (microstrain)
200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
Truck Position (ft)
SG NOE
SG NM
SG NIE
SG SIE
SG SM
SG SOE



Strain (microstrain)
200
180
160
140
120
100
80
60
40
20
0
0
9.25
18.5
Position Along Bridge (ft)
10 ft
20 ft
30 ft
40 ft
50 ft
60 ft
70 ft
80 ft

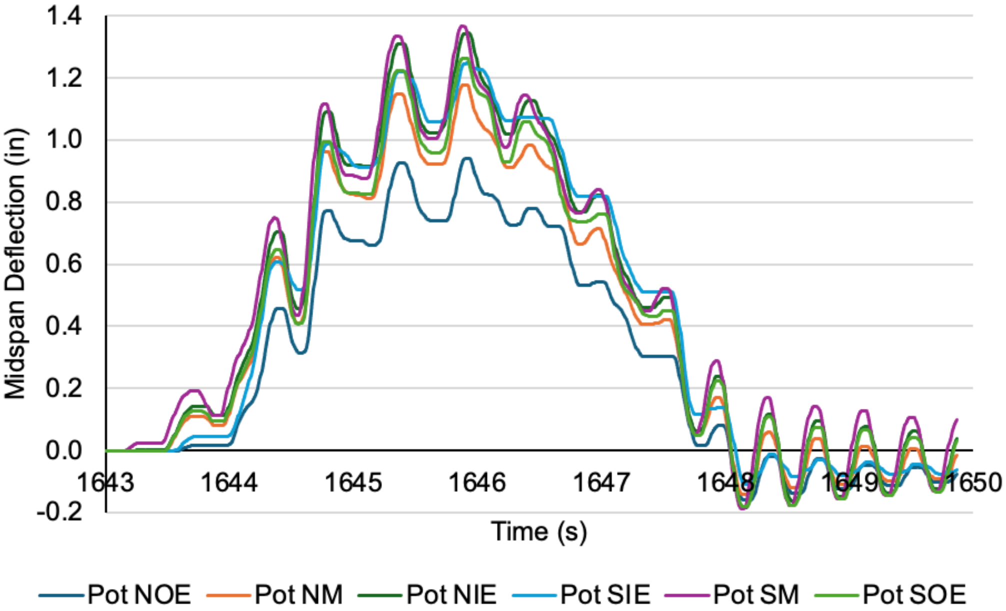


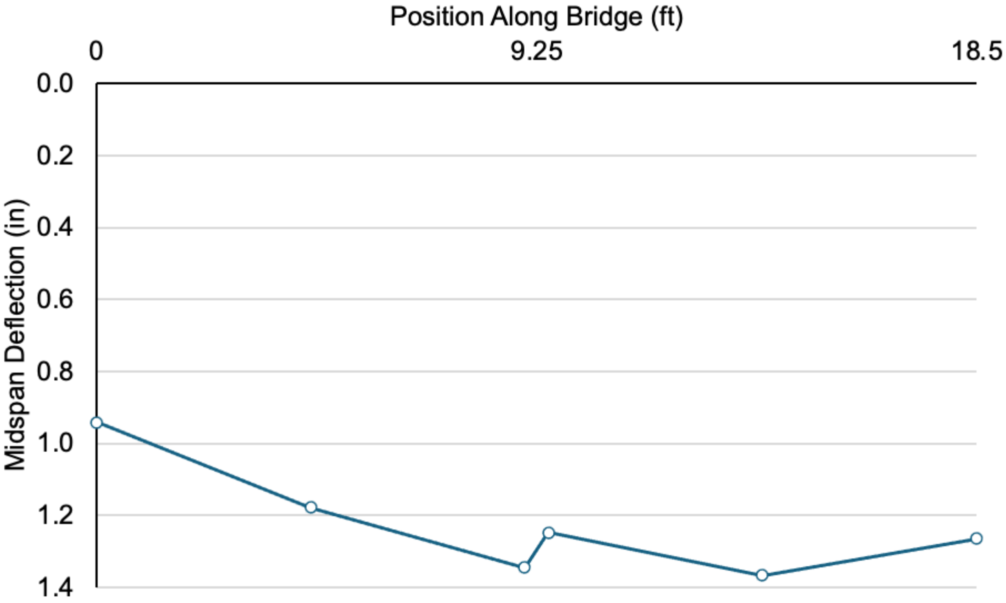
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Deflection (in)
0
20
40
60
80
Truck Position (ft)
Pot SM
Pot END

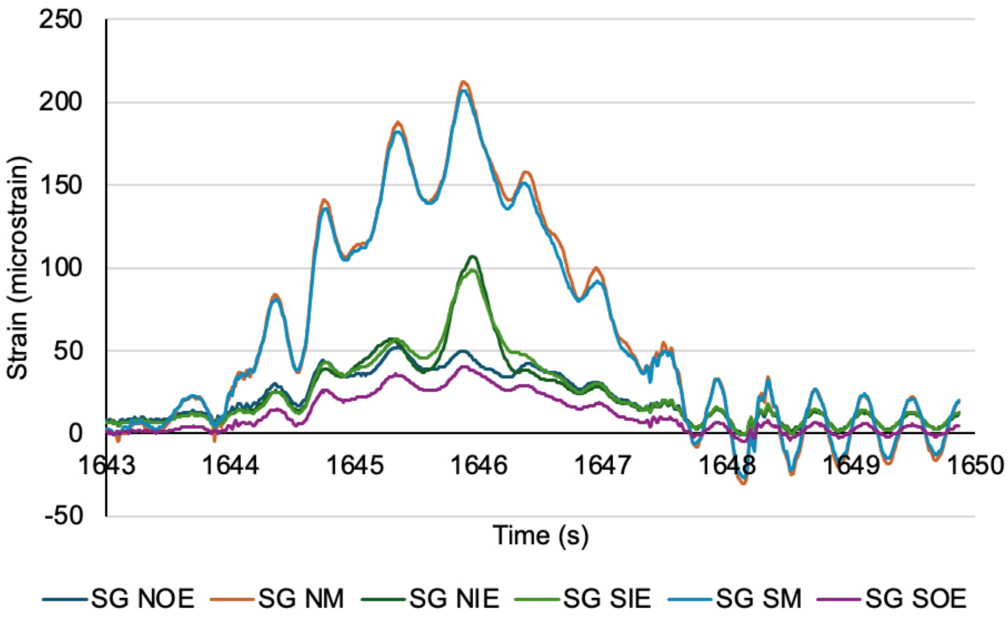


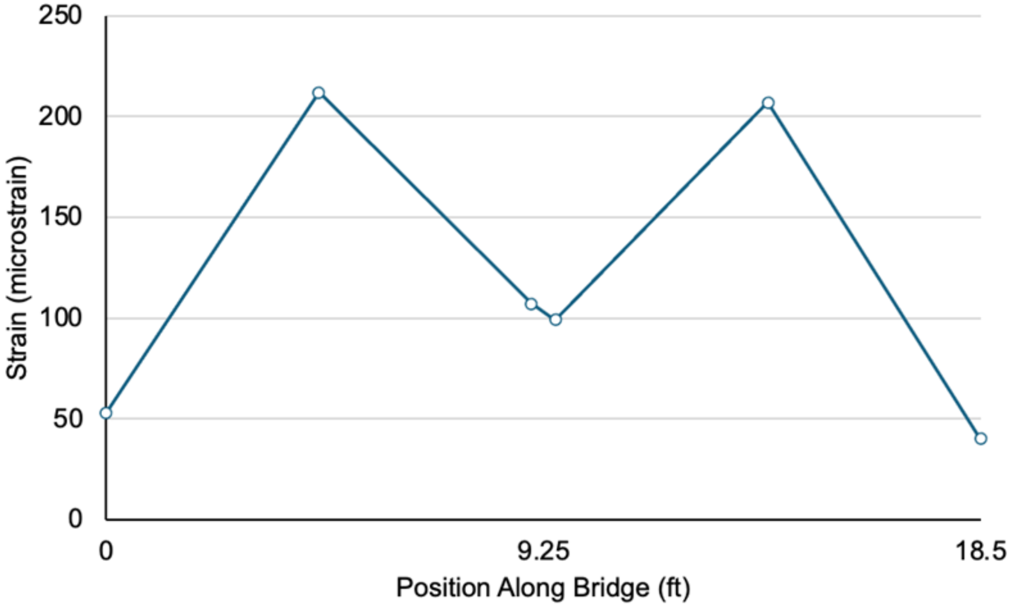
200
180
160
140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG SM
SG END

