Report No. KS-16-06 ▪ APPENDICES ▪ August 2016

Repair of Distortion-Induced Fatigue Damage in Bridge No. 135-87 (043SB and 044NB) Using Newly-Developed Strengthening Schemes

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Due to file size, the full report without appendices is available in a separate file located at:

http://kdotapp.ksdot.org/kdotlib/kdotlib2.aspx

or by contacting the KDOT Library at KDOT#Research.Library@ksdot.org.

Appendix A: Calibration Constants

Strain Transducers from Bridge Diagnostics Inc. (BDI)

Calibrations are provided by Bridge Diagnostics Inc. but must be modified based on supplied voltage. A supply voltage of 5 V was applied to each strain transducer.

$$\text{Calibration Constant} = \frac{\text{General Factor } \mu\varepsilon/mV/\text{V} \times 1000\, mV/V}{\text{Input Voltage}\, V}$$

These modified constants for the strain transducers can be found in Table A. 1.

Table A. 1: Calibration Constants for Strain Transducers

Strain Transducer Label	General Factor	Calibration Constant (5V)
BDI 1269	503.9 με/mV/V	100,780 με/V
BDI 1270	497.0 με/mV/V	99,400 με/V
BDI 1271	503.5 με/mV/V	100,700 με/V
BDI 1272	496.7 με/mV/V	99,340 με/V
BDI 1273	493.6 με/mV/V	98,720 με/V
BDI 1274	502.4 με/mV/V	100,480 με/V

Appendix B: Kansas Bridge 135-087 (043/044) Plans

Original Plans

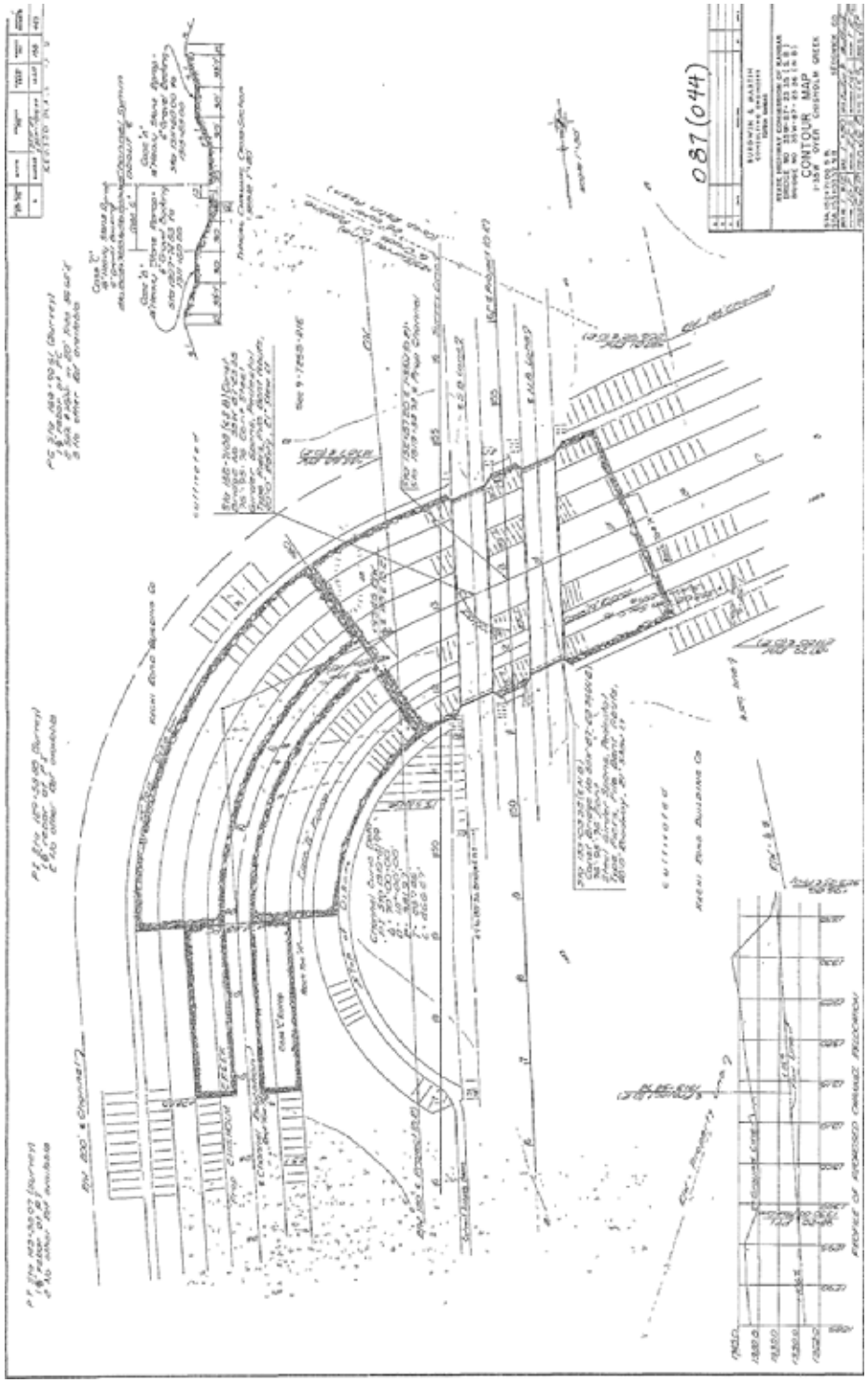


Figure B. 1: Contour map.

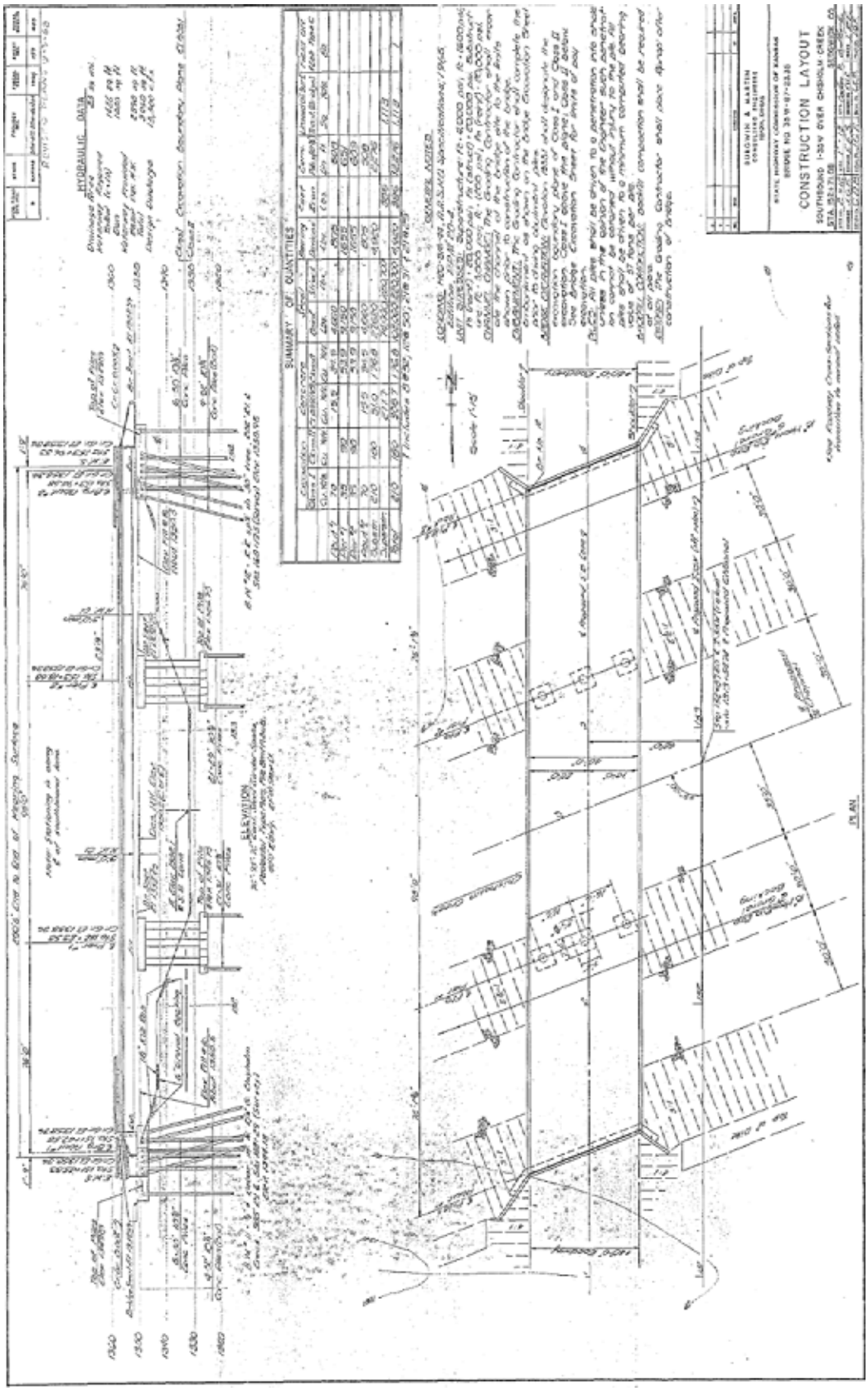


Figure B. 2: Construction layout of southbound bridge.

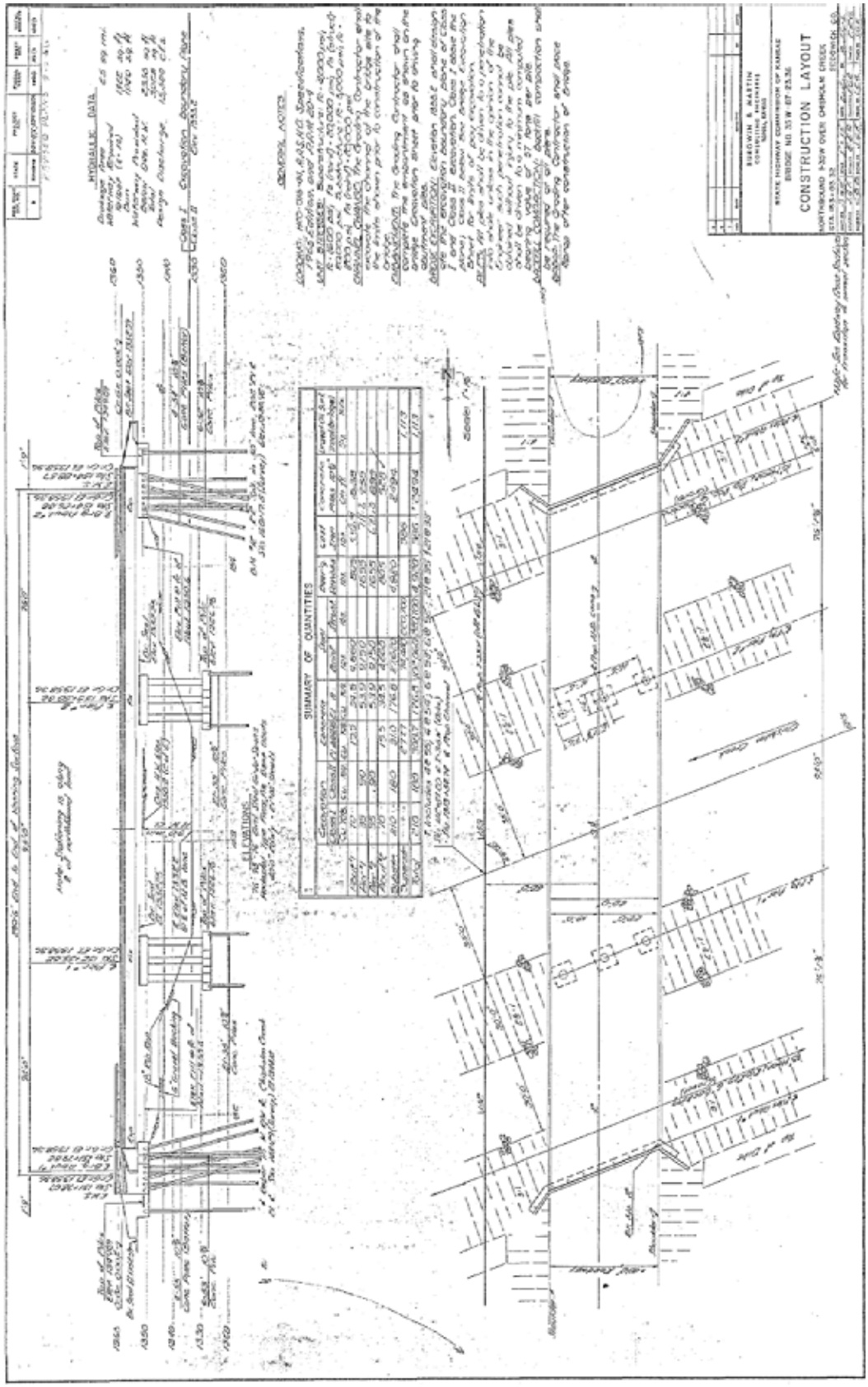


Figure B. 3: Construction layout of northbound bridge.

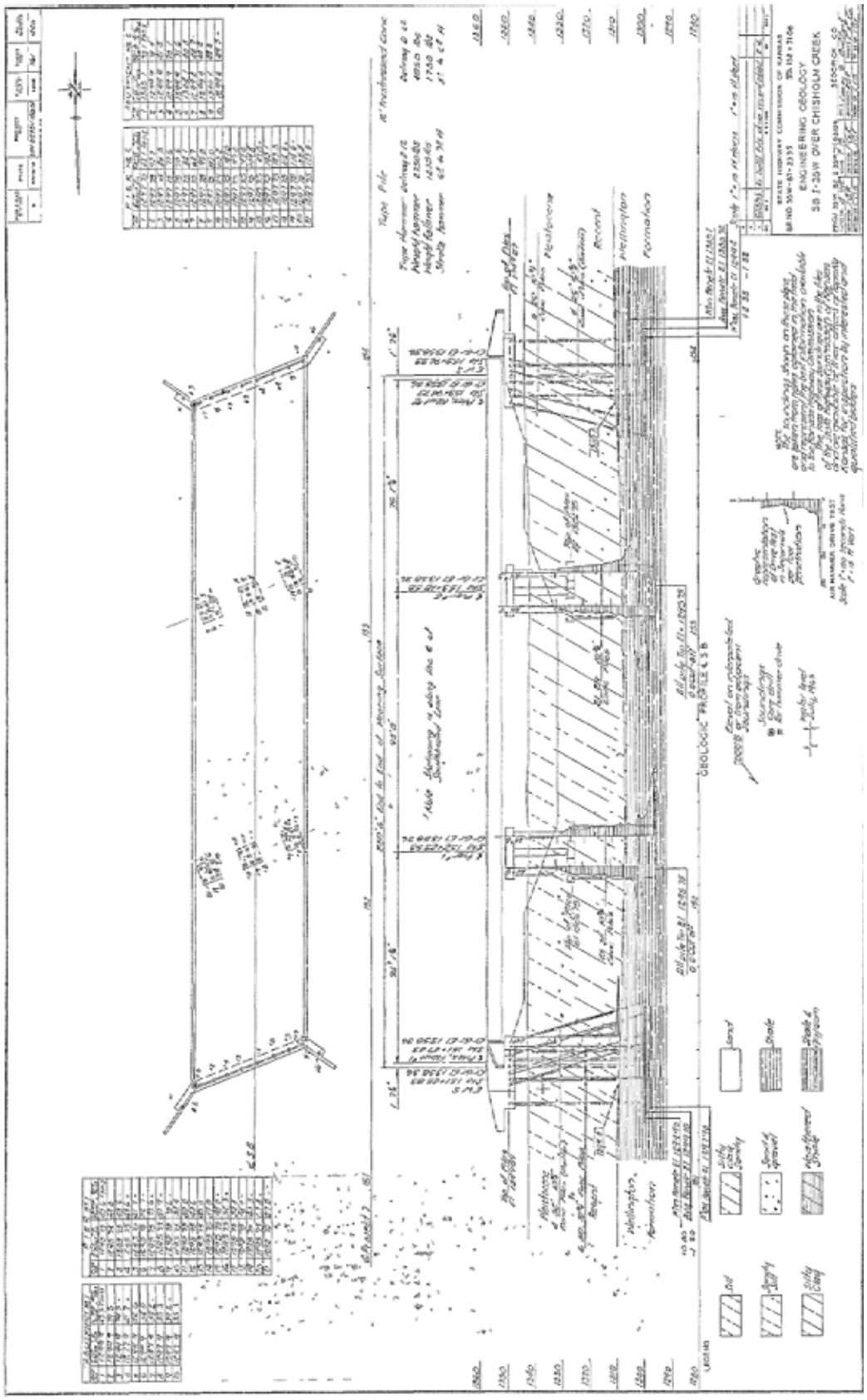


Figure B. 4: Engineering geology.