A.4. Truck Filled with Water, Dynamic Run

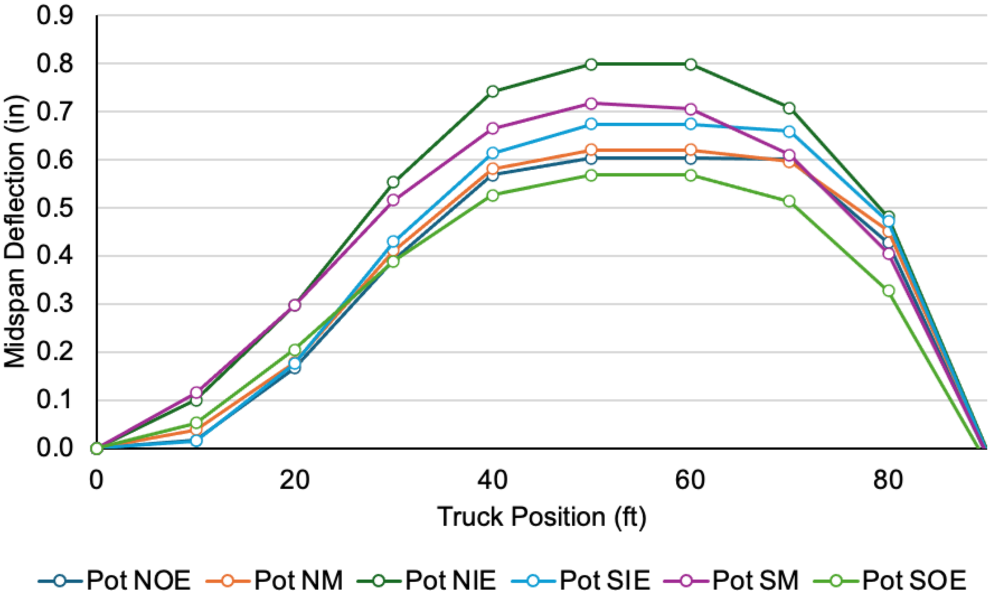


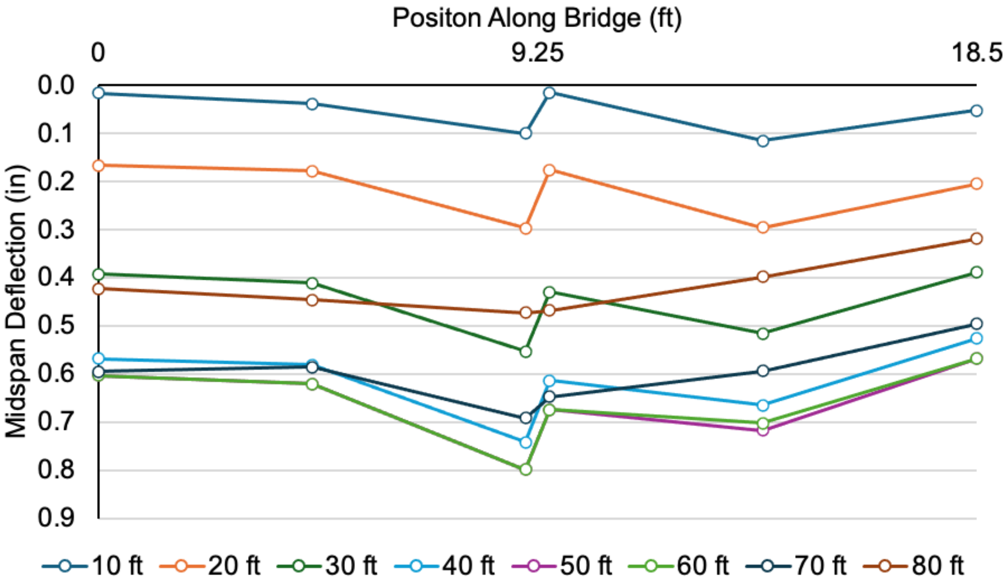


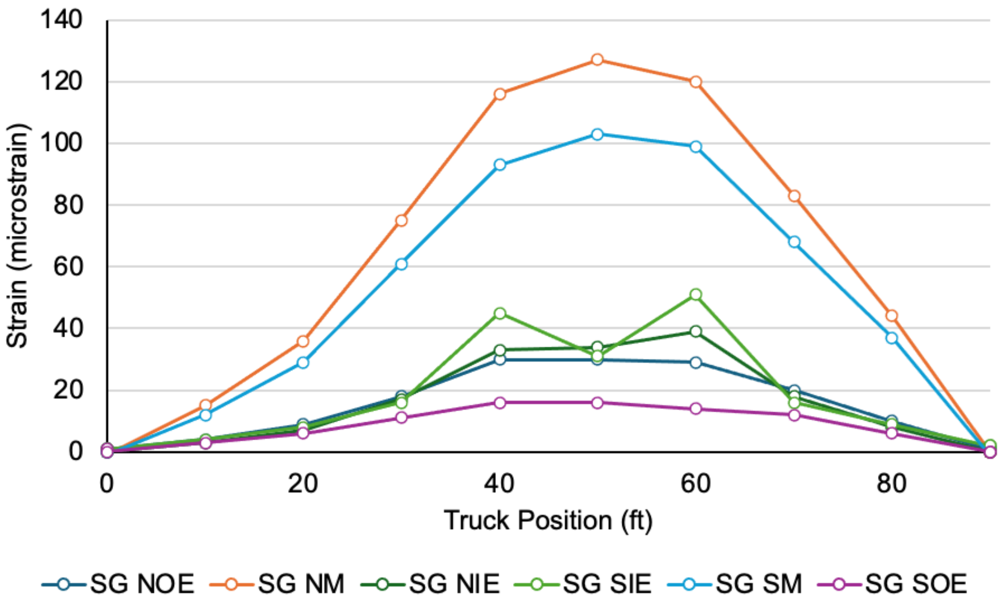

250
200
150
100
50
0
-50
Strain (microstrain)
1643
1644
1645
1646
1647
1648
1649
1650
Time (s)
SG NOE
SG NM
SG NIE
SG SIE
SG SM
SG SOE

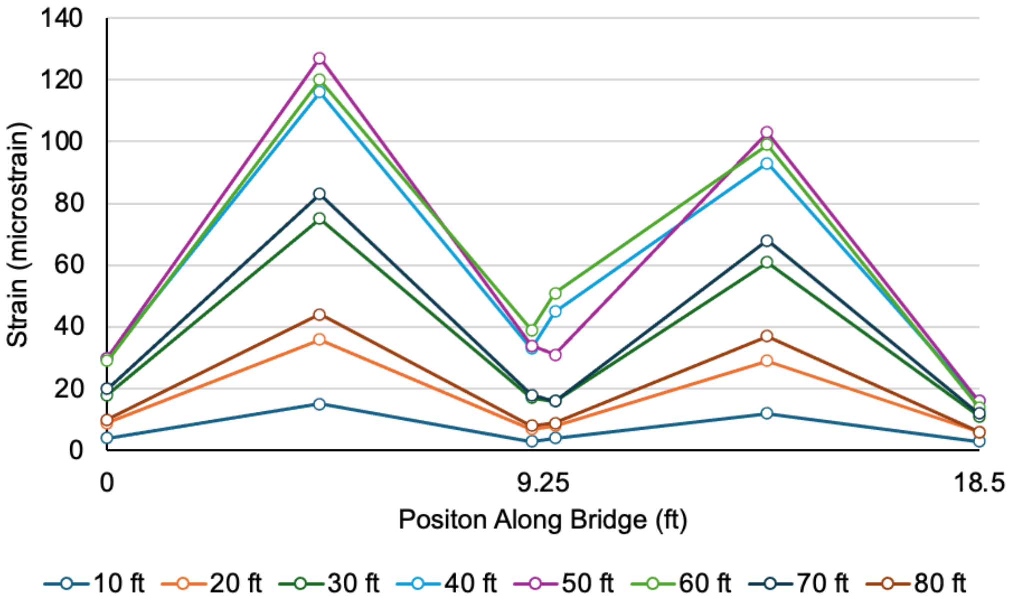

250
200
150
100
50
0
Strain (microstrain)
0
9.25
18.5
Position Along Bridge (ft)