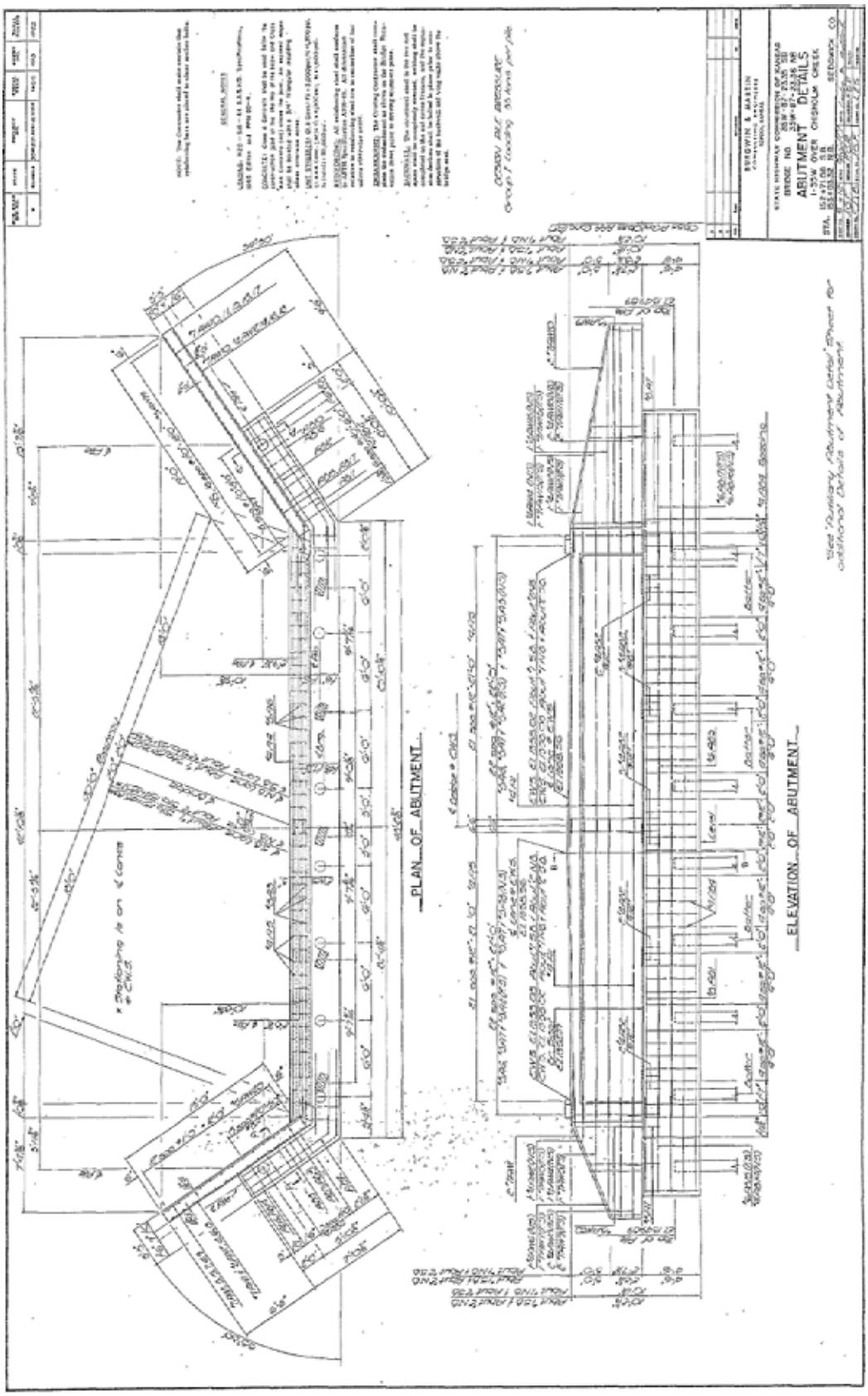


Figure B. 5: Abutment details.

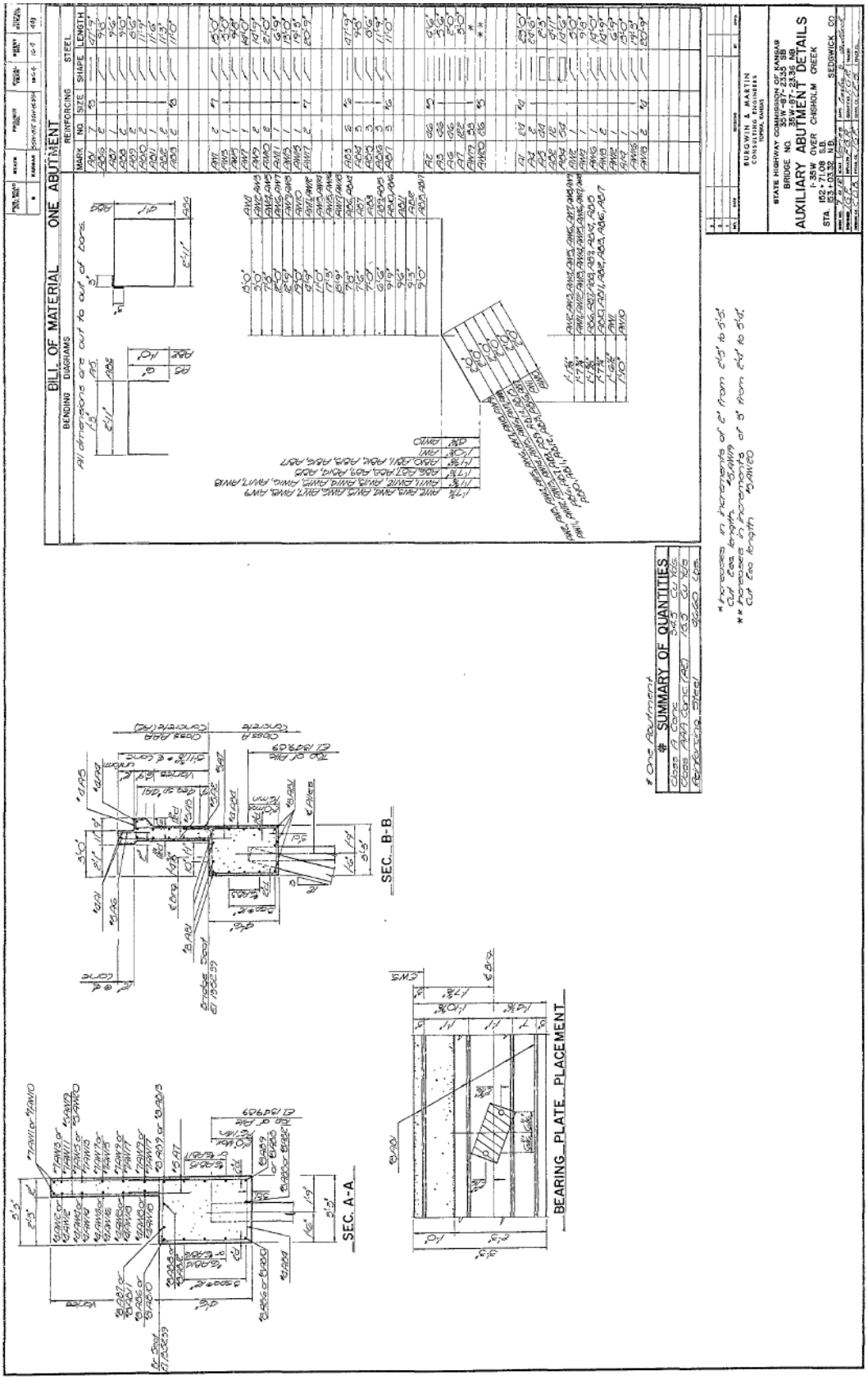


Figure B. 6: Auxiliary abutment details.

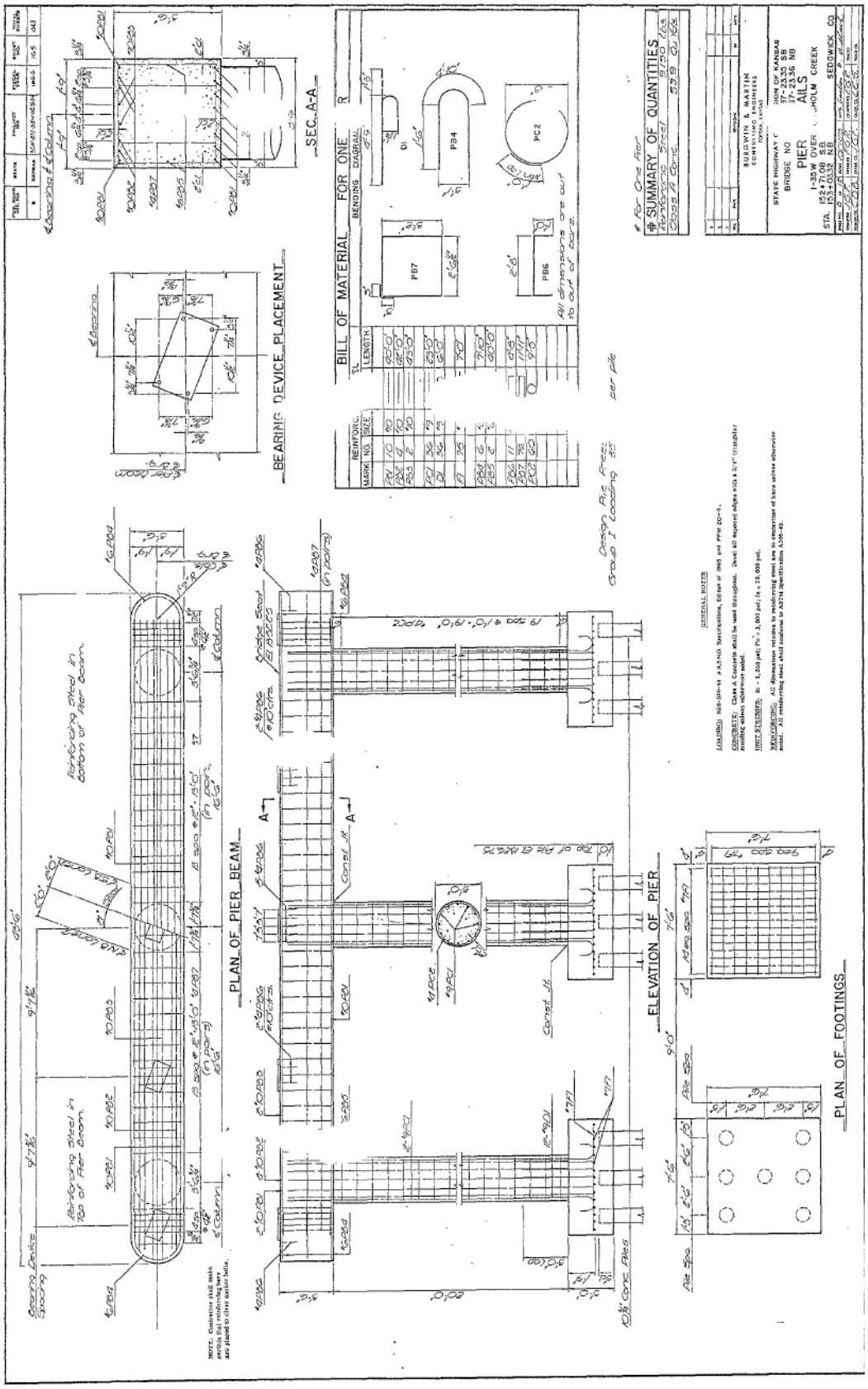


Figure B. 7: Pier details.

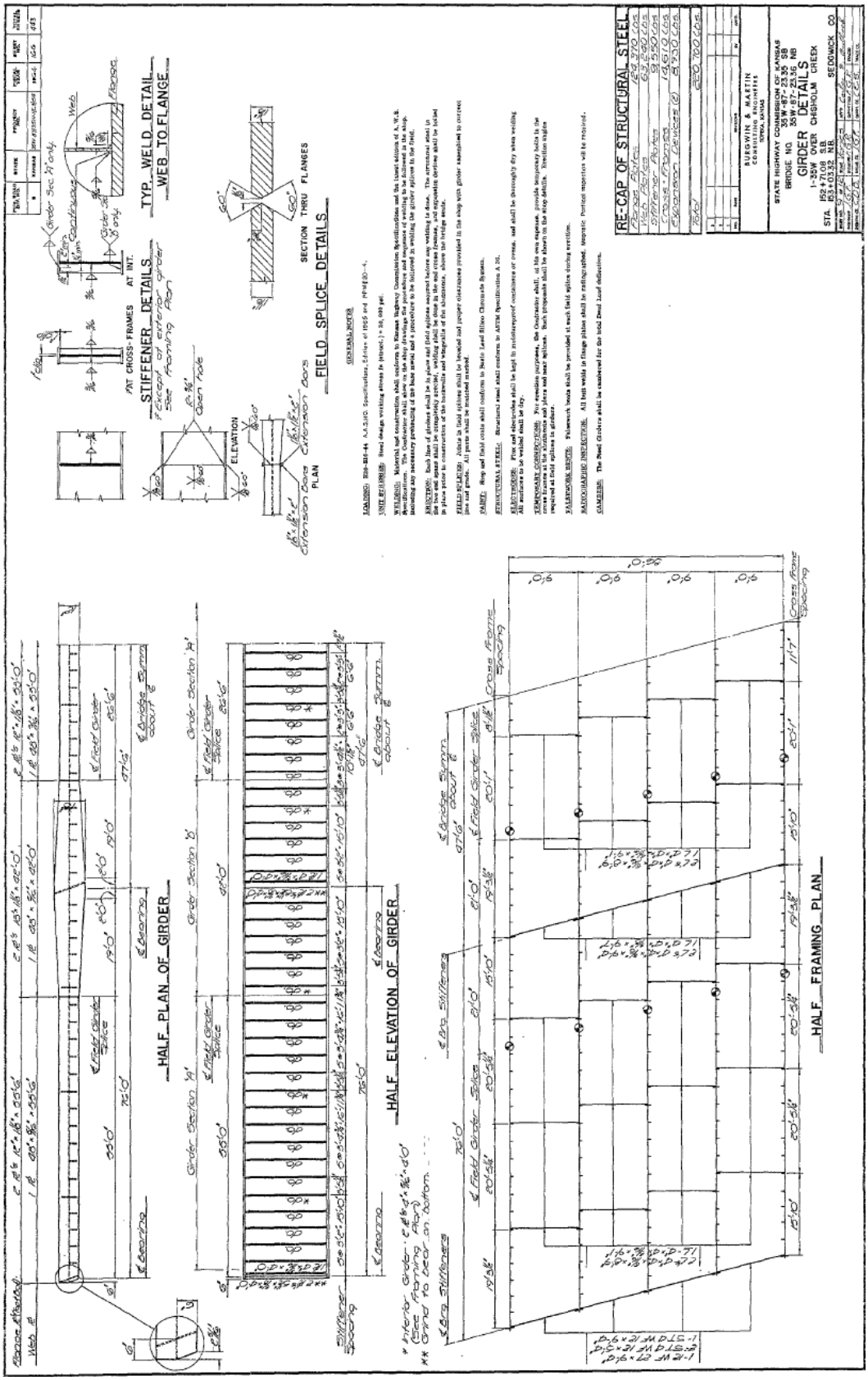


Figure B. 8: Girder details.

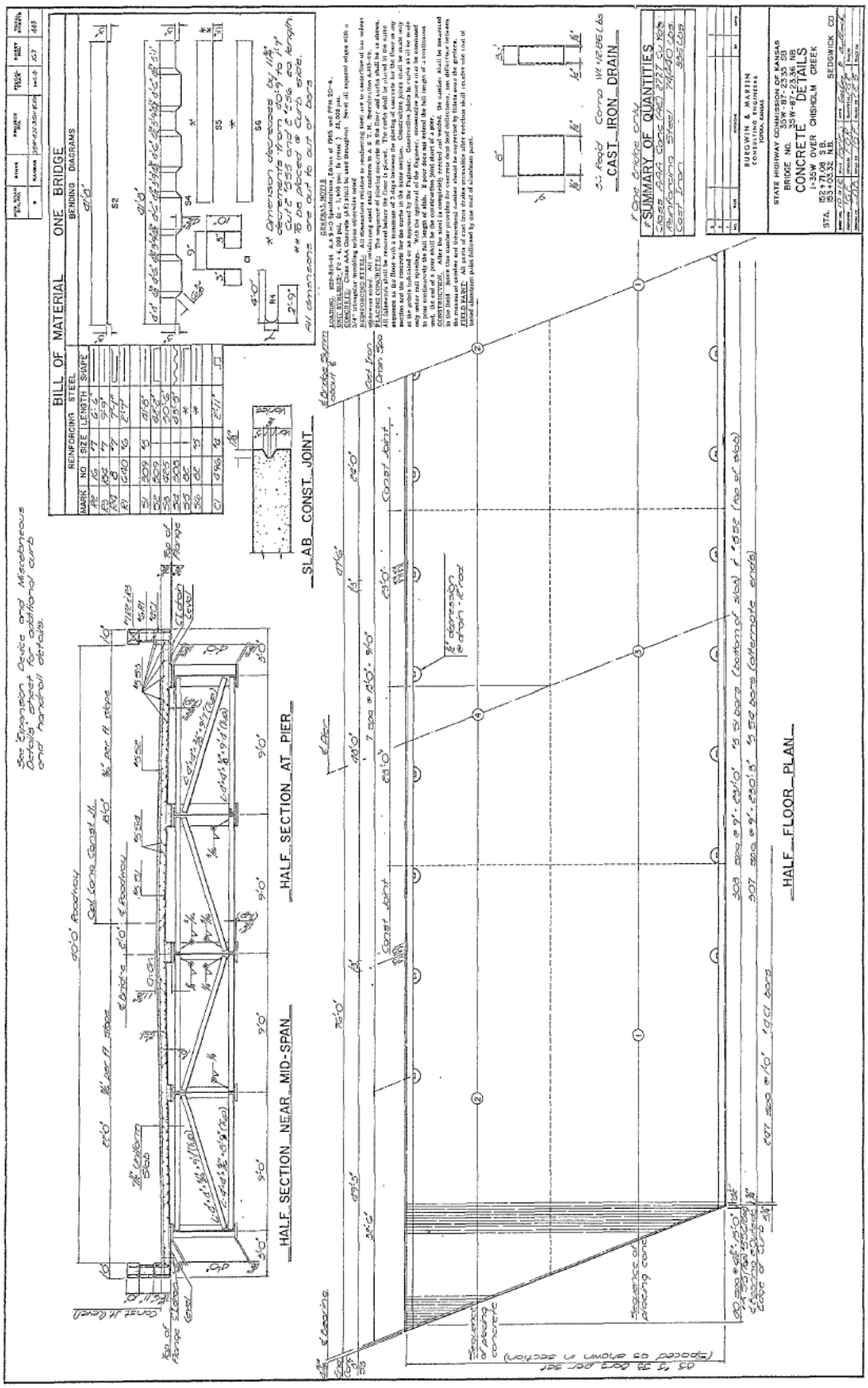


Figure B. 9: Concrete details.