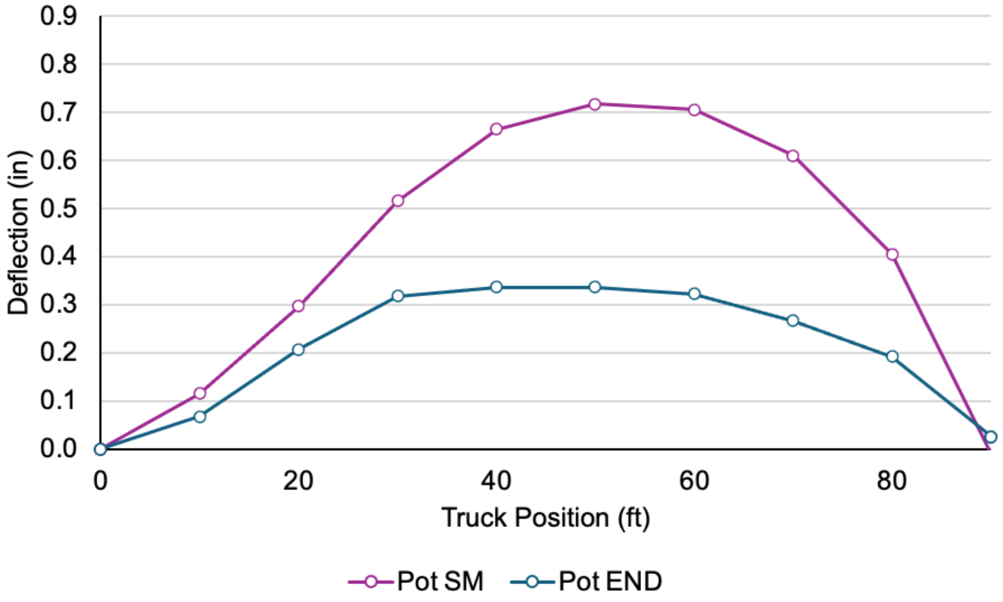
A.5. Empty Truck, Centered Alignment

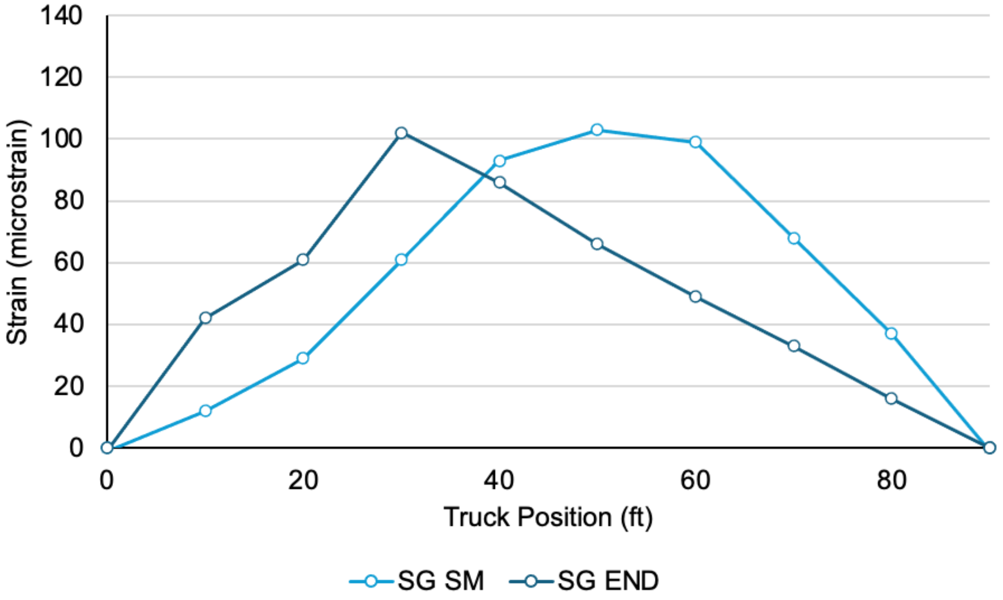




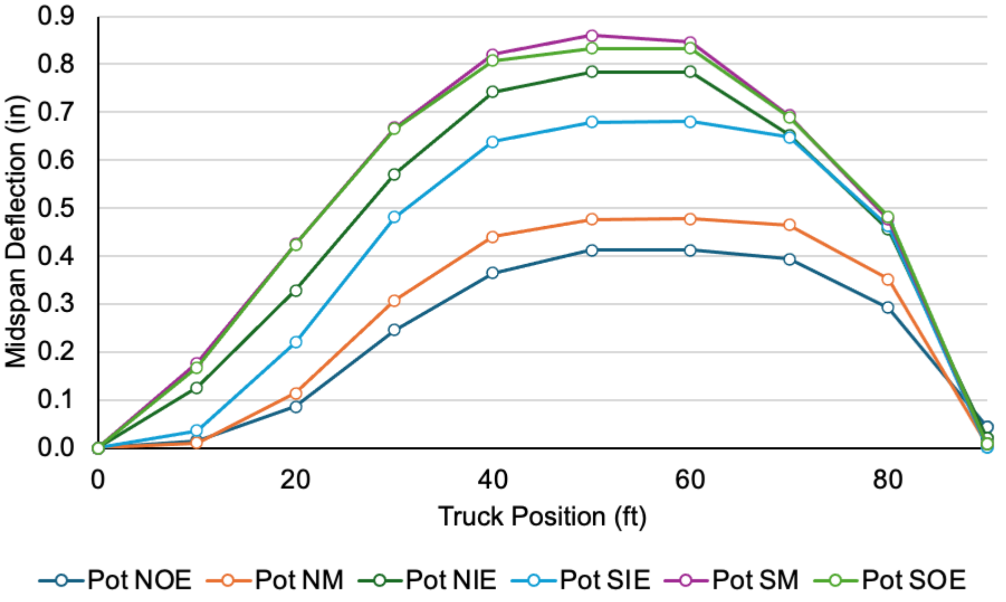

Strain (microstrain)
0
20
40
60
80
100
120
140
Truck Position (ft)
0
20
40
60
80
SG NOE
SG NM
SG NIE
SG SIE
SG SM
SG SOE

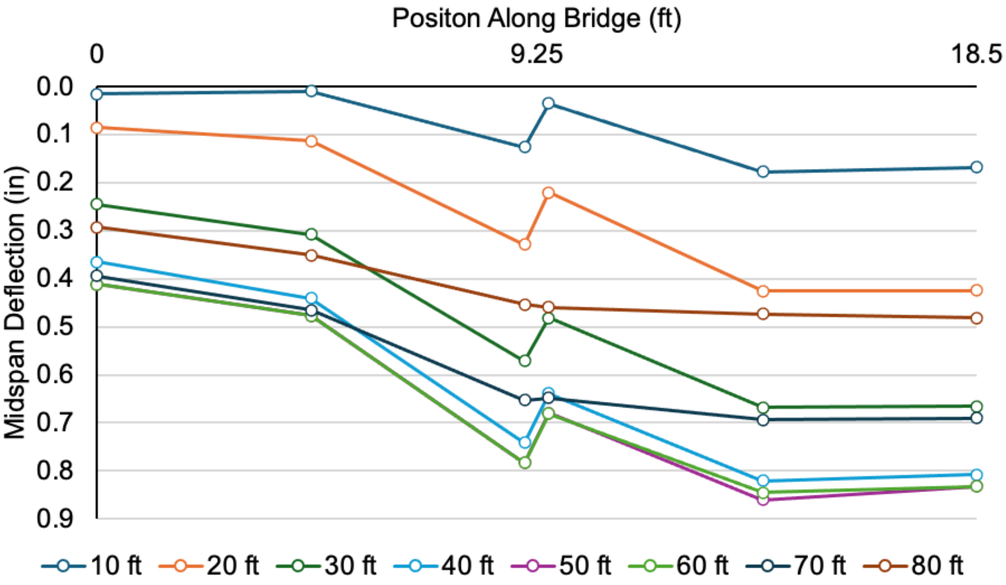

Strain (microstrain)
0
20
40
60
80
100
120
140
Positon Along Bridge (ft)
0
9.25
18.5
10 ft
20 ft
30 ft
40 ft
50 ft
60 ft
70 ft
80 ft

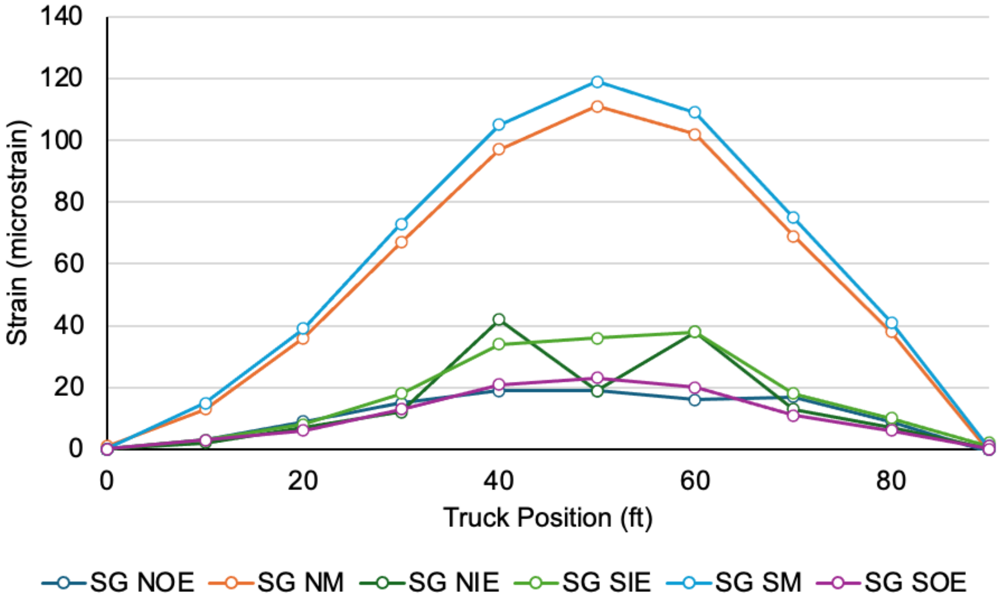

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Deflection (in)
0
20
40
60
80
Truck Position (ft)
Pot SM
Pot END