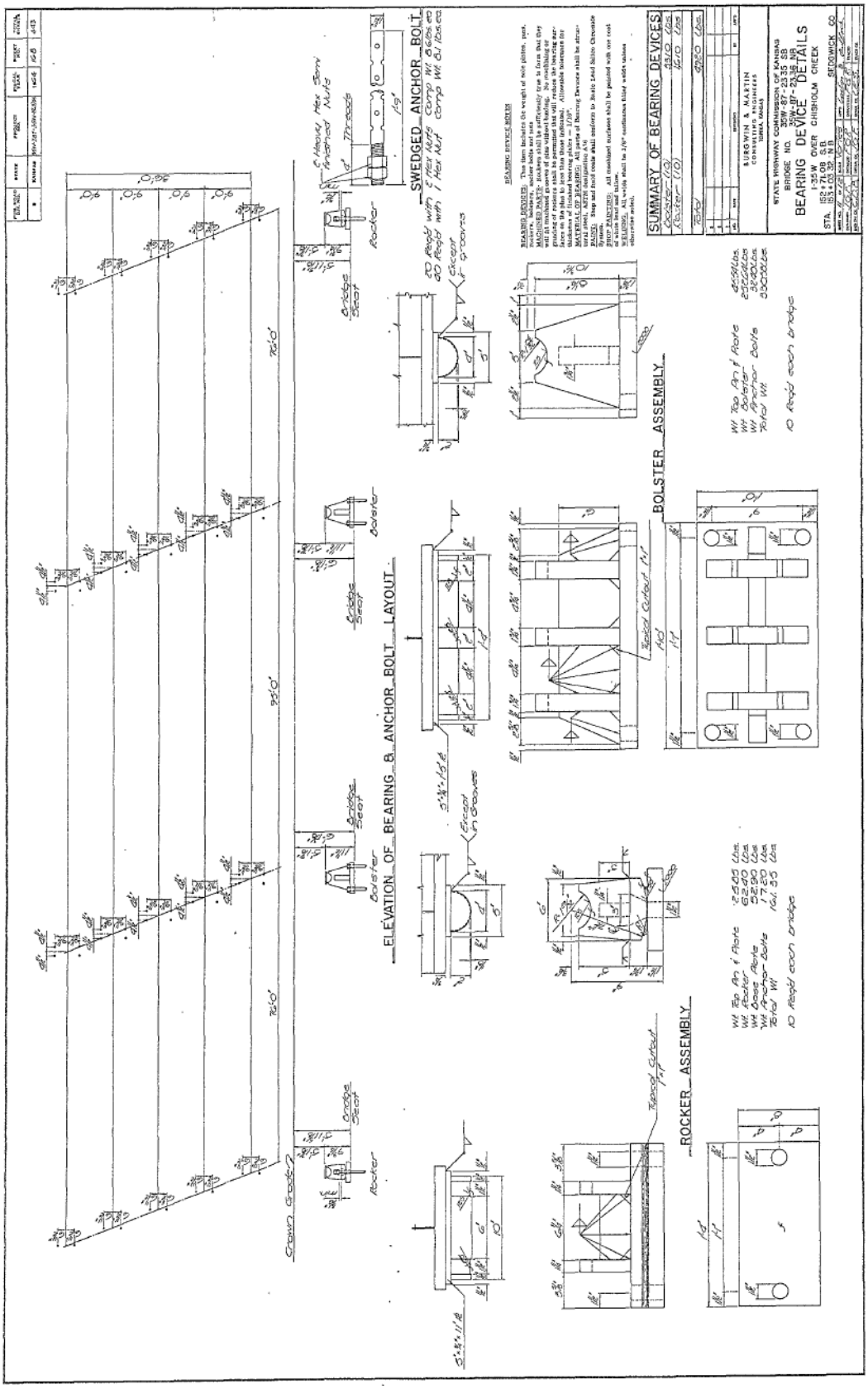


Figure B. 10: Bearing device details.

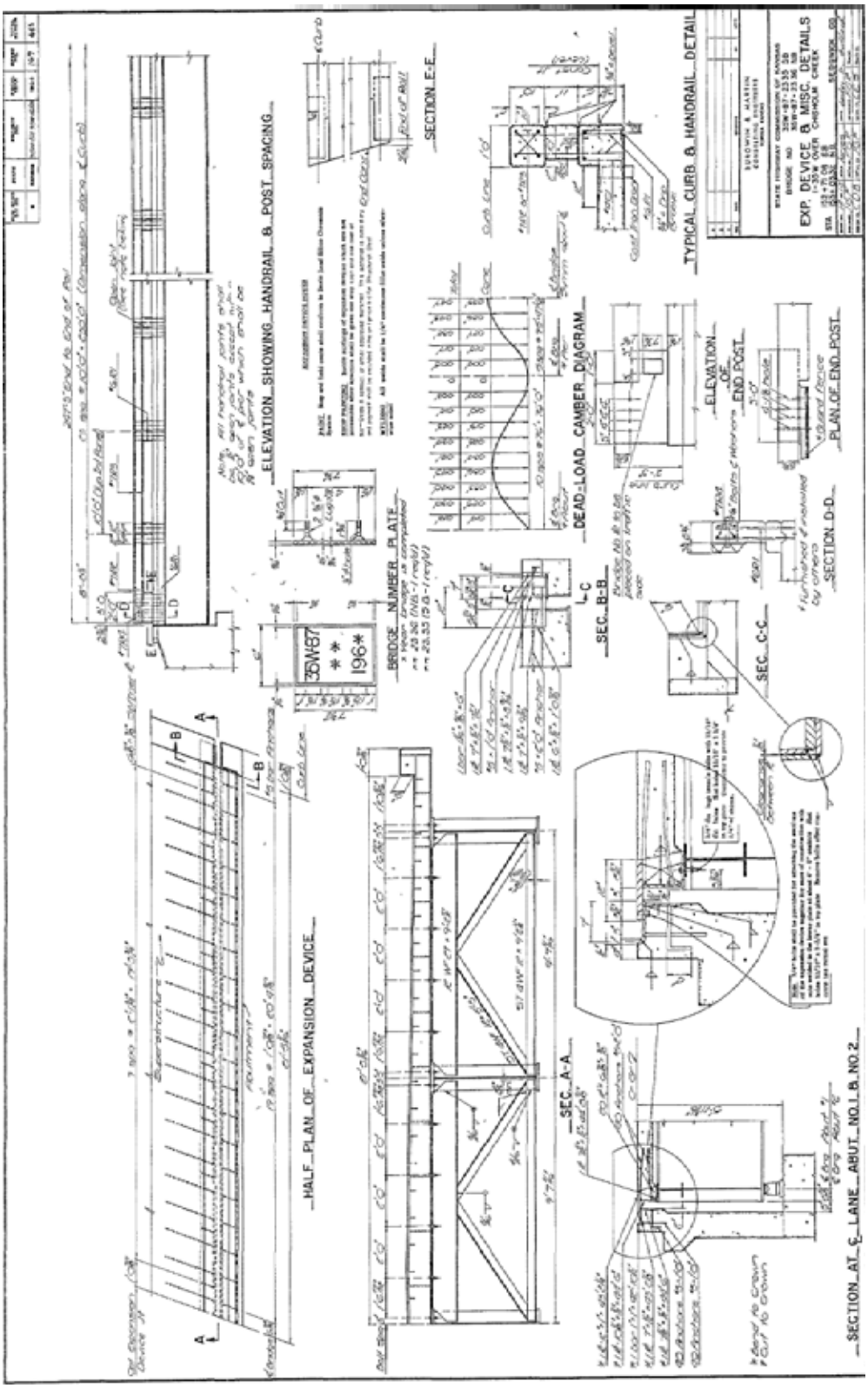


Figure B. 11: Expansion device and miscellaneous details.

Repair Plans

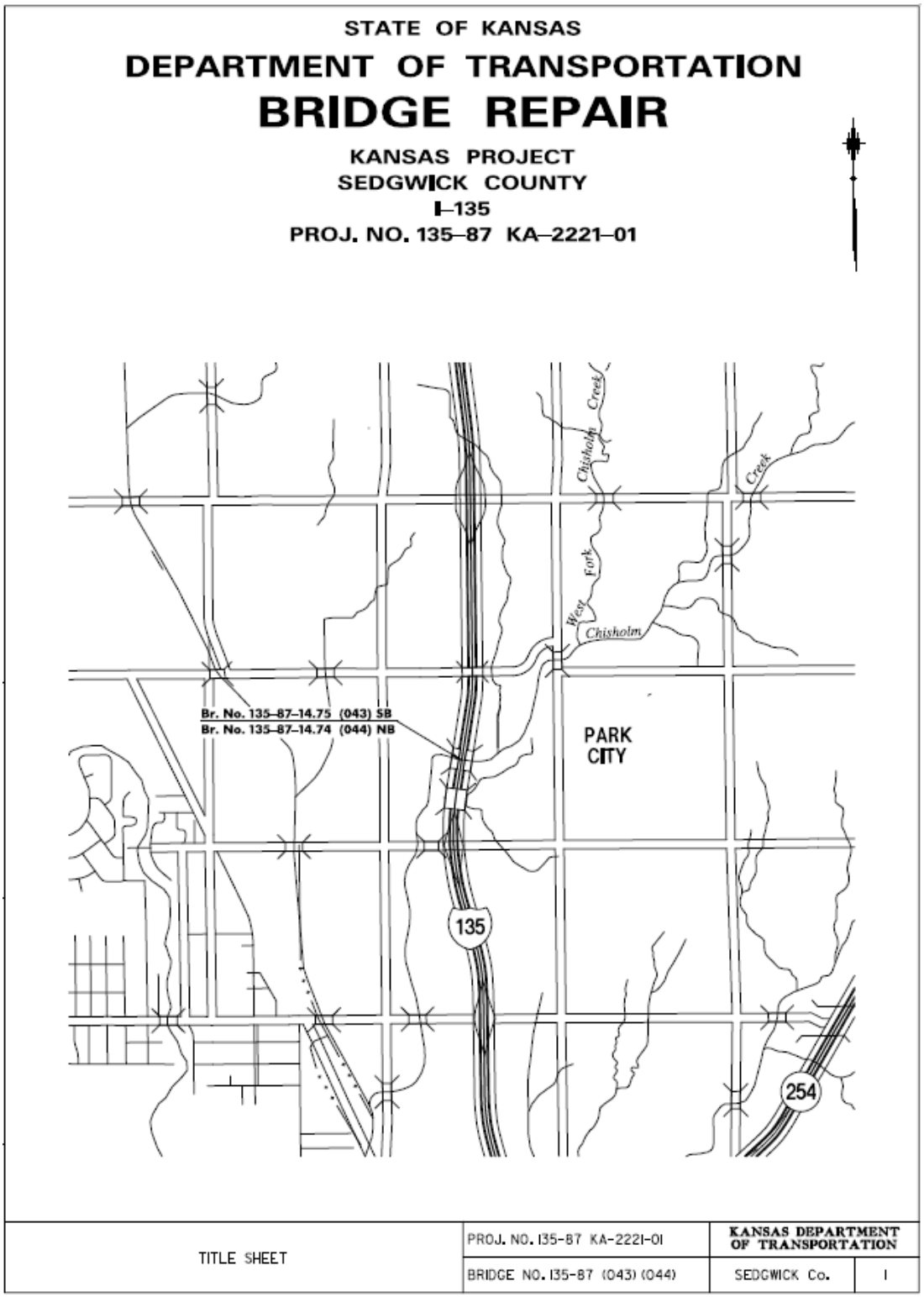


Figure B. 12: Title sheet.

SUMMARY OF STRUCTURAL STEEL QUANTITIES (For Information only)						
Bridge Number	Connection Angle 8" x 6" x 3/4" x 3 1/2" (Each)	* Plate 1" x 7 1/4" x 10 1/2" (Each)	* Plate 3/4" x 3 1/4" x 7 1/4" (Each)	Backing Plate 1" x 7 1/4" x 1'-10" (Each)	Fill Plate 5/16" x 3 1/2" x 7 1/4" (Each)	Fill Plate 5/16" x 3 1/2" x 3 1/2" (Each)
(043)	160	60	60	50	60	80
(044)	320	120	120	100	120	160
Total	480	180	180	150	180	240

* To be used in "Fabricated Backing Plate Angle".

POUNDS OF STRUCTURAL STEEL:
Single Web Stiffener Locations
Br. No. (043)....3,300 lbs.
Br. No. (044)....6,600 lbs.
Double Web Stiffener Locations
Br. No. (043)....2,354 lbs.
Br. No. (044)....4,708 lbs.
TOTAL:
Br. No. (043)....5,654 lbs
Br. No. (044)...11,308 lbs.
TOTAL.....16,962 lbs.

3/4"ø A325 Bolts:
3 1/2" - 960 Total
3 3/4" - 330 Total

INDEX TO DRAWINGS	
Sheet No.	Drawing
1	Title Sheet
2-3	General Notes and Quantities
4	Construction Layout
5	Framing Plan
6	Existing Girder Details at Cross Frames
7-8	Proposed Girder Web Repair Details at Cross Frames (Single Web Stiffener Locations)
9-10	Proposed Girder Web Repair Details at Cross Frames (Double Web Stiffener Locations)
11	Structural Steel Details

SUMMARY OF QUANTITIES		
ITEM	UNITS	QUANTITY
Bridge Repair	Lump Sum	Lump Sum
Flagger (Set)	Hour	1
Mobilization	Lump Sum	Lump Sum

ID #1: 150 Single Web Stiffener Locations
ID #2: 90 Double Web Stiffener Locations

Note: On Bridge (043), repair connections at the bottom flanges only.
On Bridge (044), repair connections at both the bottom and top flanges.

GENERAL NOTES AND QUANTITIES	PROJ. NO. 135-87 KA-2221-01	KANSAS DEPARTMENT OF TRANSPORTATION	
	BRIDGE NO. 135-87 (043) (044)	SEDGWICK Co.	2

Figure B. 13: General notes and quantities.

GENERAL NOTES

EXISTING DIMENSION VERIFICATION: Dimensions of the existing structure are based on old plans. Verify, by field measurement, the as-built dimensions of the existing structure and submit such verification in writing to the Engineer. The verification will include sketches, drawings, photographs and descriptions as needed to clearly define the as-built dimensions that will be incorporated in the new construction.

EXISTING STRUCTURE: Plans of the existing structure are on file and available for inspection by qualified bidders at the State Bridge Office, KDOT, Eisenhower State Office Building, 700 SW Harrison, Topeka, KS.

BRIDGE REPAIR: The bid item "Bridge Repair (Lump Sum)" shall be full compensation for materials, labor and equipment necessary to perform the work as shown.

STRUCTURAL STEEL: Structural steel shall be ASTM A709 Gr. 36. The structural steel shall be shipped unpainted.

BOLTS: All bolts, nuts and hardened flat washers shall conform to the heavy hex structural requirements of ASTM A325, Type 1, and KDOT Specifications unless otherwise noted. Direct Tension Indicators (DTIs) are to comply with the requirements of the latest edition of ASTM F959. No allowance will be made for high strength bolts used for permanent or temporary connections. This work is subsidiary to the bid item, "Bridge Repair" (Lump Sum). The number of bolts is shown for the convenience of the Contractor.

BOLTED CONNECTIONS: Use 3/4" diameter heavy hex structural bolts for all connections. Use 13/16" diameter bolt holes. Slotted holes require one additional standard hardened washer or plate washer.

Use Direct Tension Indicators (DTIs) on all high strength bolts. Place the DTI under the bolt head and turn the nut to tighten. This method is preferred whenever possible. Face the protrusions on the DTI to the underside of the bolt head. Place a hardened flat washer under the nut. See KDOT Specifications.

PAINTING: Paint all surfaces that have been exposed by repair procedures. Paint all new structural steel. The surfaces to be painted shall be cleaned to meet Steel Structures Painting Council Specifications SSPC-SP6. The field coats applied shall conform to an organic zinc primer with a waterborne acrylic finish coat. The finish coat will be Kansas dark green. The color shall match Federal Standard #34102. Painting shall be subsidiary to the bid item "Bridge Repair (Lump Sum)".

QUANTITIES: Items not listed separately in the Summary of Quantities are subsidiary to other items in the proposal.

GENERAL NOTES AND QUANTITIES	PROJ. NO. 135-87 KA-2221-01	KANSAS DEPARTMENT OF TRANSPORTATION	
	BRIDGE NO. 135-87 (043) (044)	SEDGWICK Co.	3

Figure B. 14: General notes and quantities.

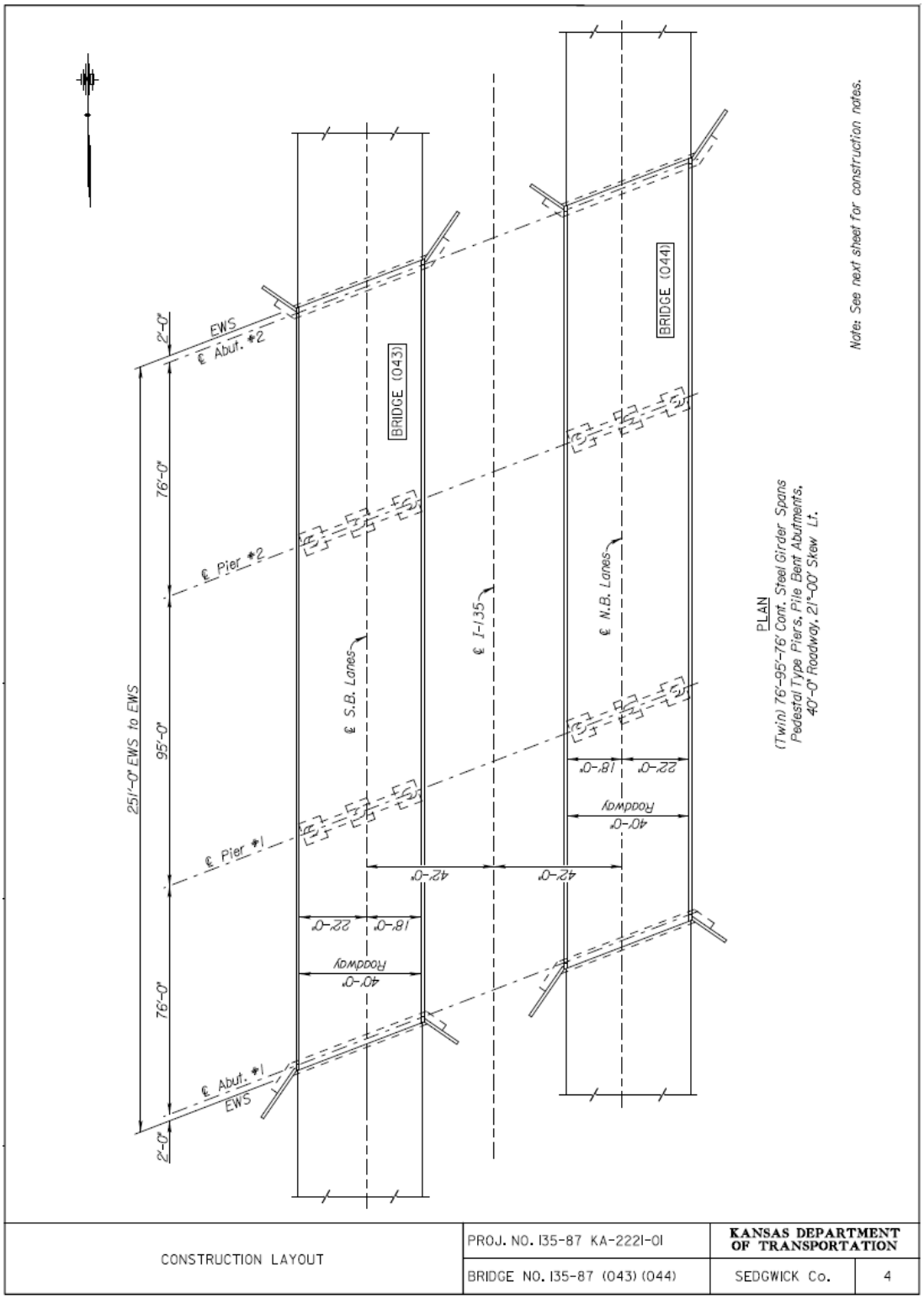


Figure B. 15: Construction layout.