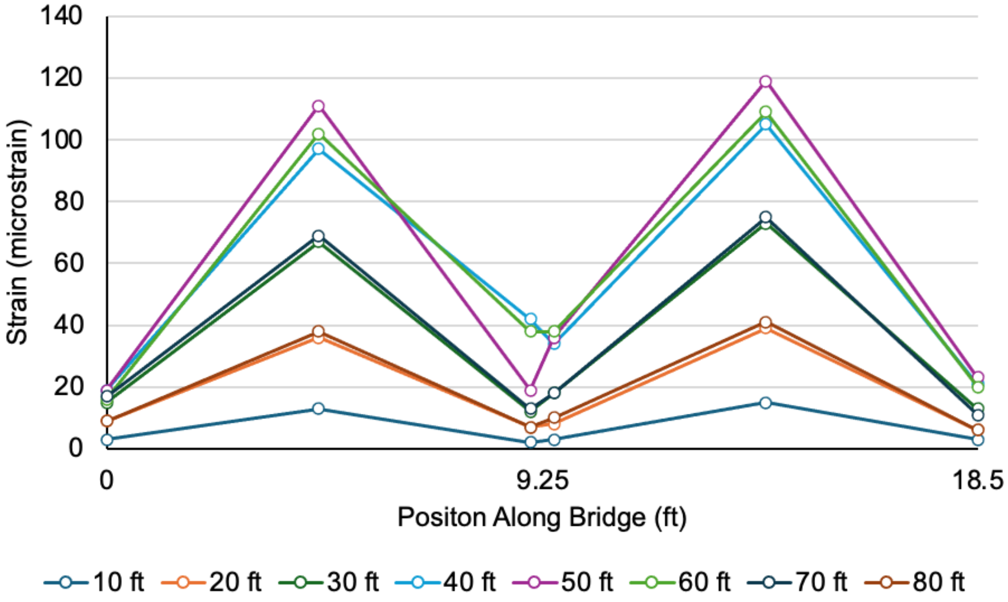

140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG SM
SG END

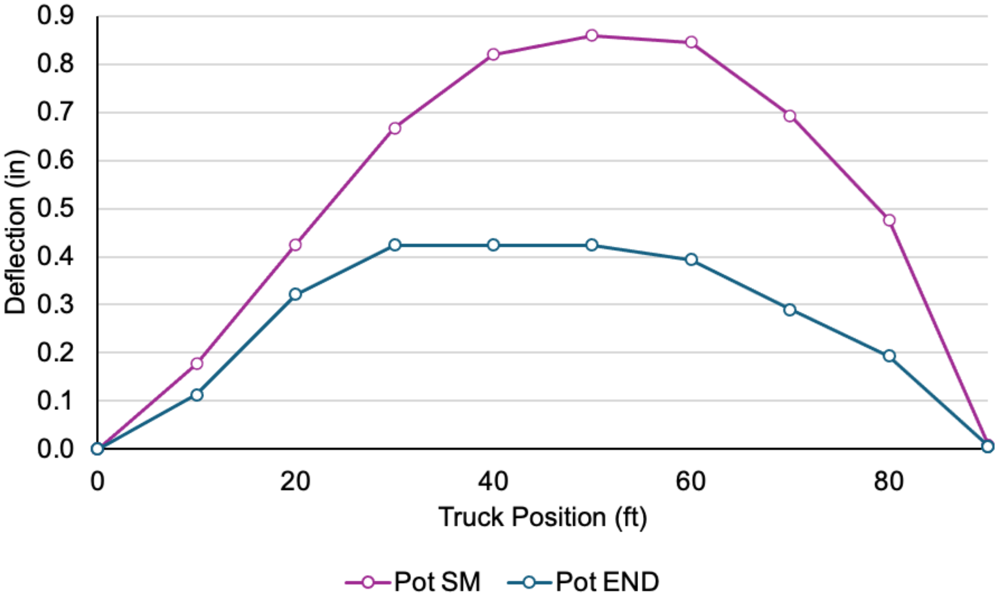
A.6. Empty Truck, South Rail Alignment

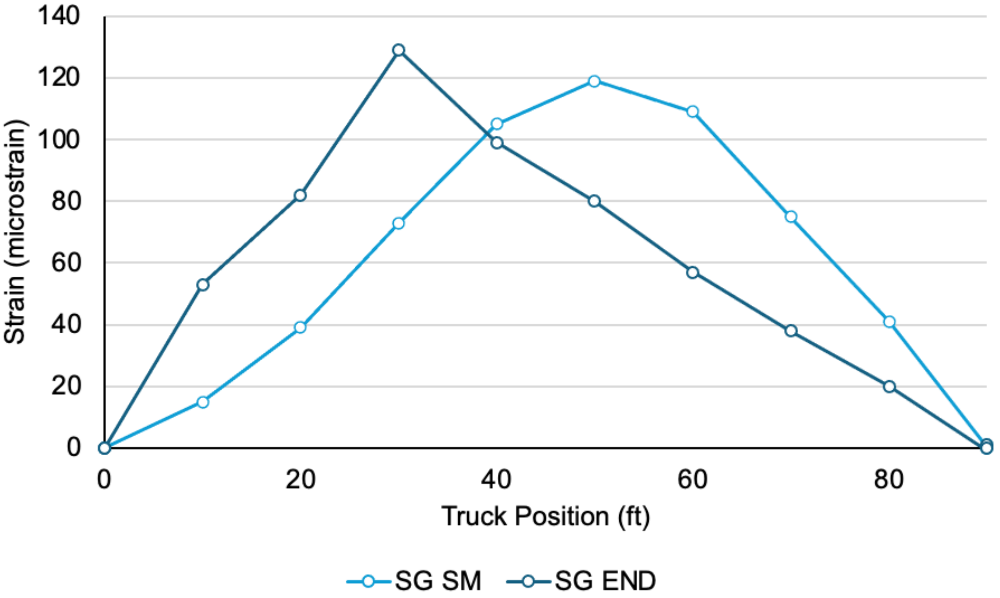




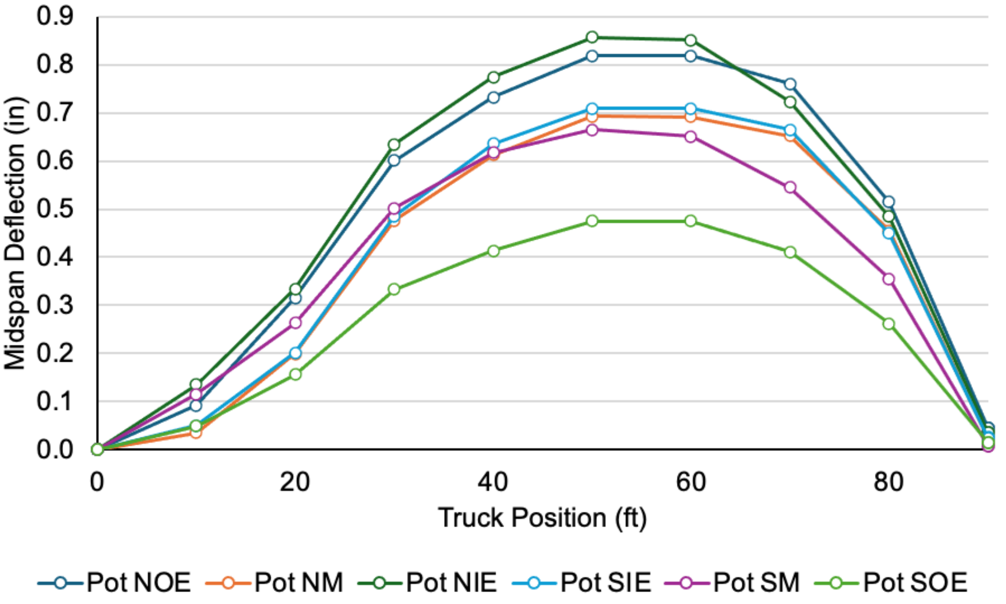

140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG NOE
SG NM
SG NIE
SG SIE
SG SM
SG SOE

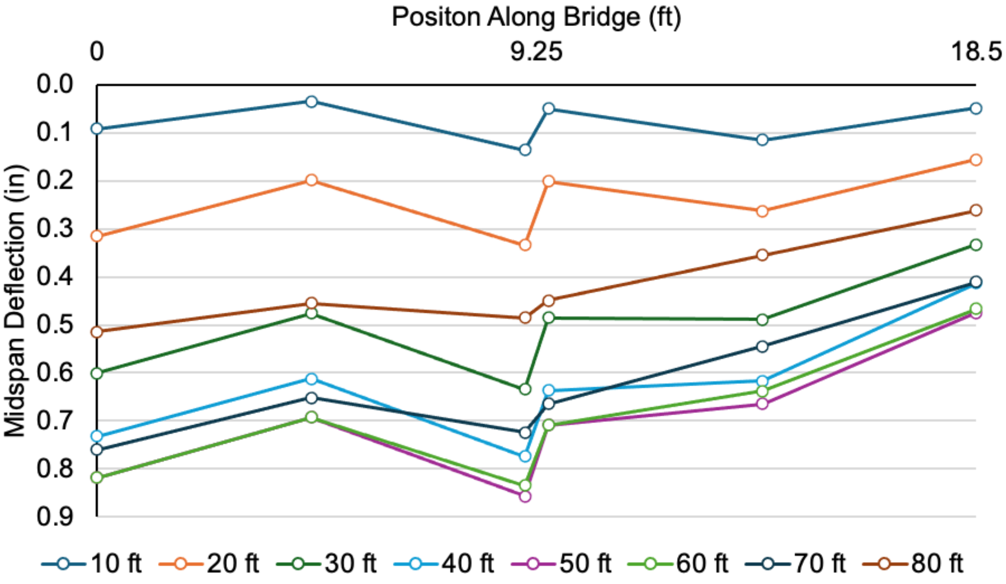

140
120
100
80
60
40
20
0
Strain (microstrain)
0
9.25
18.5
Positon Along Bridge (ft)
10 ft
20 ft
30 ft
40 ft
50 ft
60 ft
70 ft
80 ft

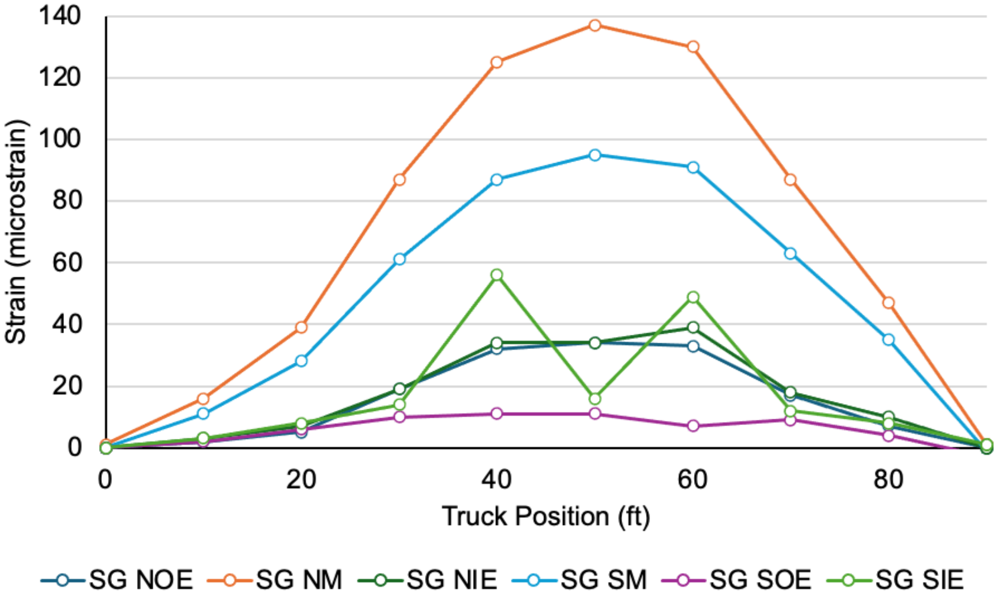

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Deflection (in)
0
20
40
60
80
Truck Position (ft)
Pot SM
Pot END