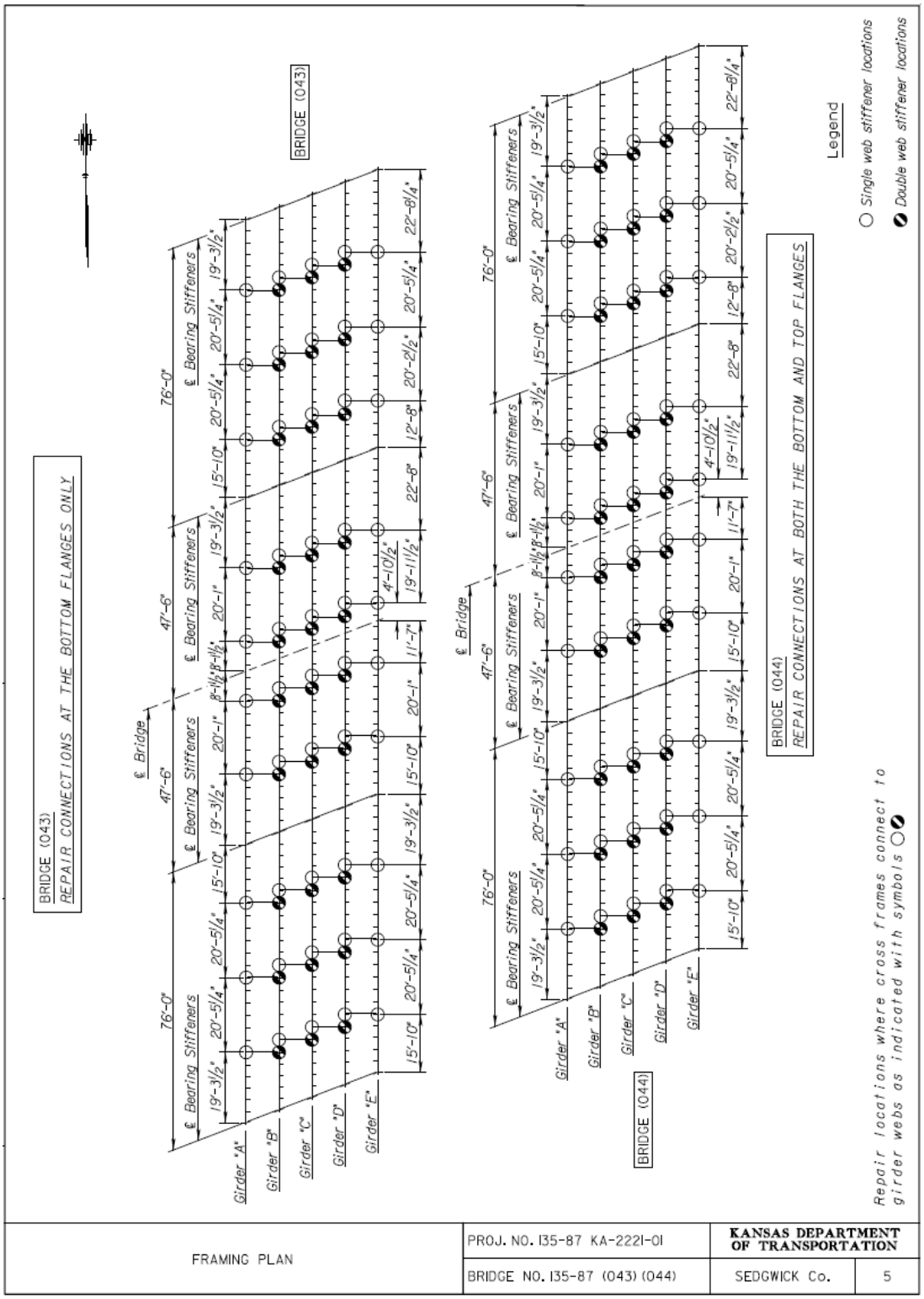


Figure B. 16: Framing plan.

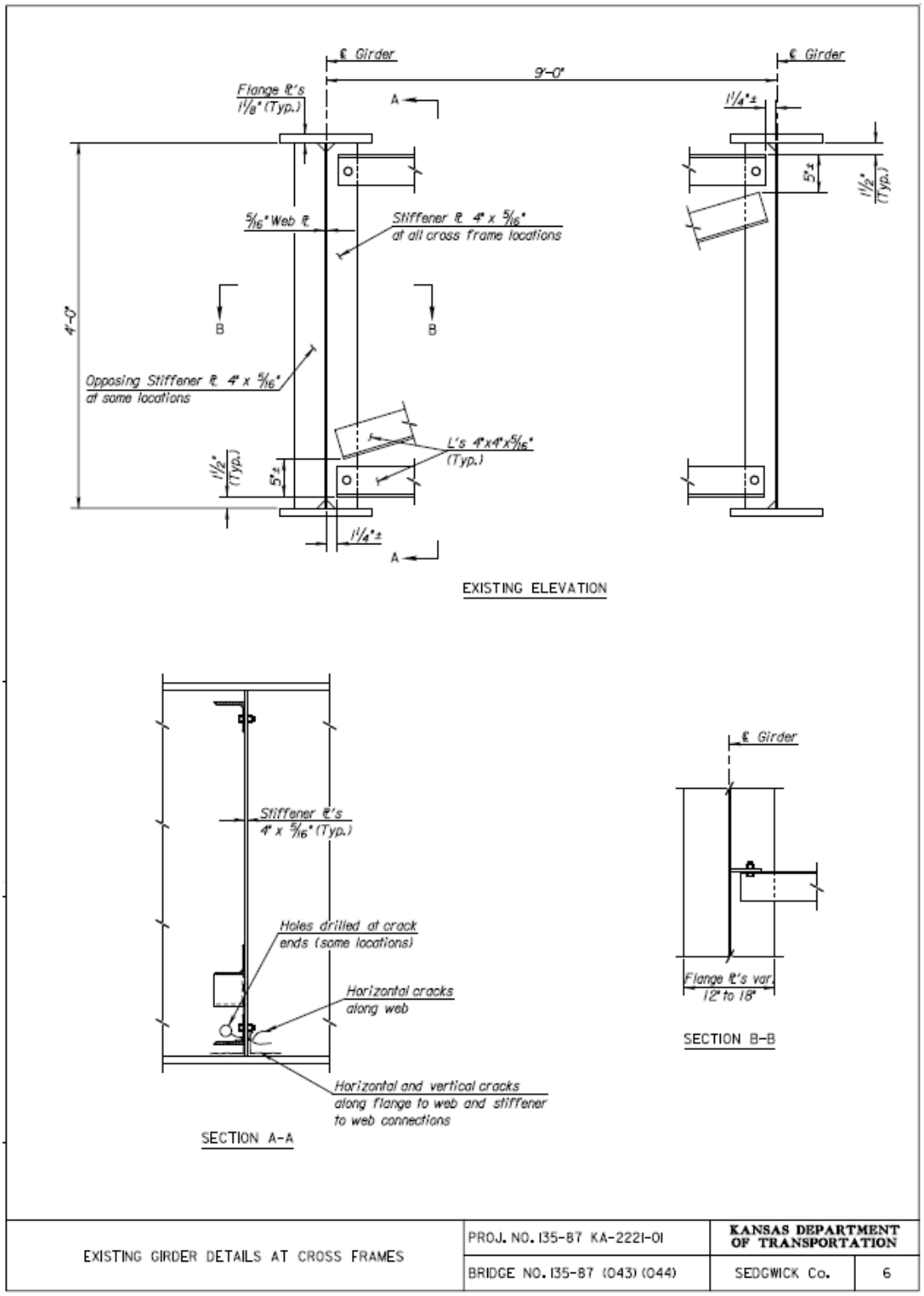


Figure B. 17: Existing girder details at cross frames.

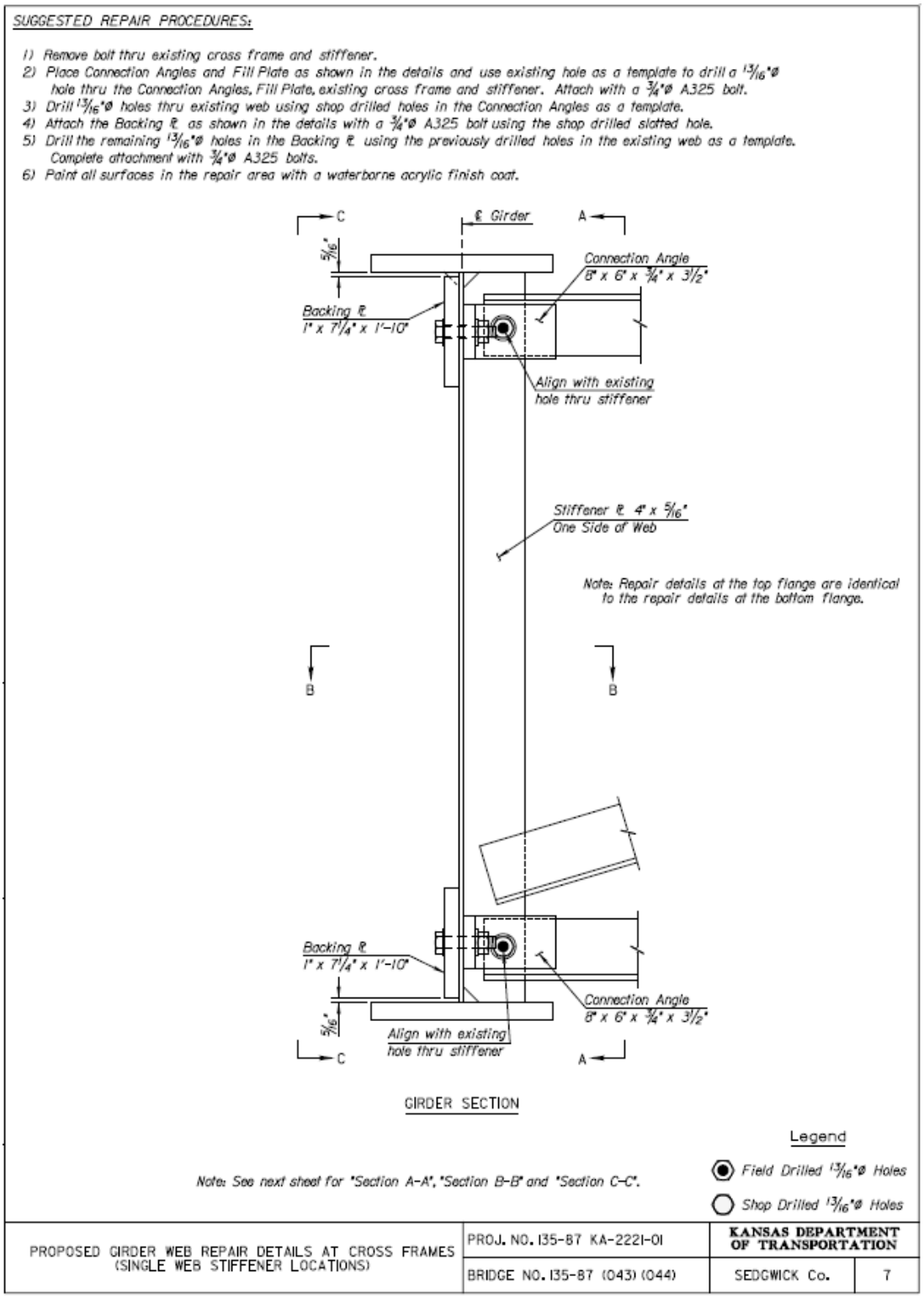


Figure B. 18: Proposed girder web repair details at cross frames (single web stiffener locations).

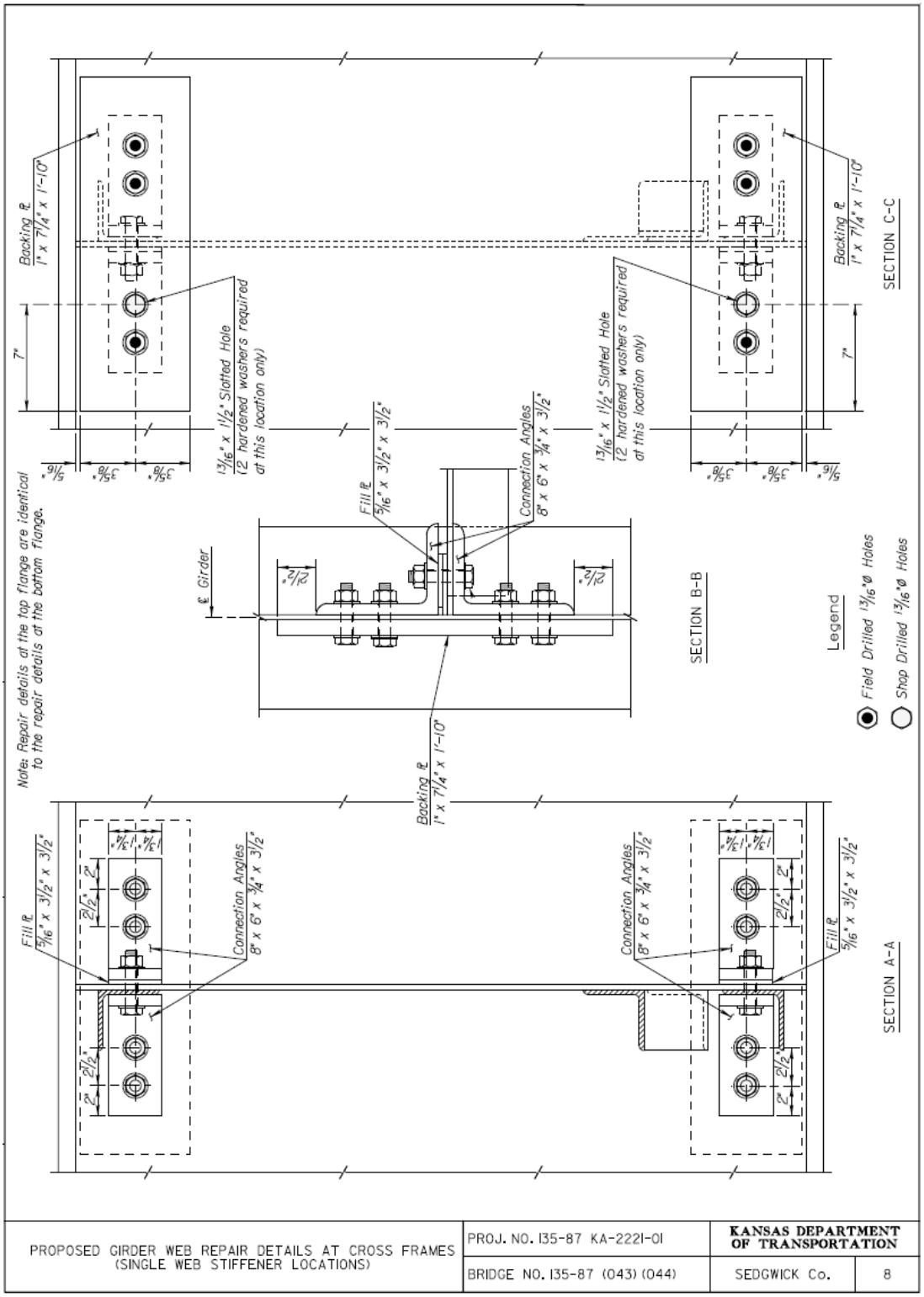


Figure B. 19: Proposed girder web repair details at cross frames (single web stiffener locations).

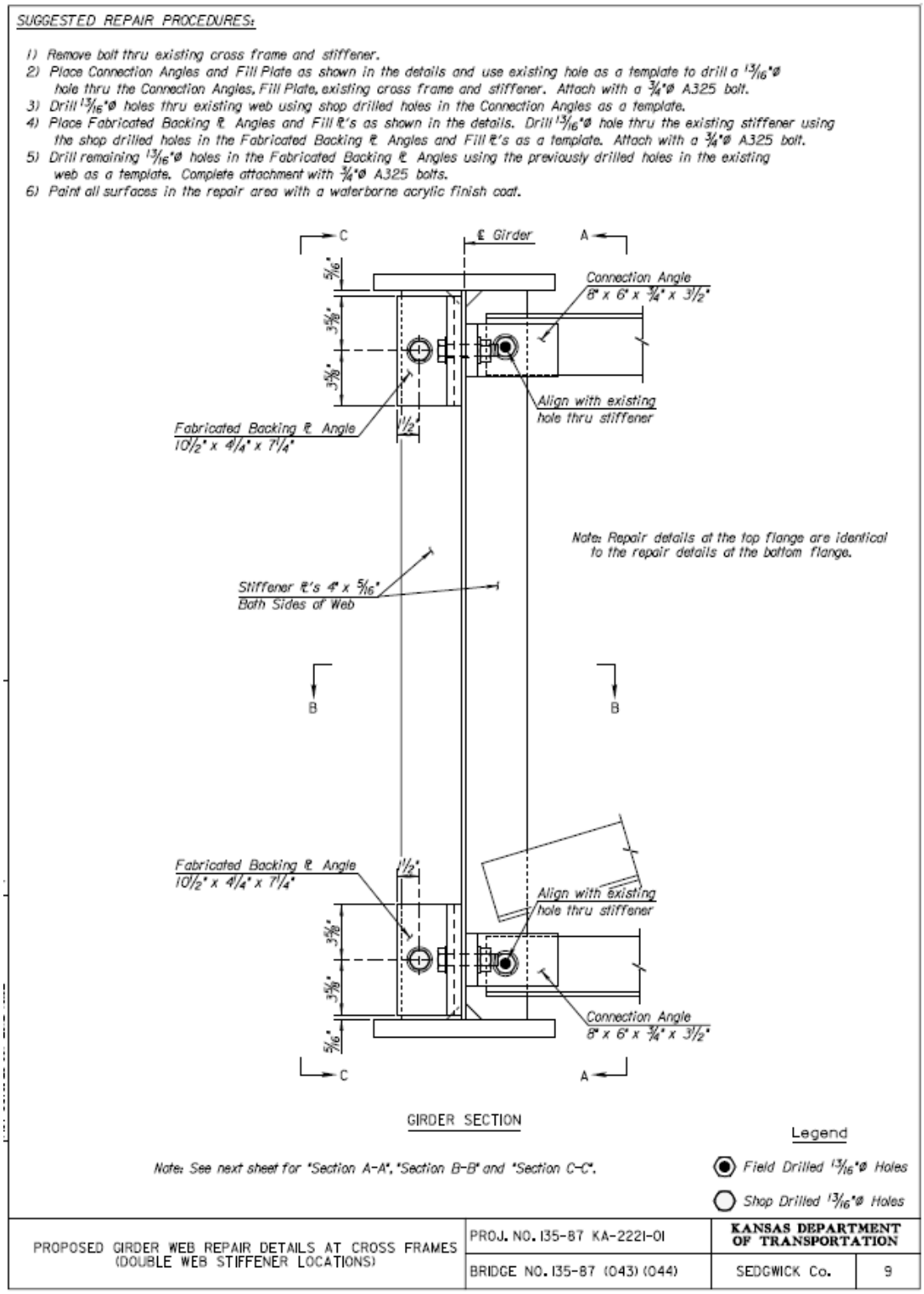


Figure B. 20: Proposed girder web repair details at cross frames (double web stiffener locations).