140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG SM
SG END

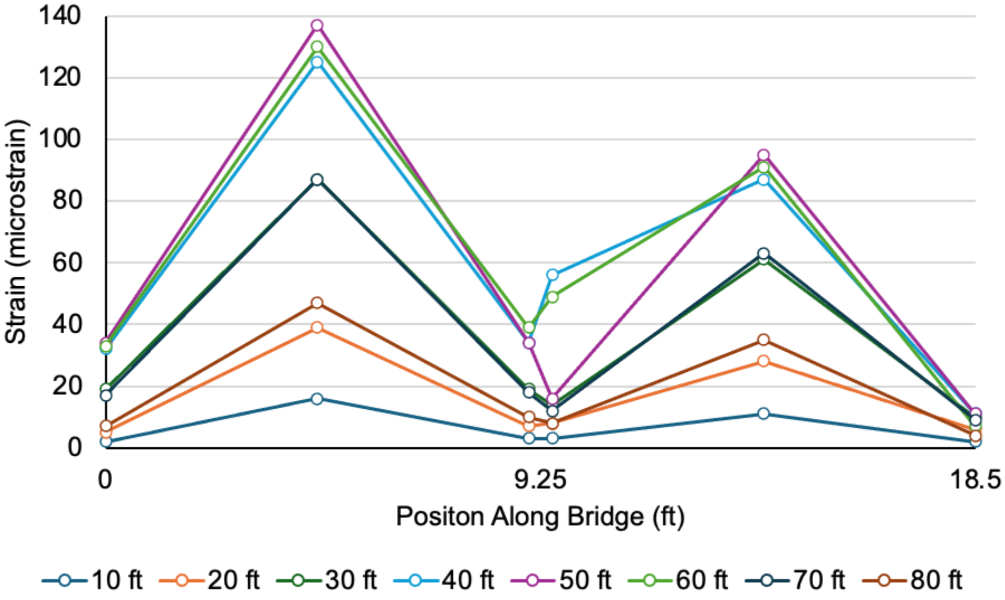
A.7. Empty Truck, North Rail Alignment



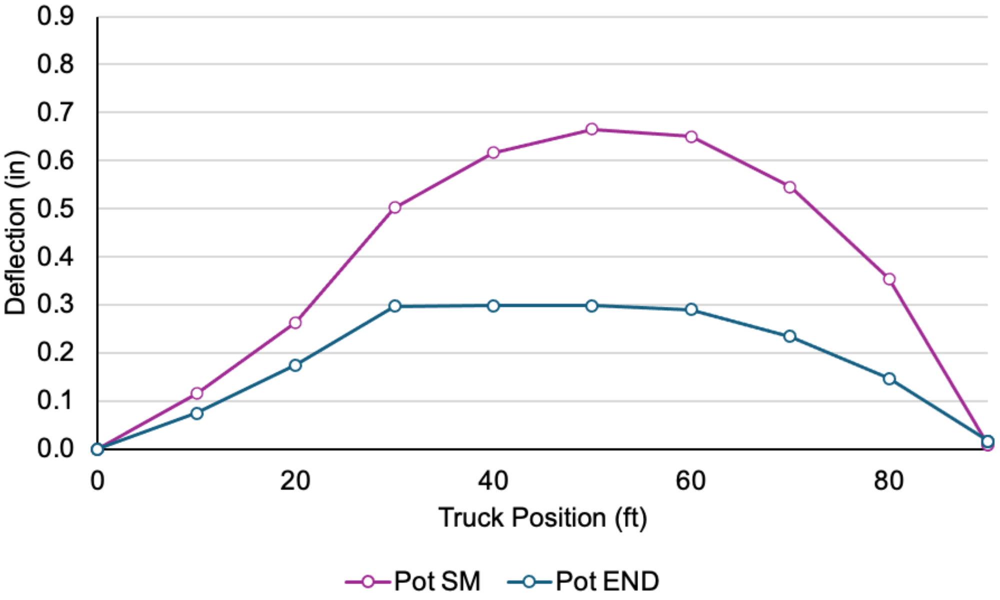


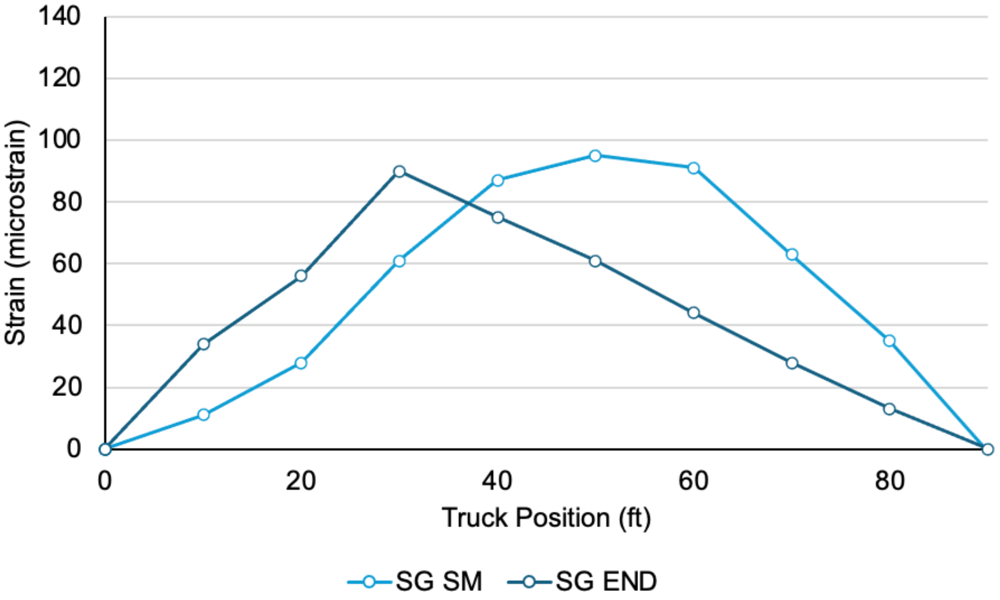


Strain (microstrain)
140
120
100
80
60
40
20
0
0
20
40
60
80
Truck Position (ft)
SG NOE
SG NM
SG NIE
SG SM
SG SOE
SG SIE

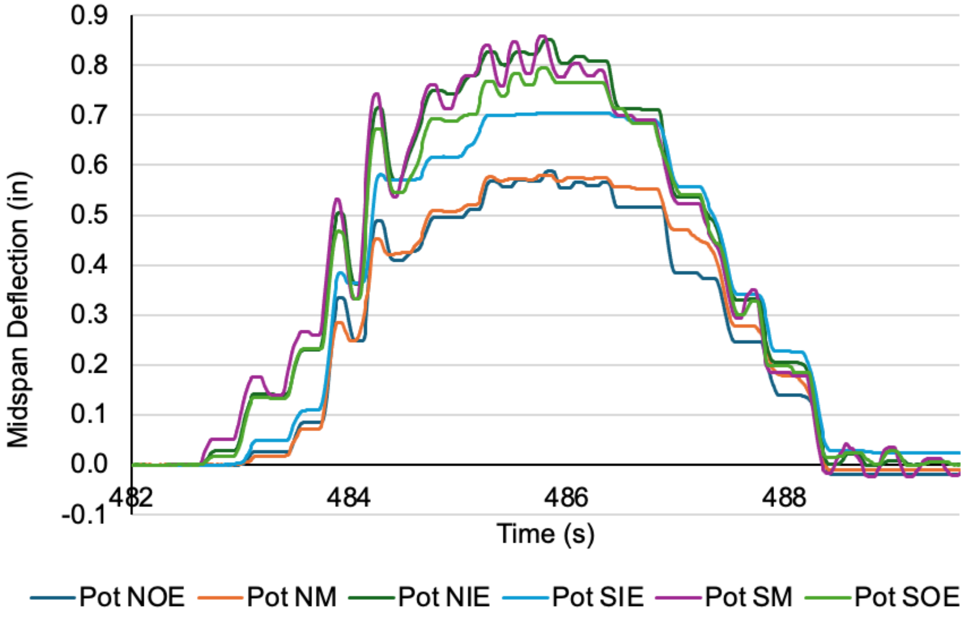


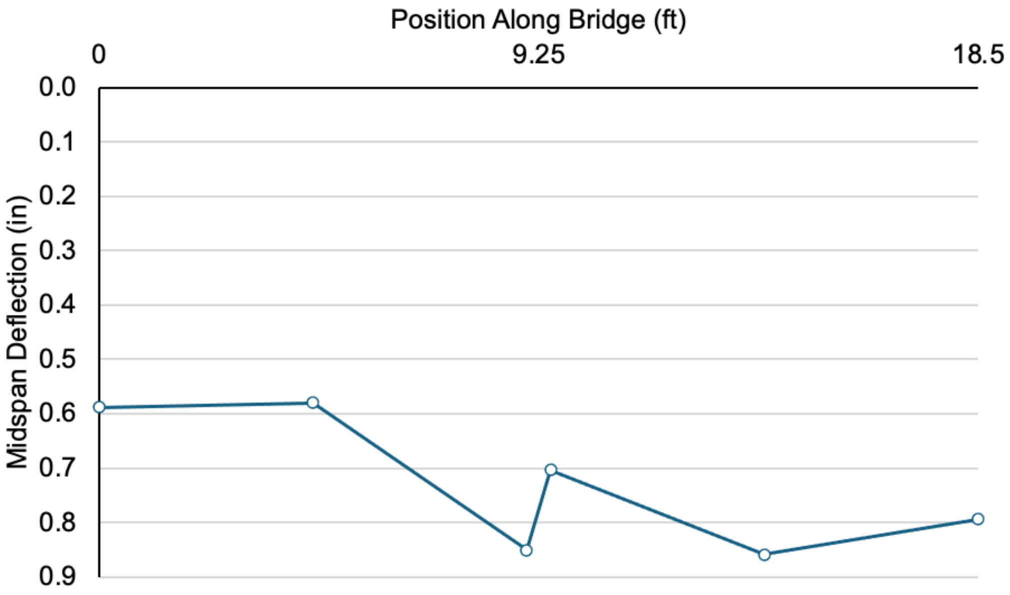
Strain (microstrain)
140
120
100
80
60
40
20
0
0
9.25
18.5
Positon Along Bridge (ft)
10 ft
20 ft
30 ft
40 ft
50 ft
60 ft
70 ft
80 ft