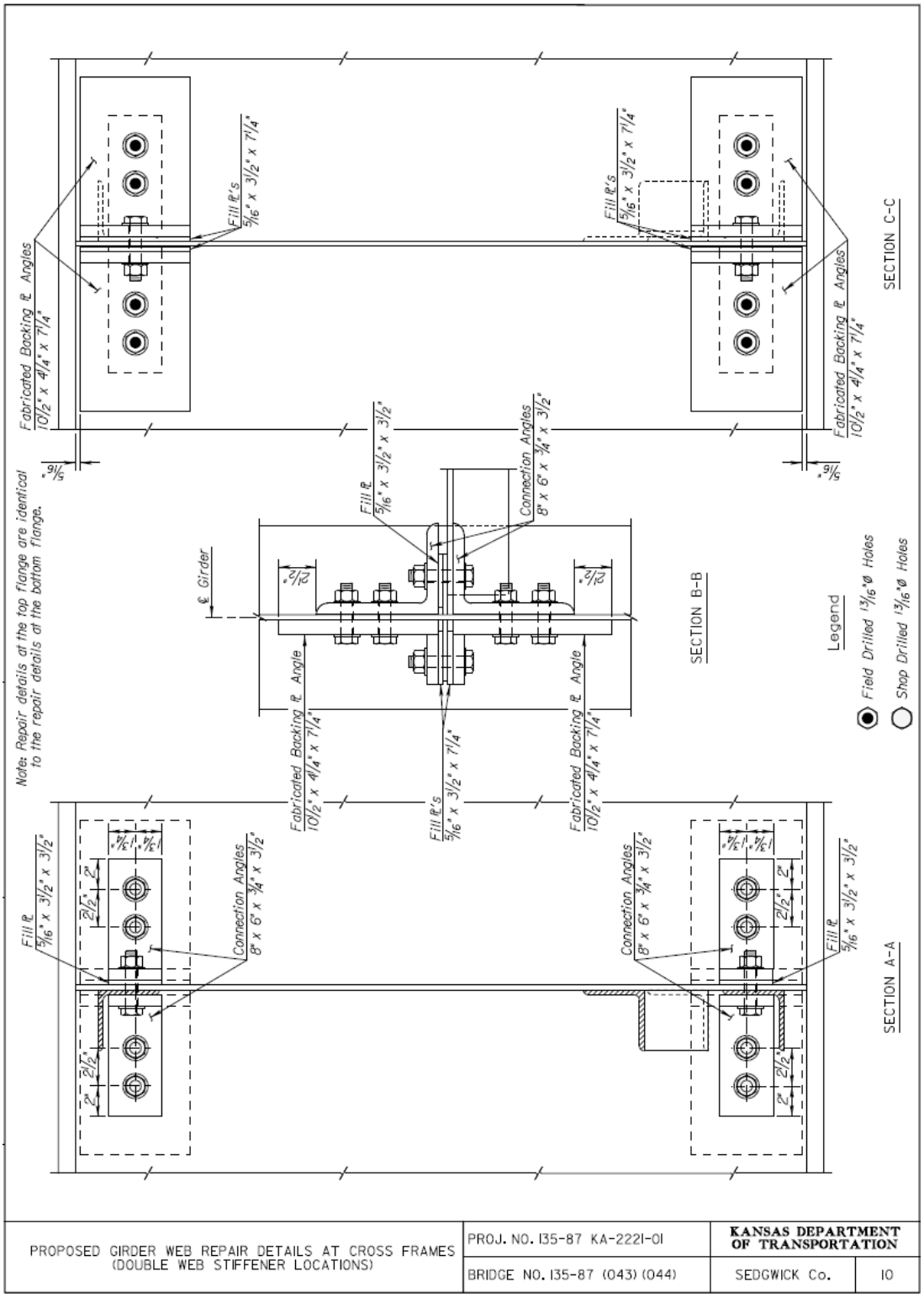


Figure B. 21: Proposed girder web repair details at cross frames (double web stiffener locations).

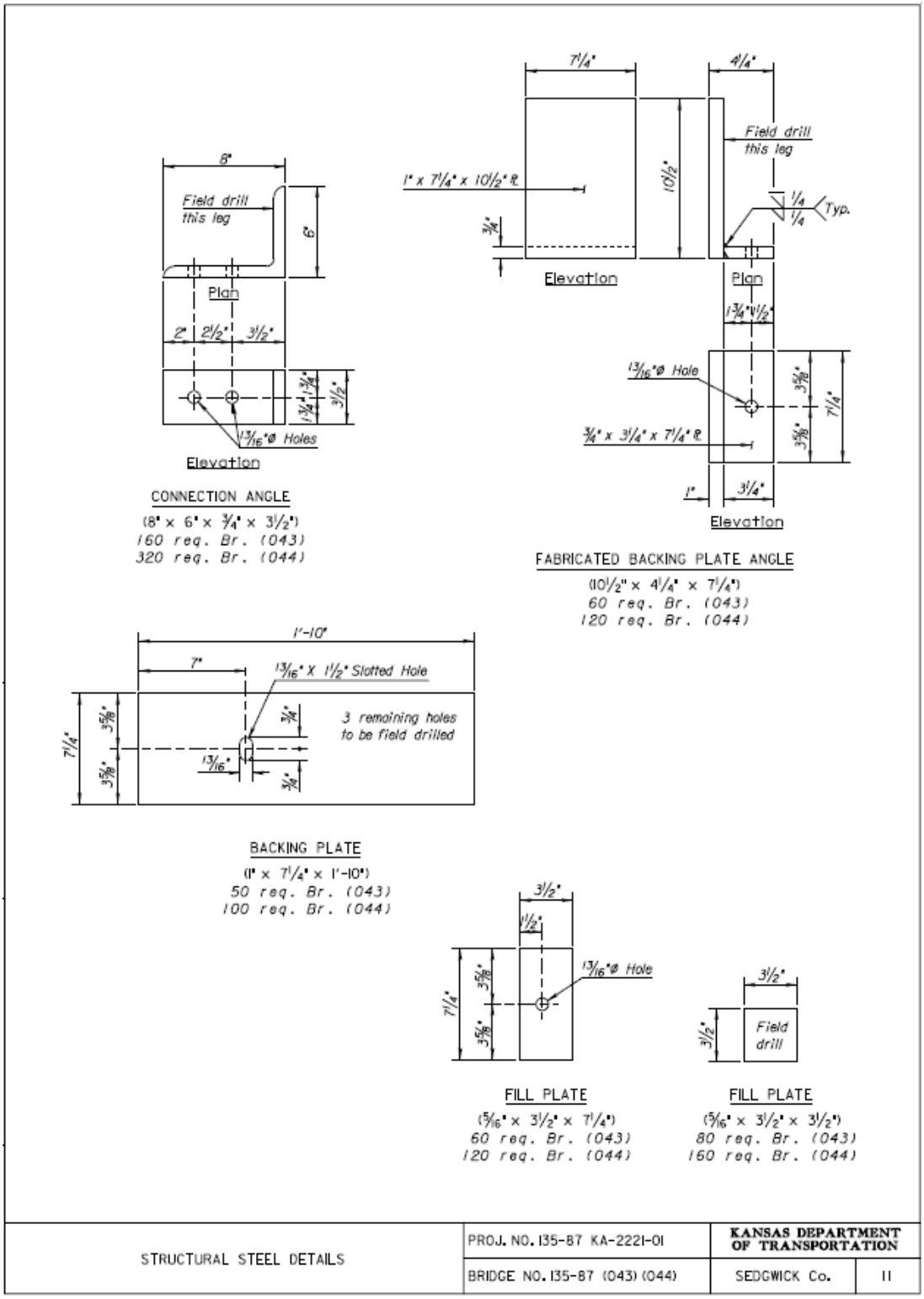


Figure B. 22: Structural steel details.

Appendix C: Filtered Field Test Data

Before Retrofit

Figure C. 1: West Truck Load Placement 8-16 kph (5-10 mph).

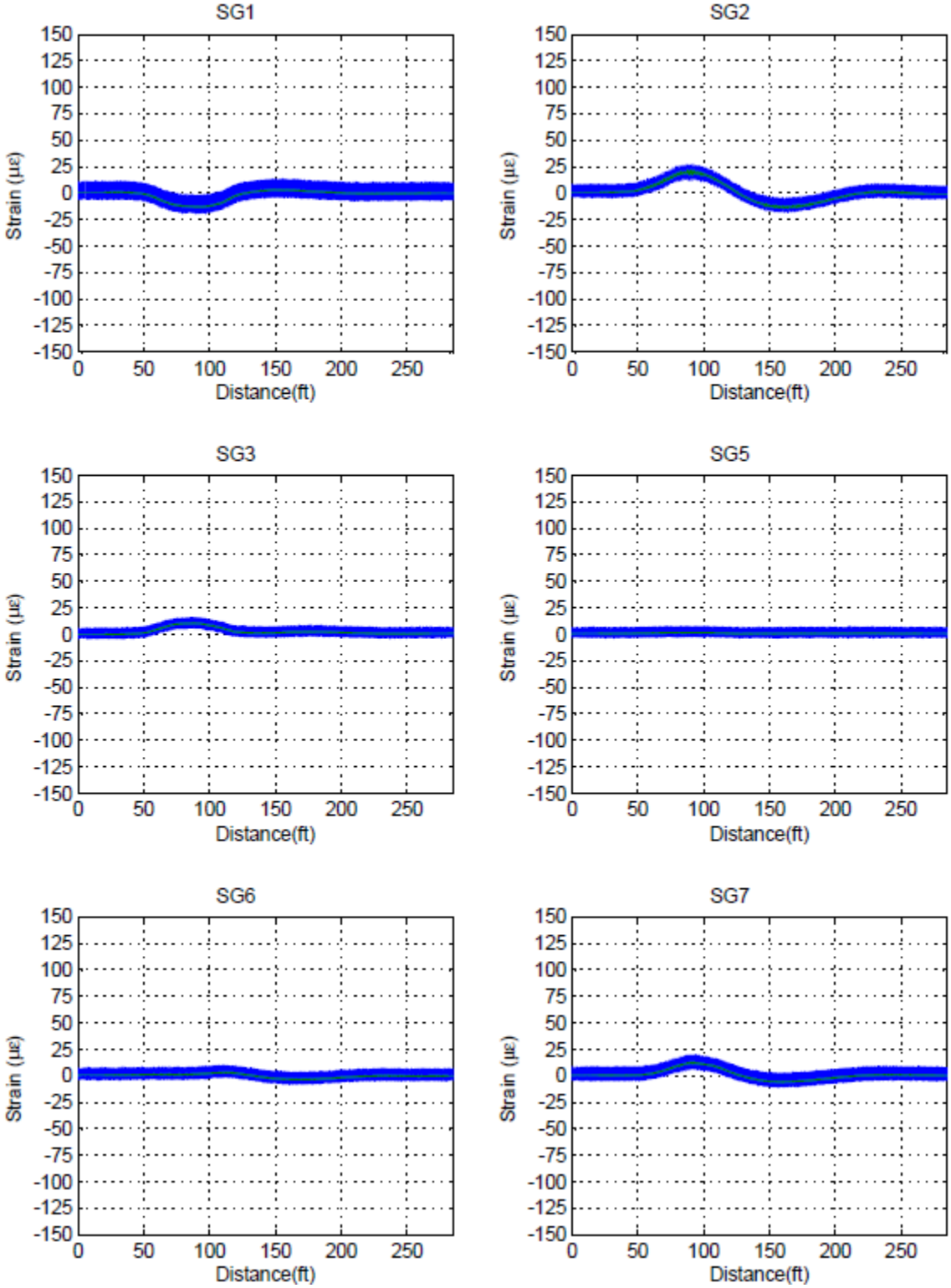


Figure C. 2: West Truck Load Placement 8-16 kph (5-10 mph).

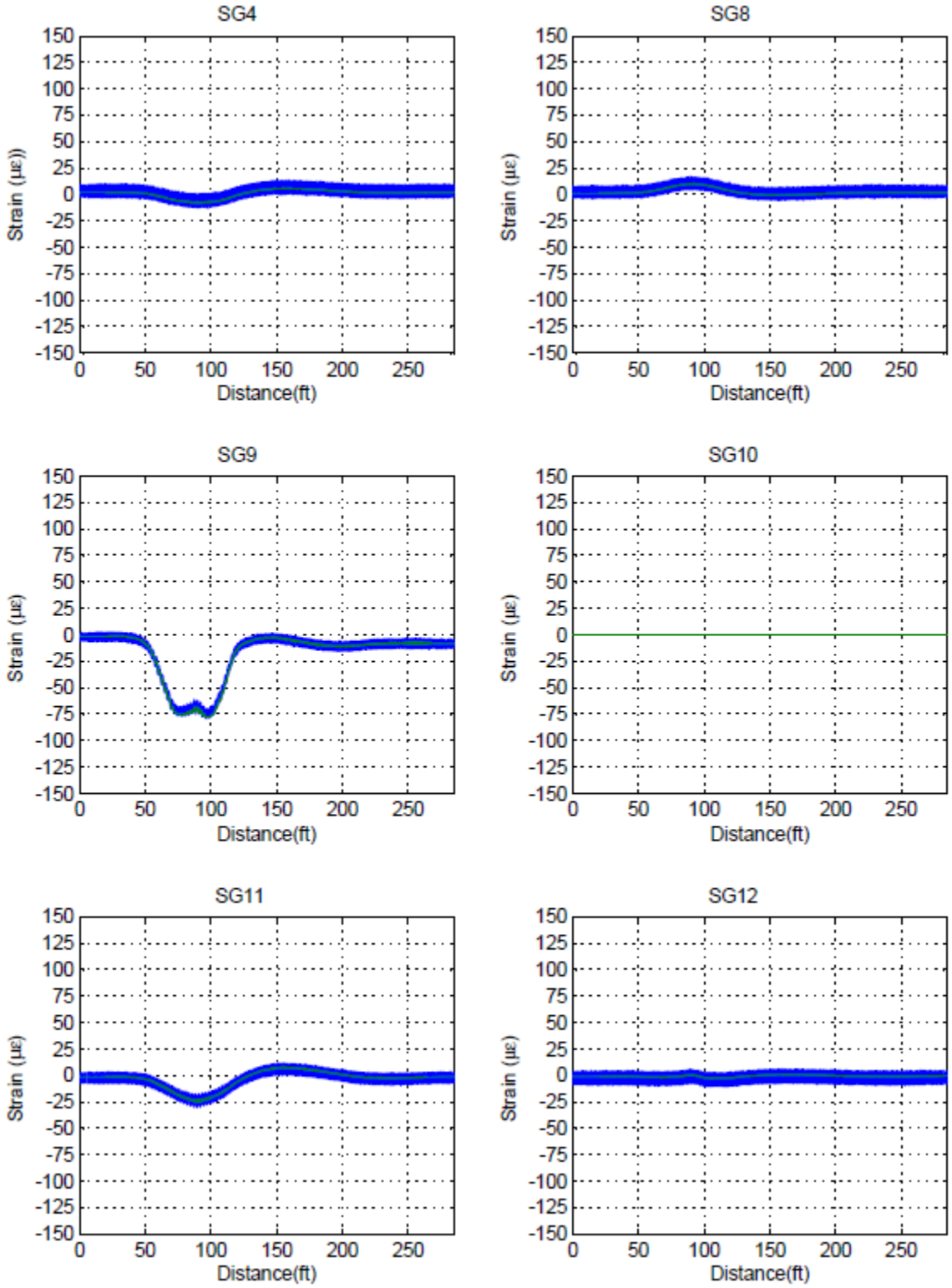


Figure C. 3: West Truck Load Placement 8-16 kph (5-10 mph).

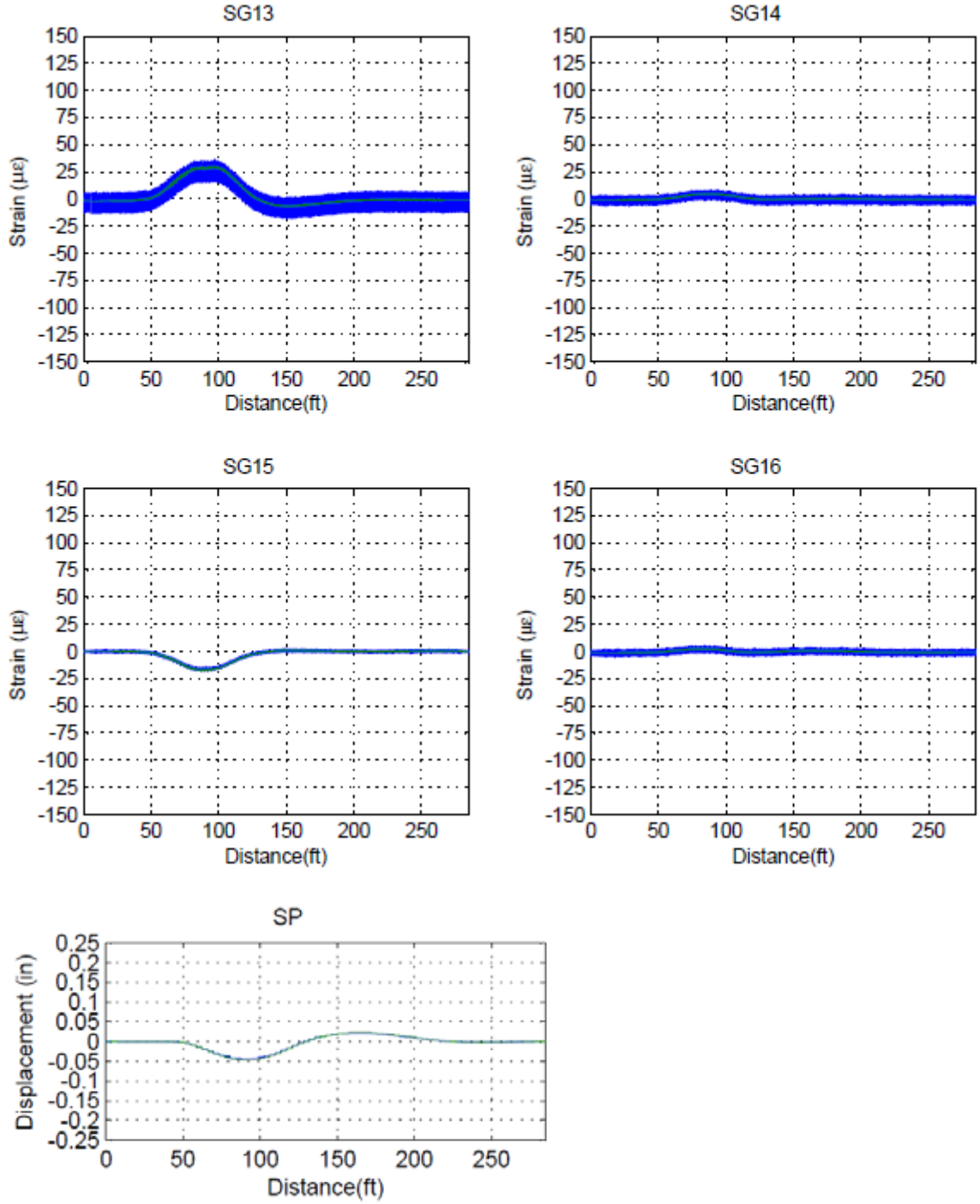


Figure C. 4: West Truck Load Placement 105-121 kph (65-75 mph).