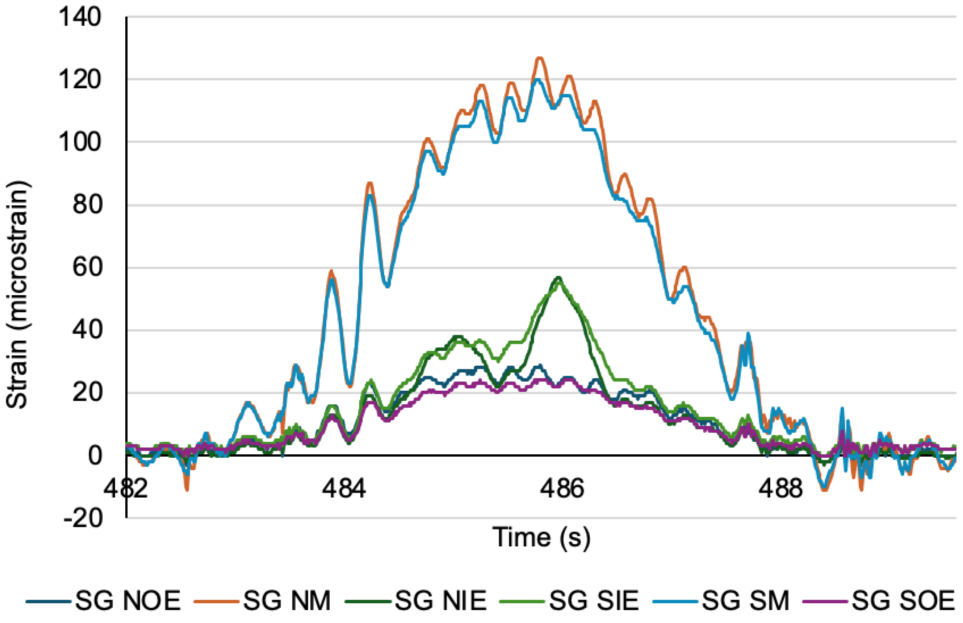

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Deflection (in)
0
20
40
60
80
Truck Position (ft)
Pot SM
Pot END

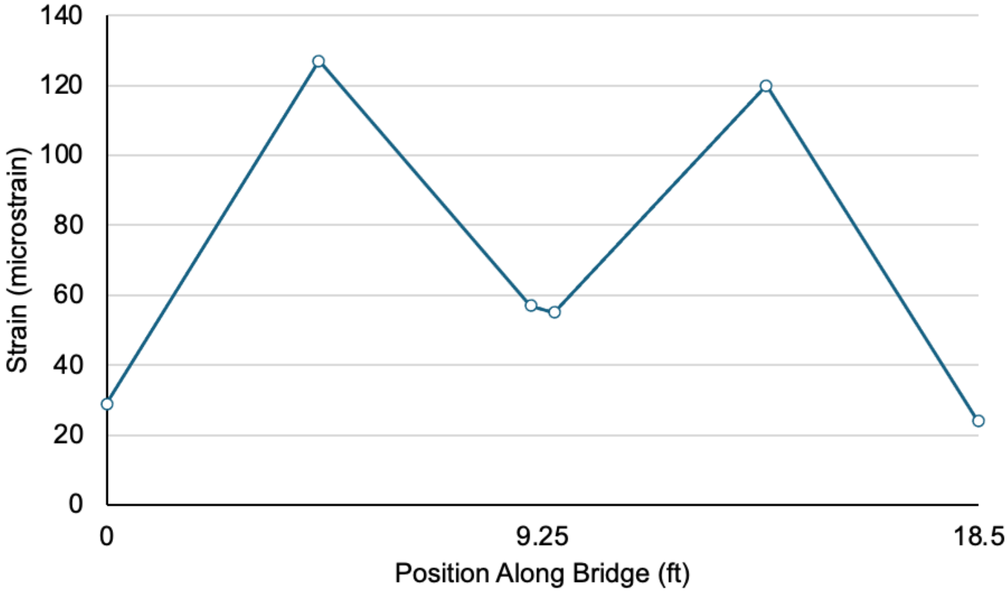

140
120
100
80
60
40
20
0
Strain (microstrain)
0
20
40
60
80
Truck Position (ft)
SG SM
SG END