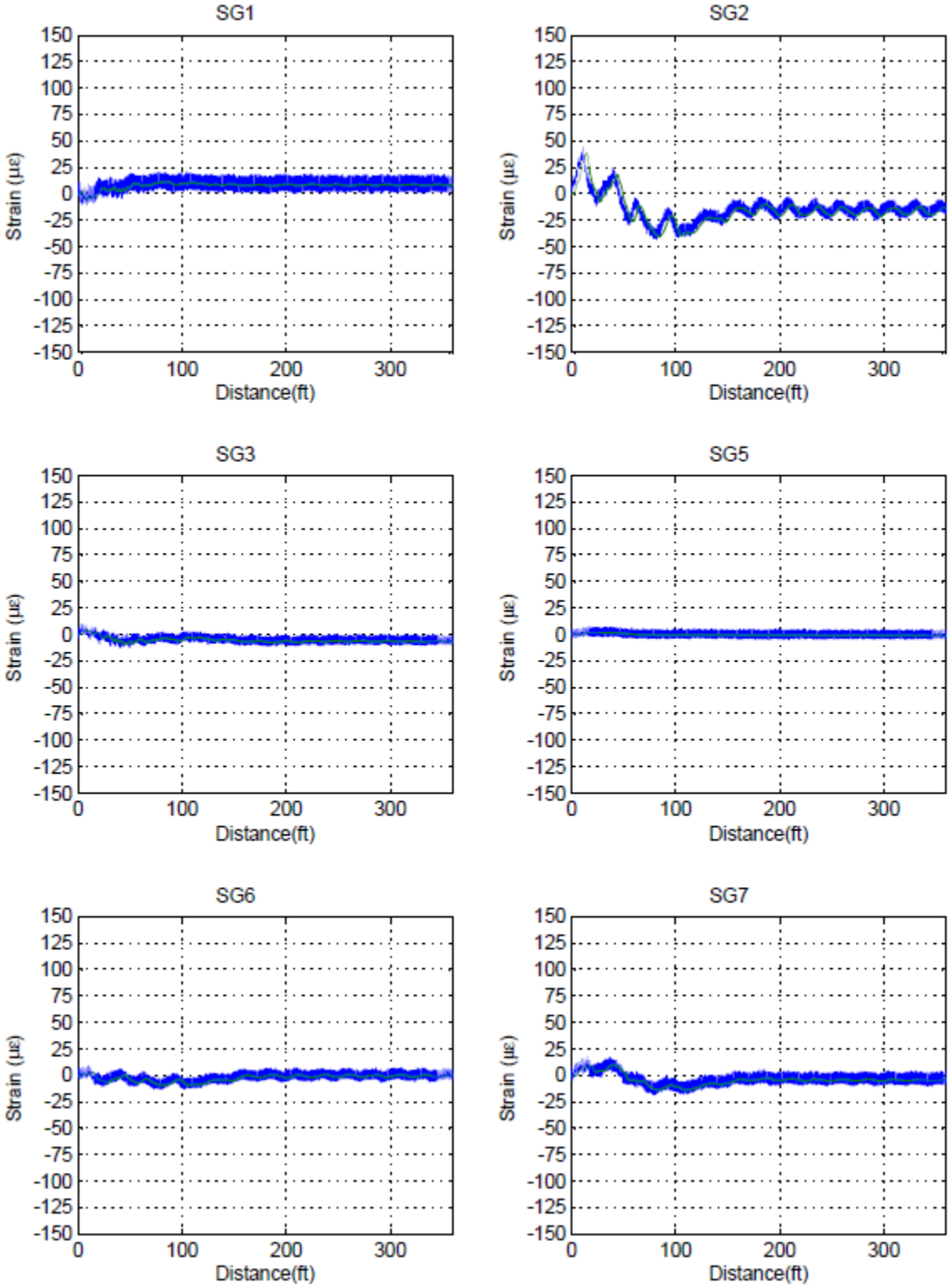


Figure C. 5: West Truck Load Placement 105-121 kph (65-75 mph).

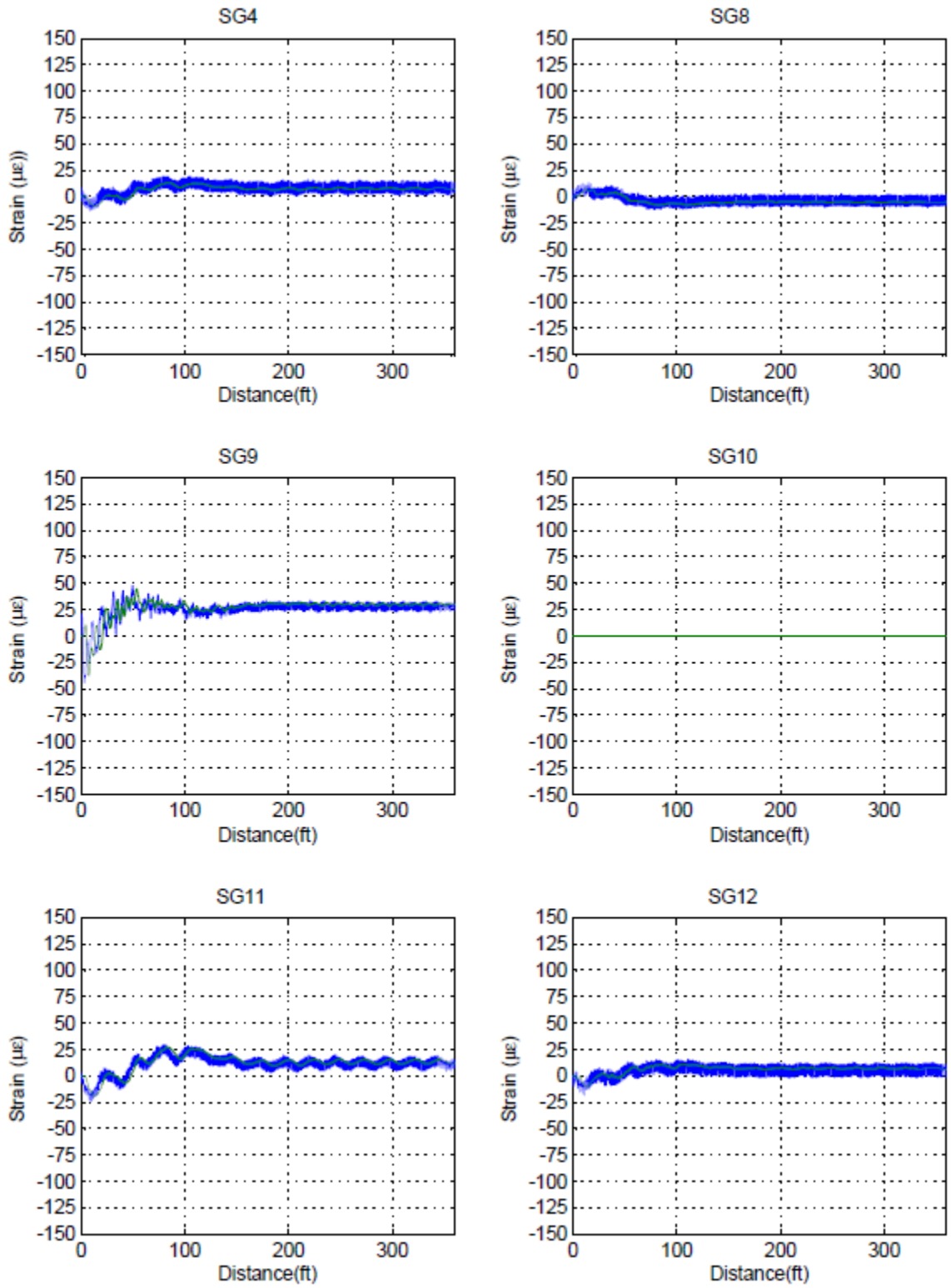


Figure C. 6: West Truck Load Placement 105-121 kph (65-75 mph).

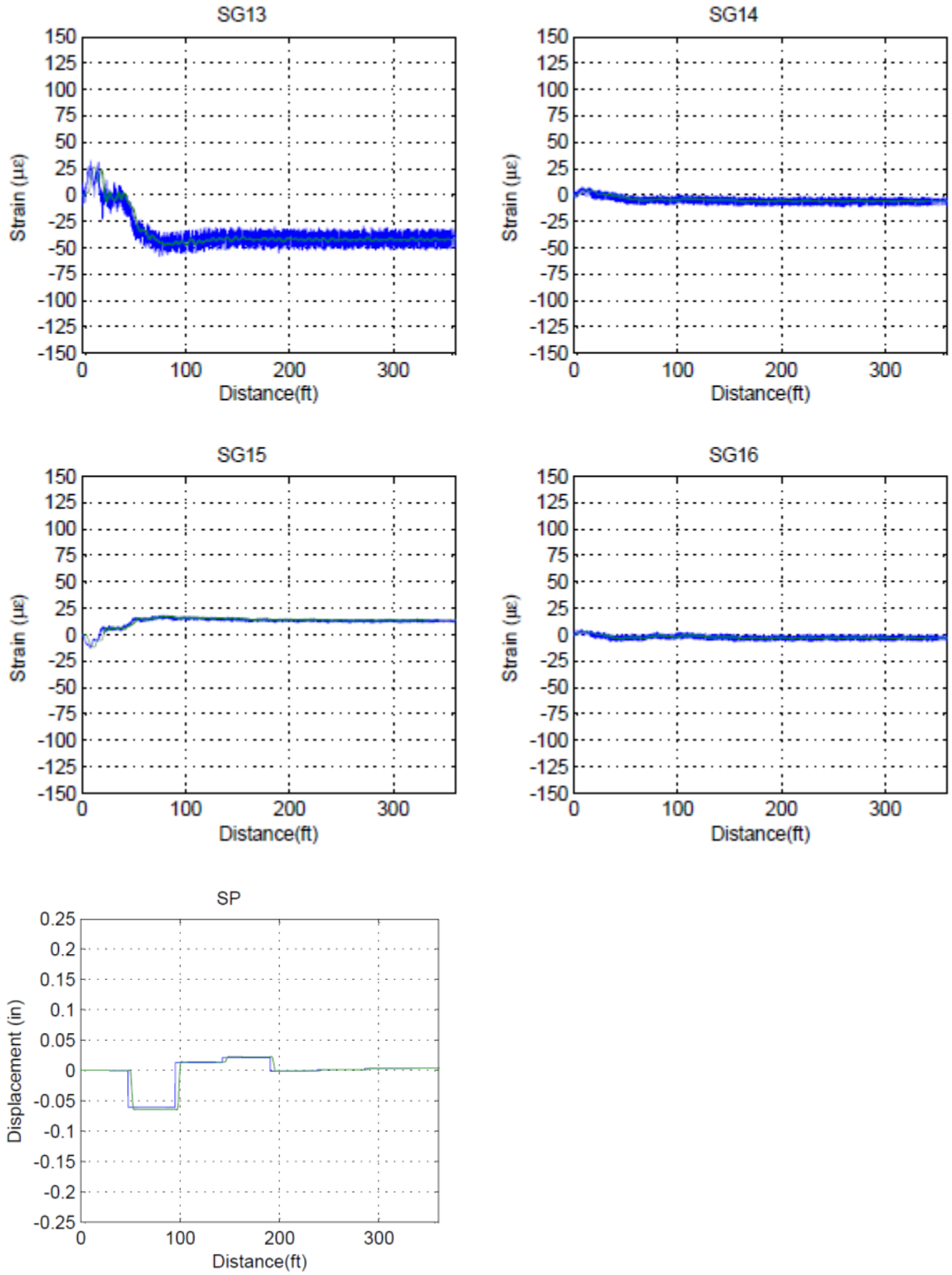


Figure C. 7: Center Truck Load Placement 8-16 kph (5-10 mph).

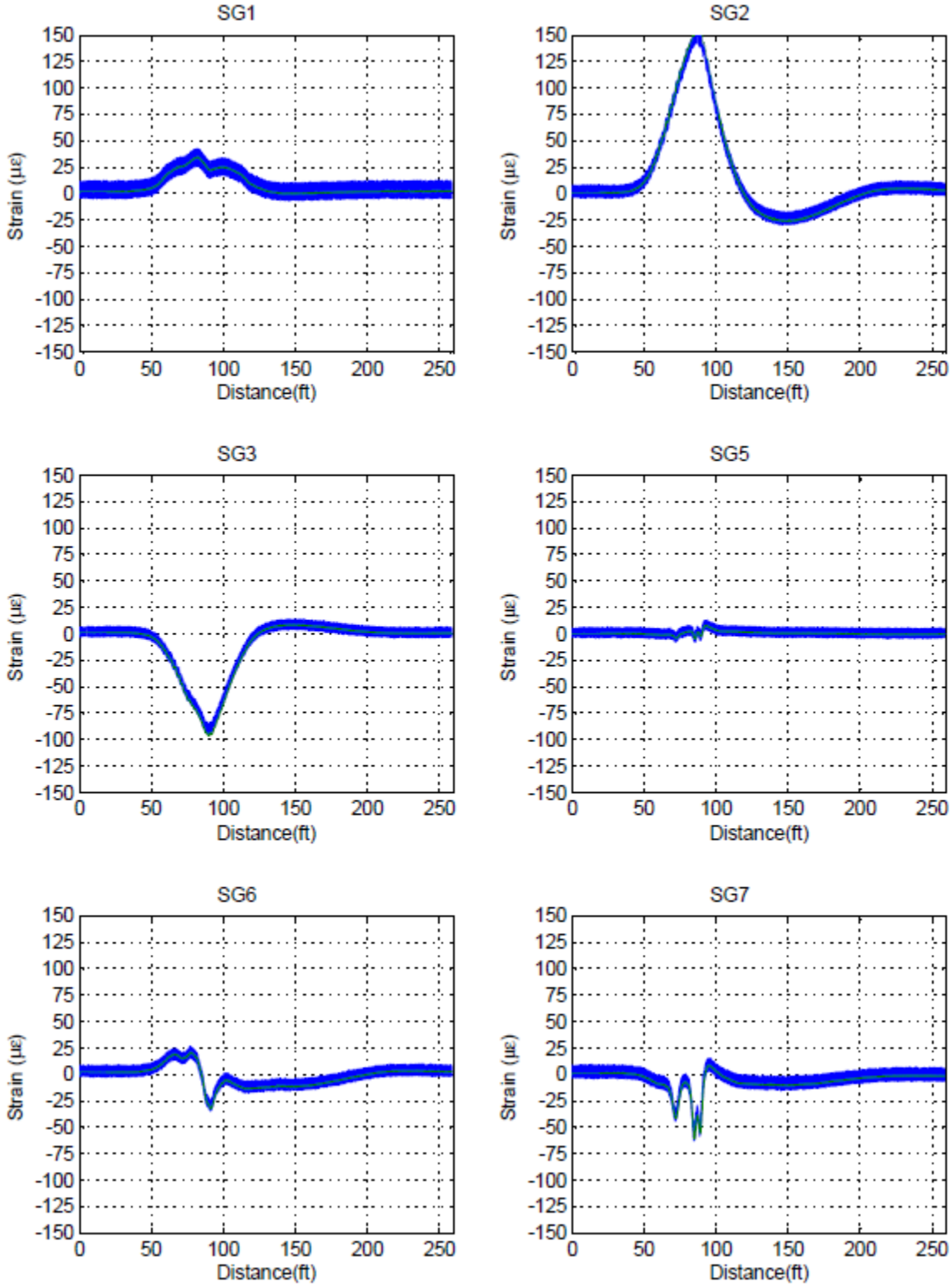


Figure C. 8: Center Truck Load Placement 8-16 kph (5-10 mph).

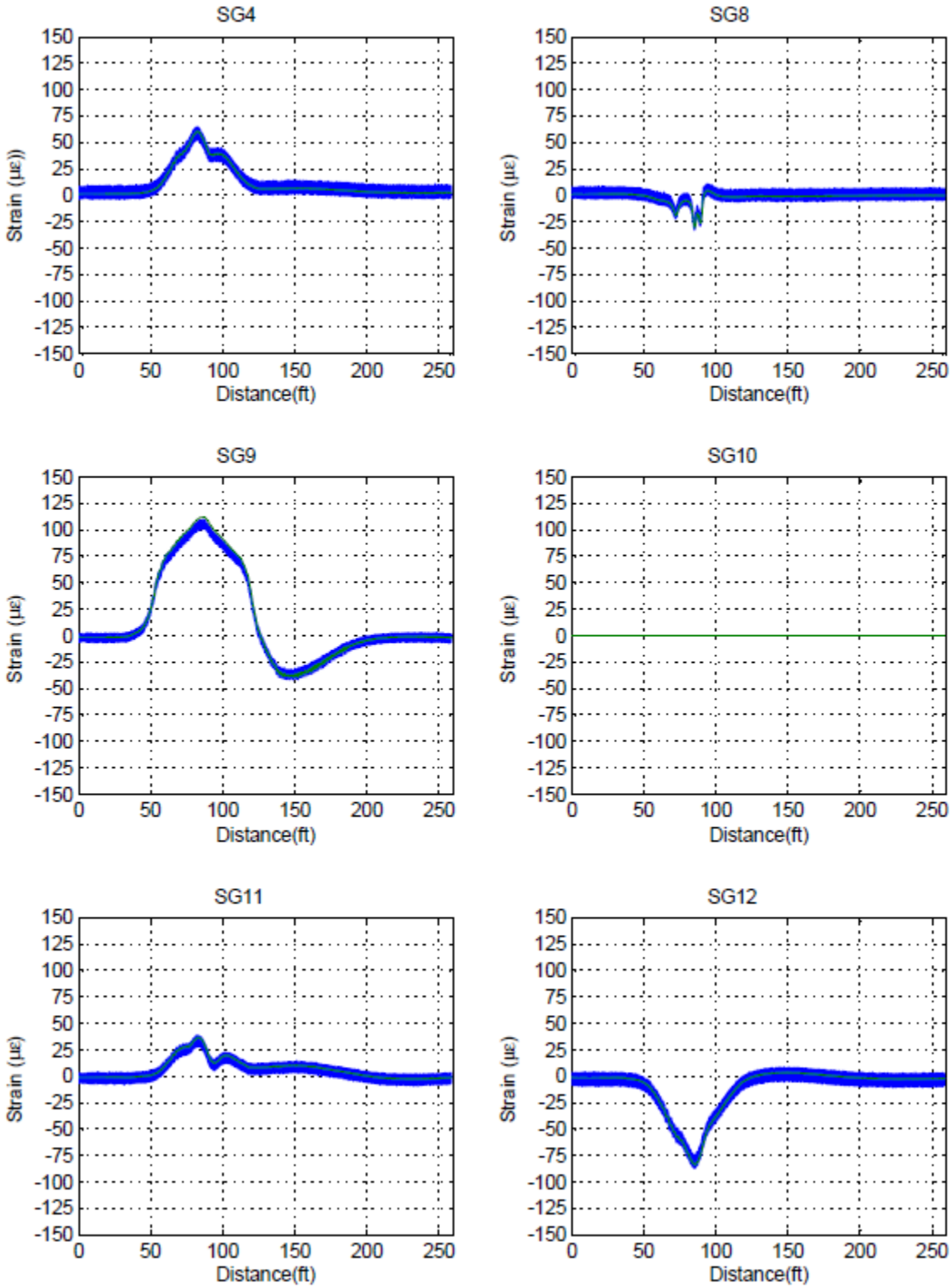


Figure C. 9: Center Truck Load Placement 8-16 kph (5-10 mph).

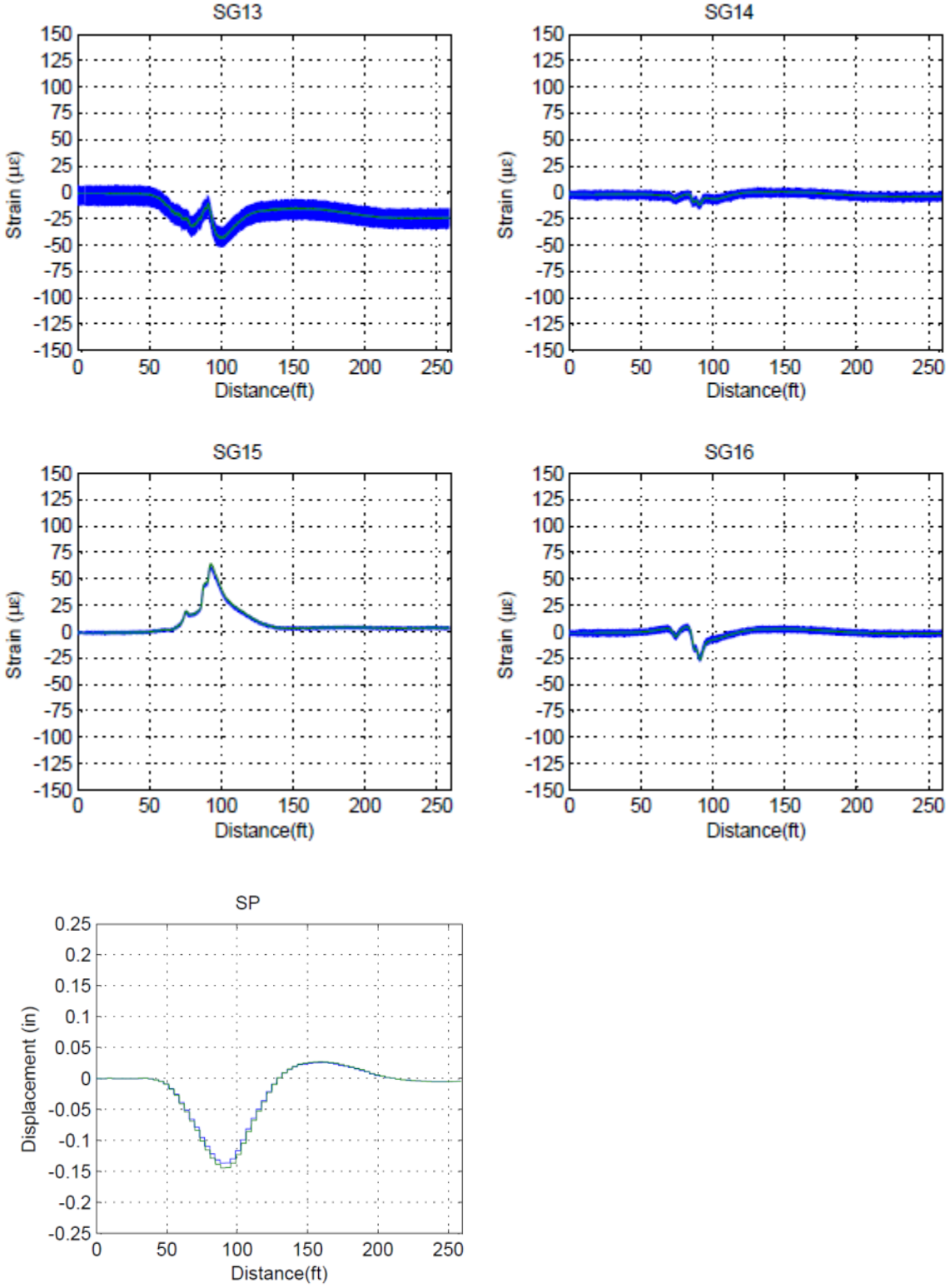


Figure C. 10: Center Truck Load Placement 105-121 kph (65-75 mph).

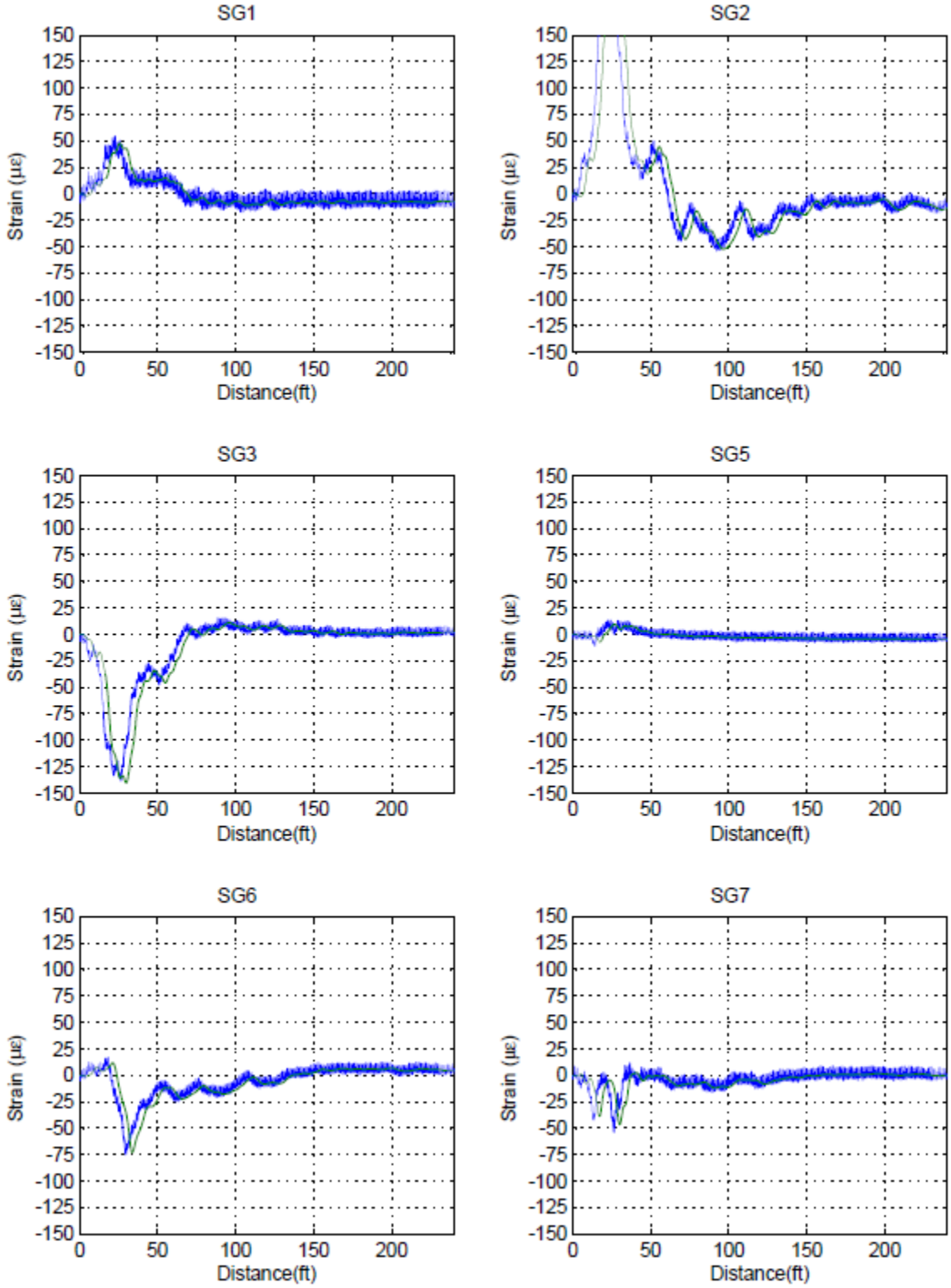


Figure C. 11: Center Truck Load Placement 105-121 kph (65-75 mph).

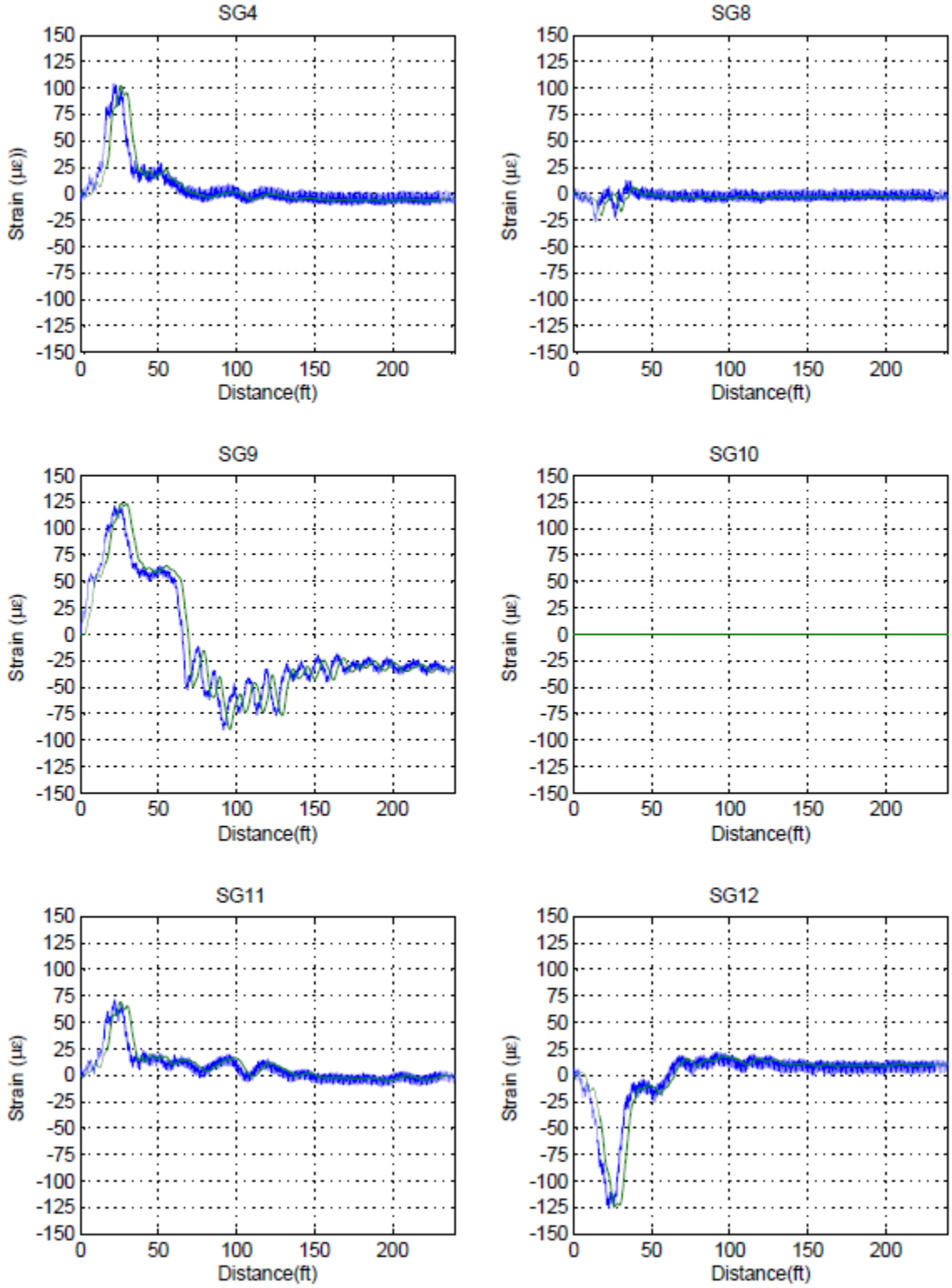


Figure C. 12: Center Truck Load Placement 105-121 kph (65-75 mph).

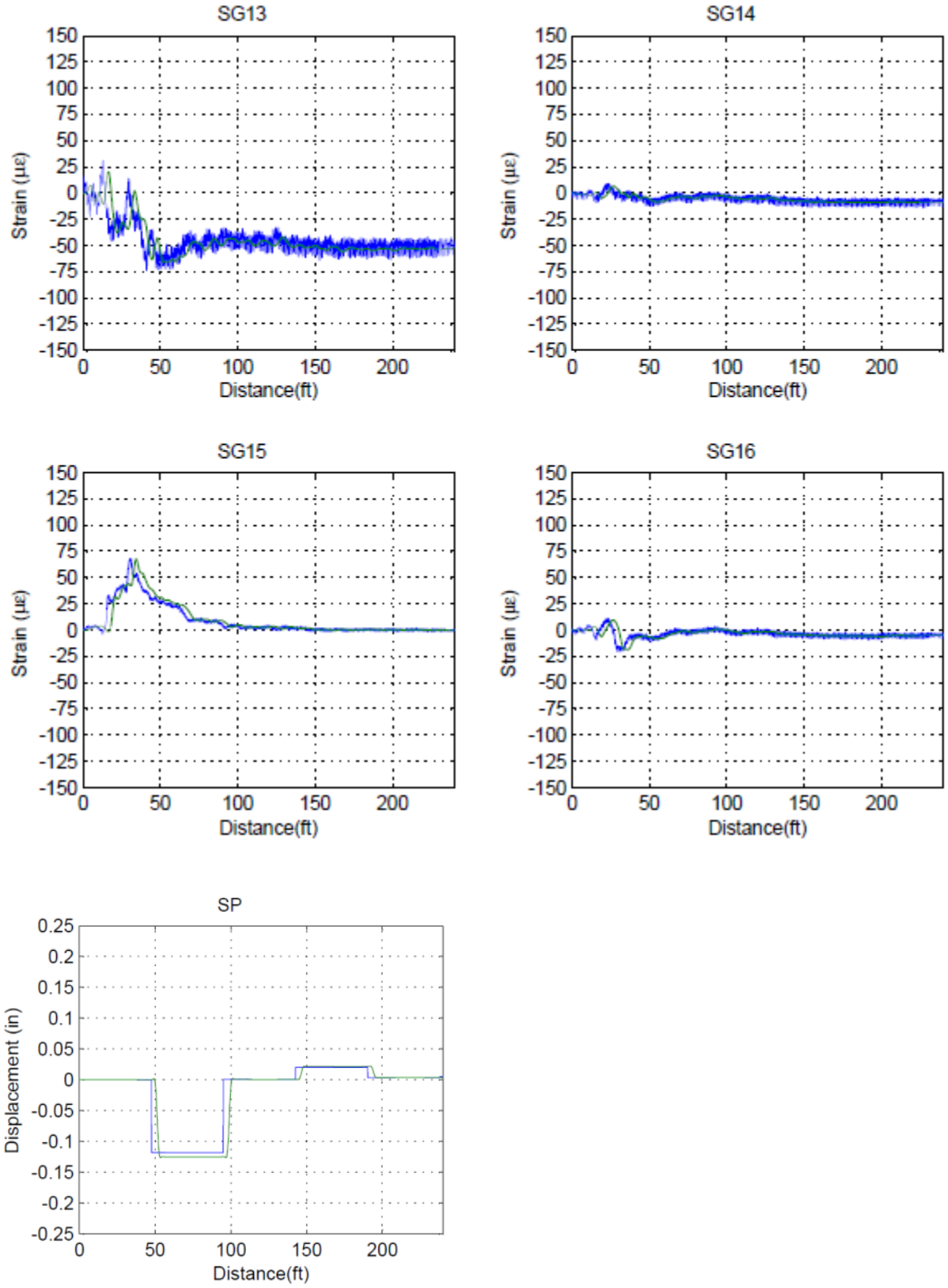


Figure C. 13: East Truck Load Placement 8-16 kph (5-10 mph).