A.8. Empty Truck, Dynamic Run

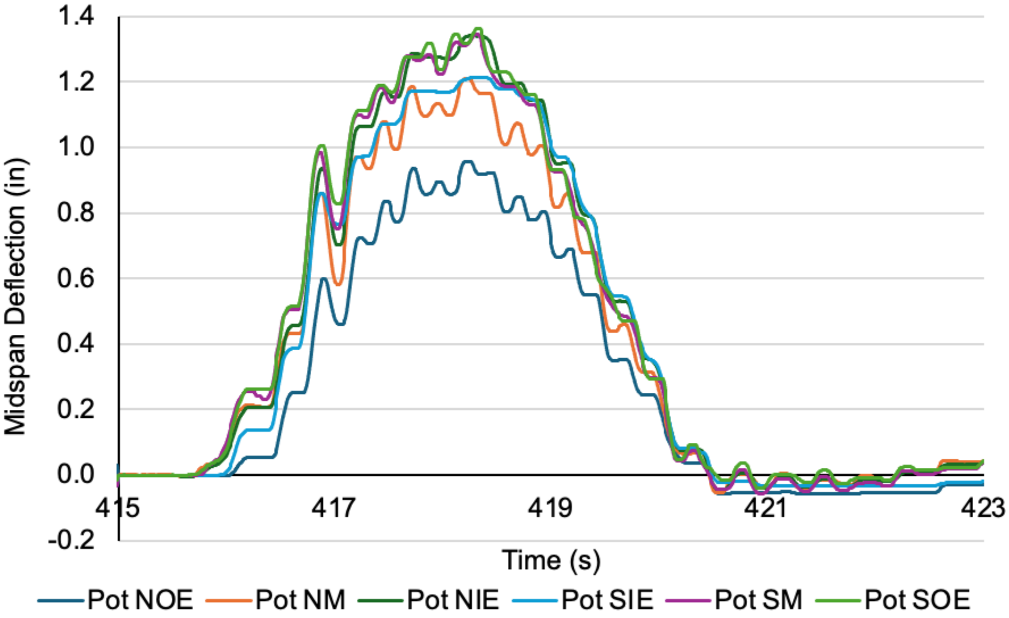


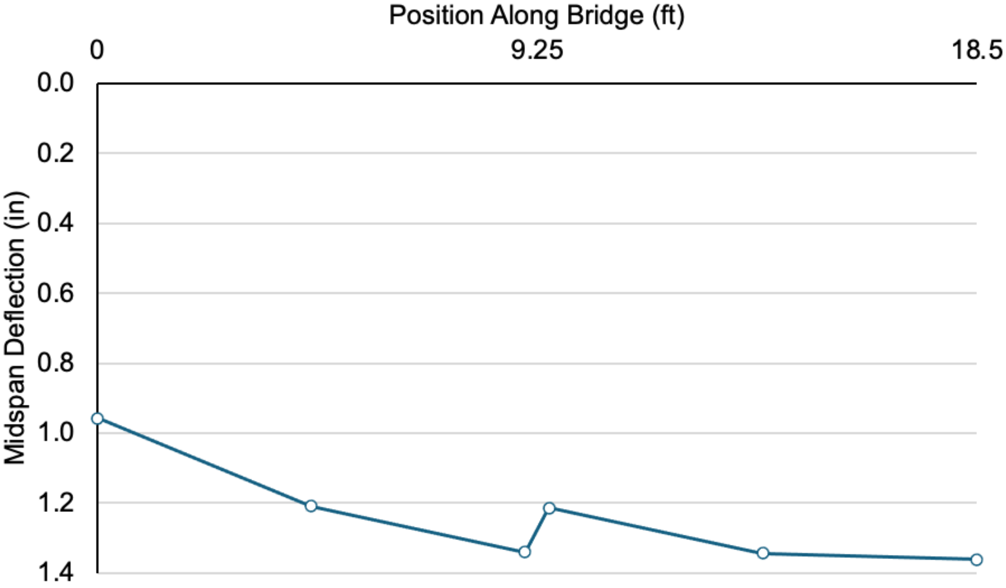



140
120
100
80
60
40
20
0
-20
Strain (microstrain)
482
484
486
488
Time (s)
SG NOE
SG NM
SG NIE
SG SIE
SG SM
SG SOE

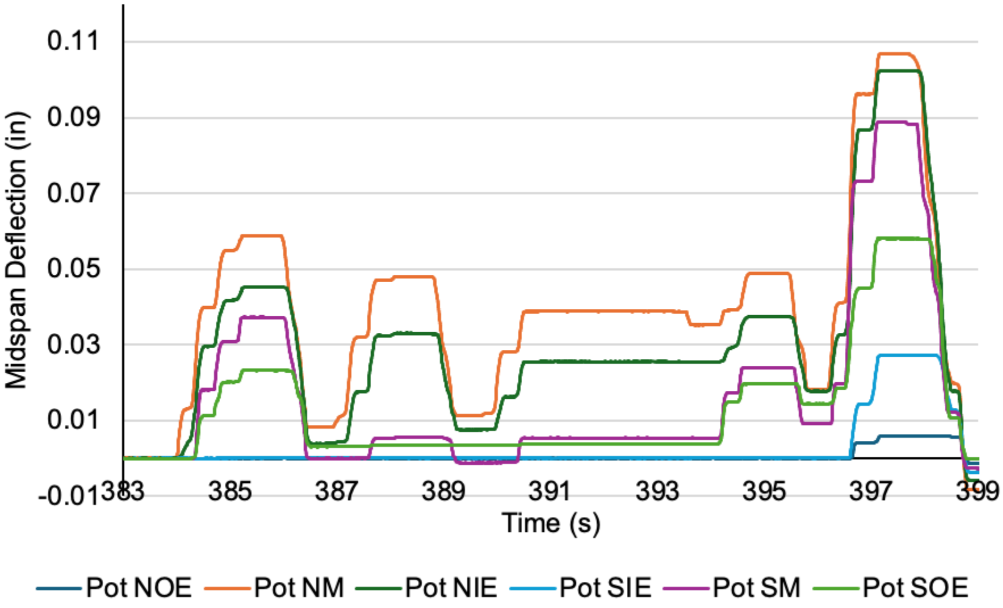

140
120
100
80
60
40
20
0
Strain (microstrain)
0
9.25
18.5
Position Along Bridge (ft)

A.9. Dynamic Data from a Garbage Truck

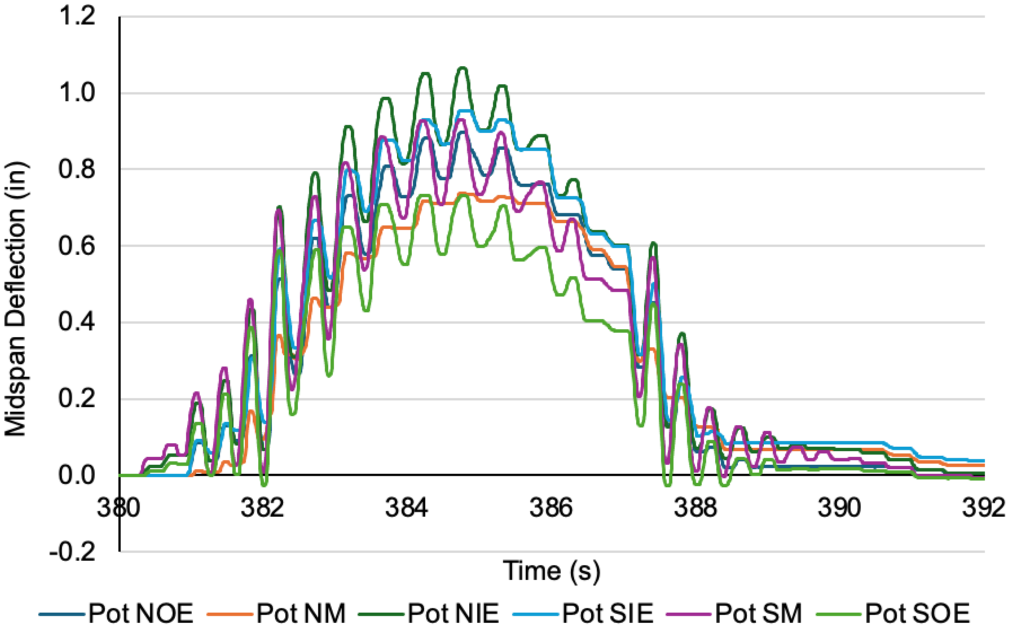




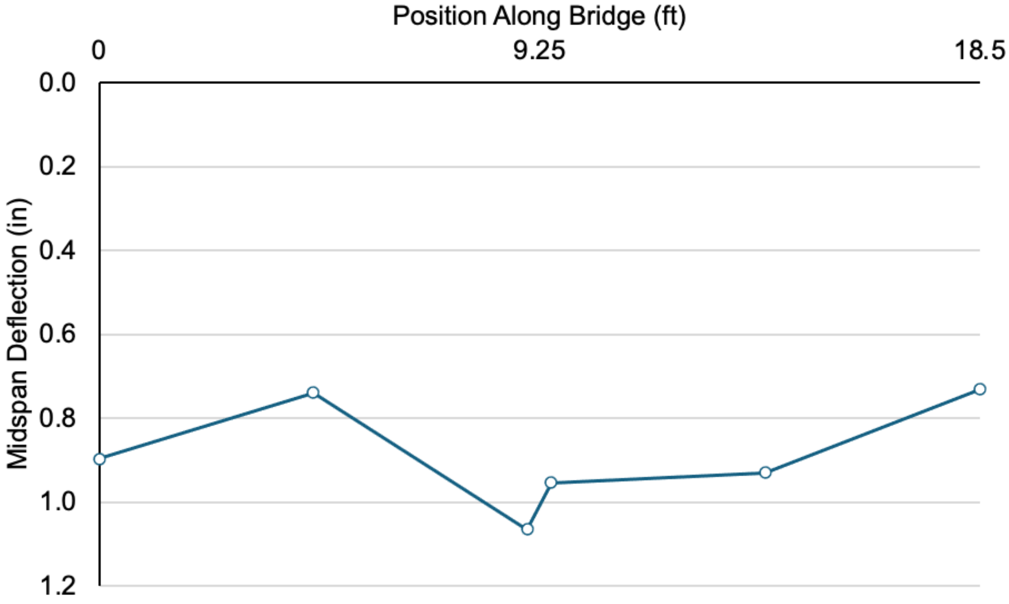
A.10. Dynamic Data from a String of Passenger Vehicles



A.11. Dynamic Data from Flatbed Delivery Truck



Midspan Deflection (in)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
380
382
384
386
388
390
392
Time (s)
Pot NOE
Pot NM
Pot NIE
Pot SIE
Pot SM
Pot SOE



Position Along Bridge (ft)
0
9.25
18.5
Midspan Deflection (in)
0.0
0.2
0.4
0.6
0.8
1.0
1.2