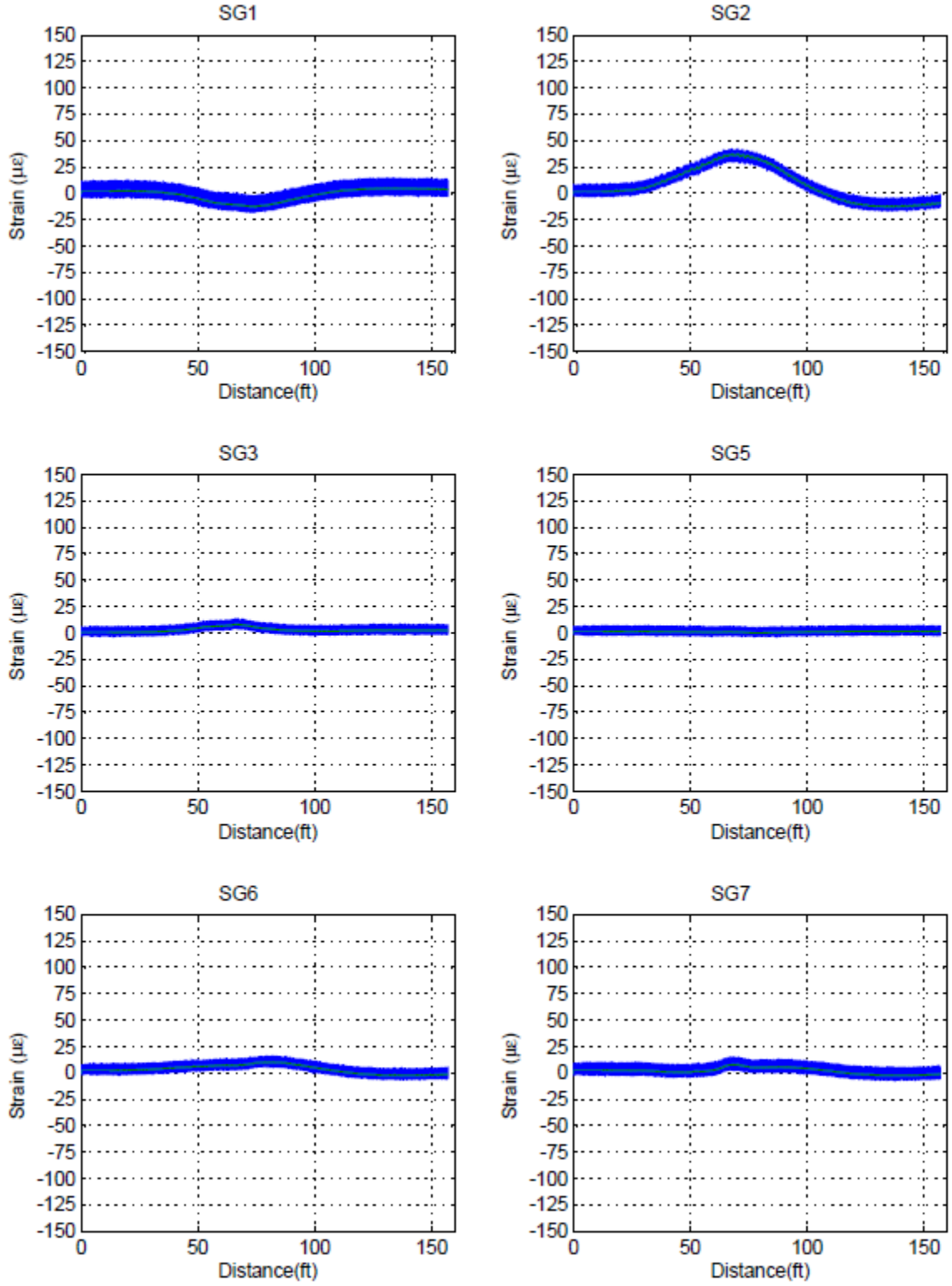


Figure C. 14: East Truck Load Placement 8-16 kph (5-10 mph).

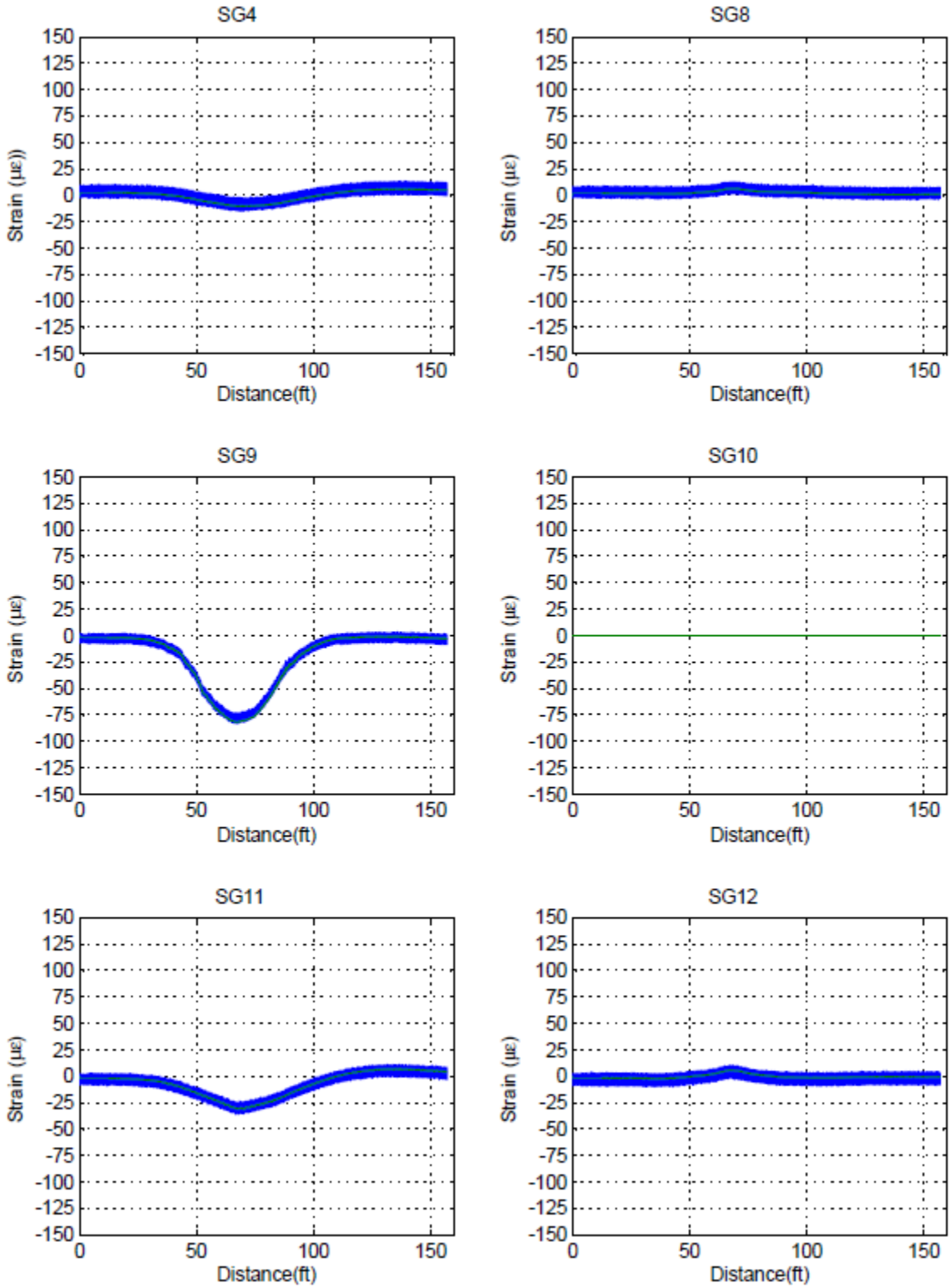


Figure C. 15: East Truck Load Placement 8-16 kph (5-10 mph).

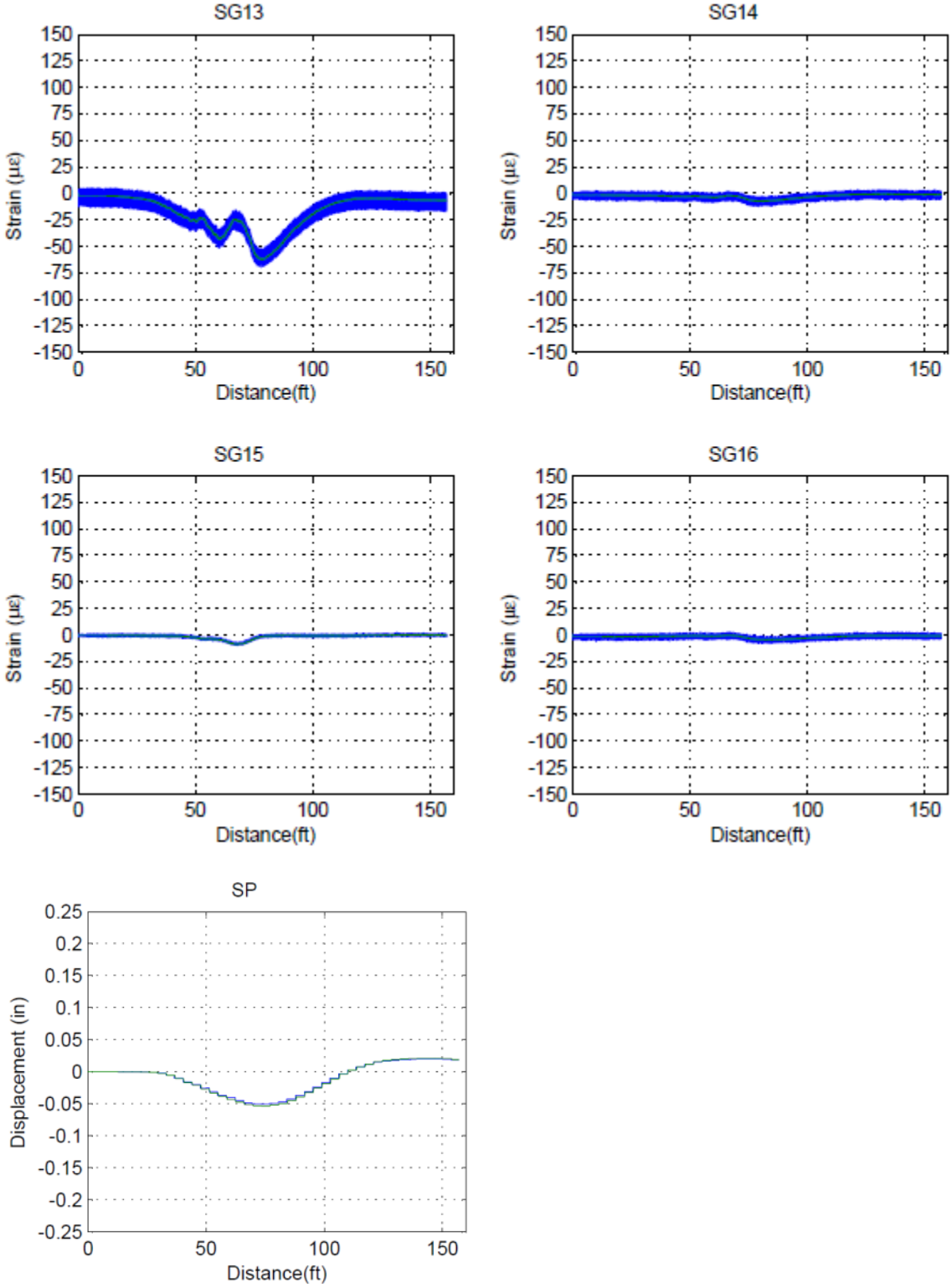


Figure C. 16: East Truck Load Placement 105-121 kph (65-75 mph).

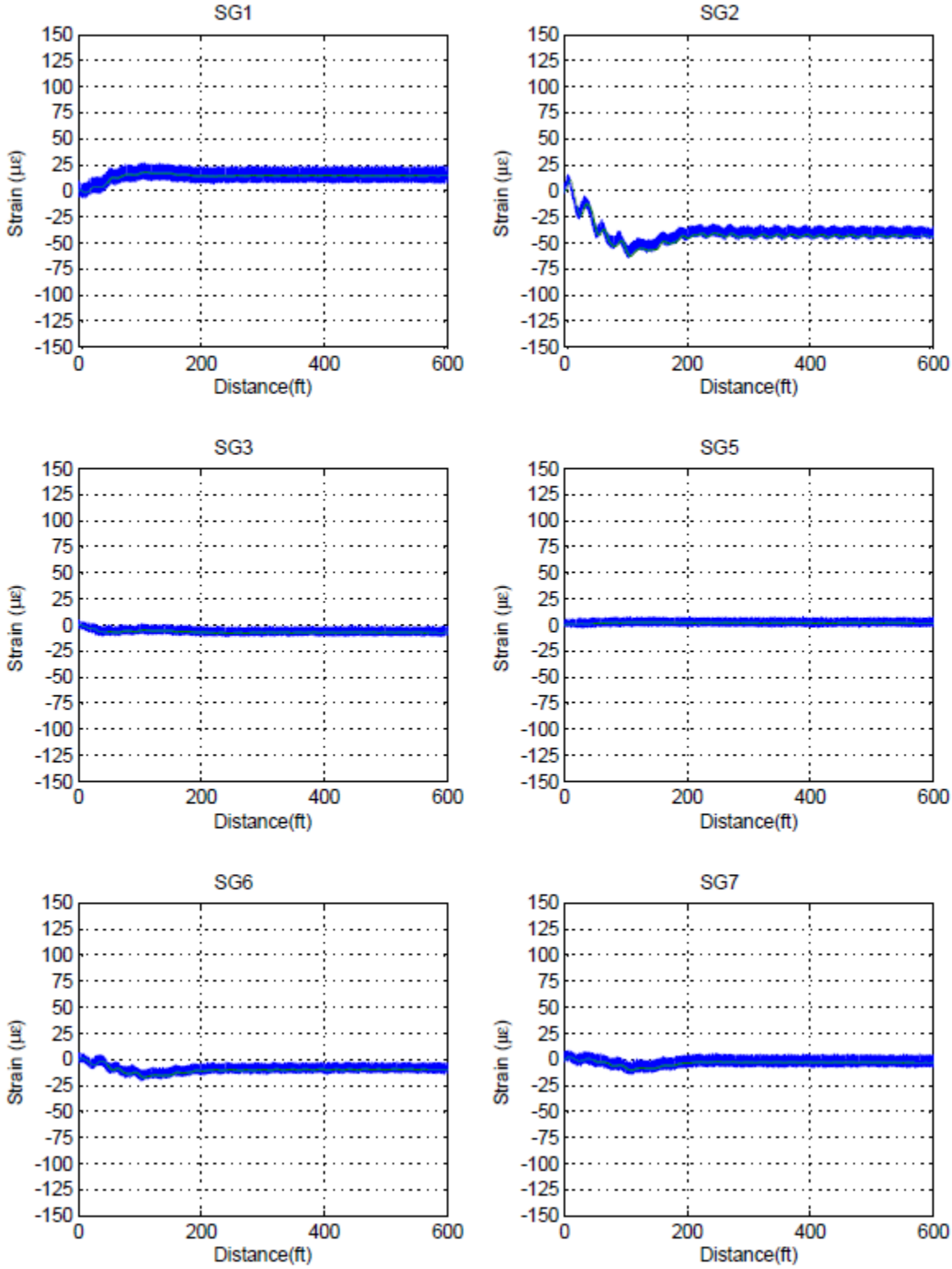


Figure C. 17: East Truck Load Placement 105-121 kph (65-75 mph).

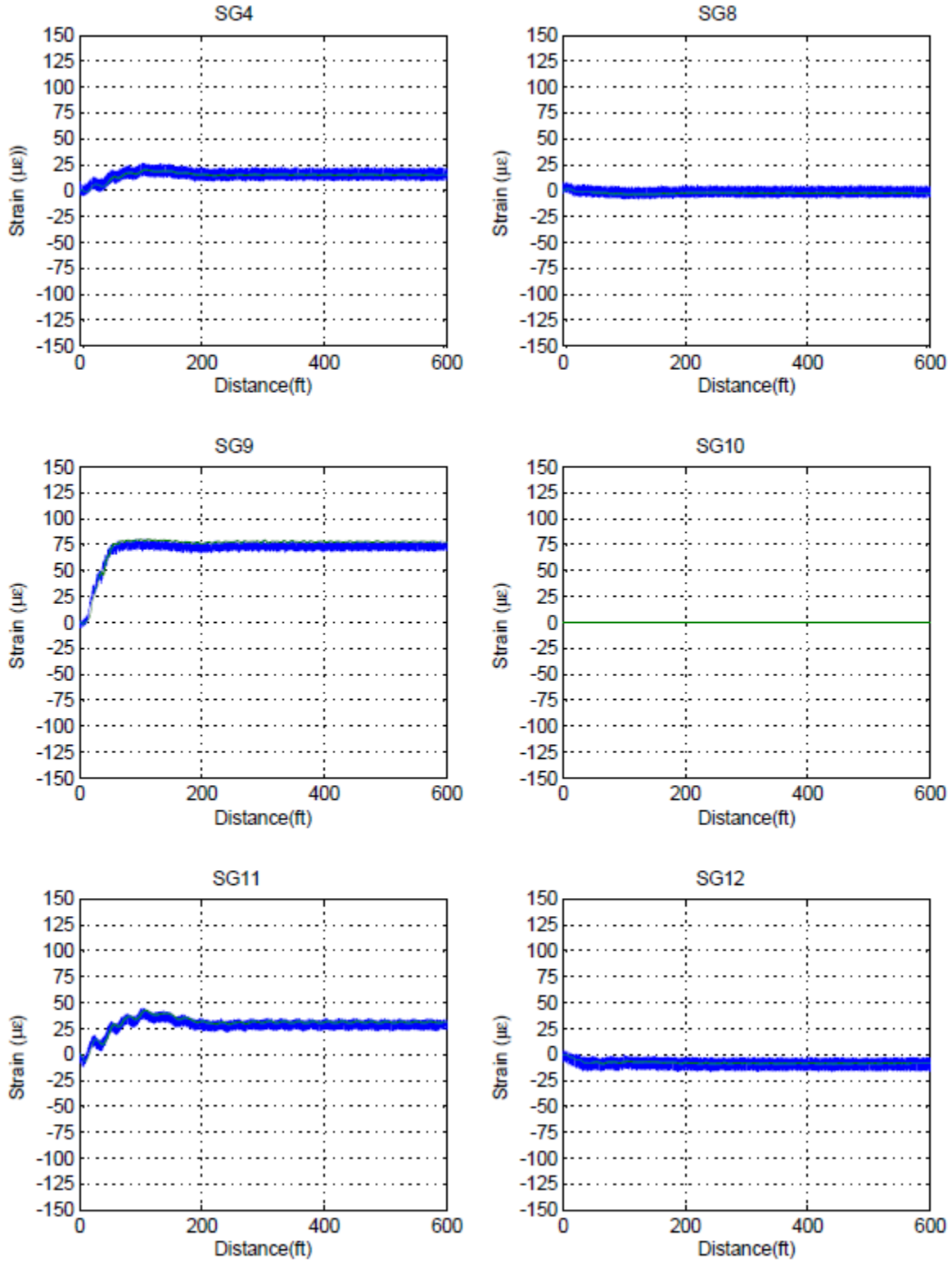
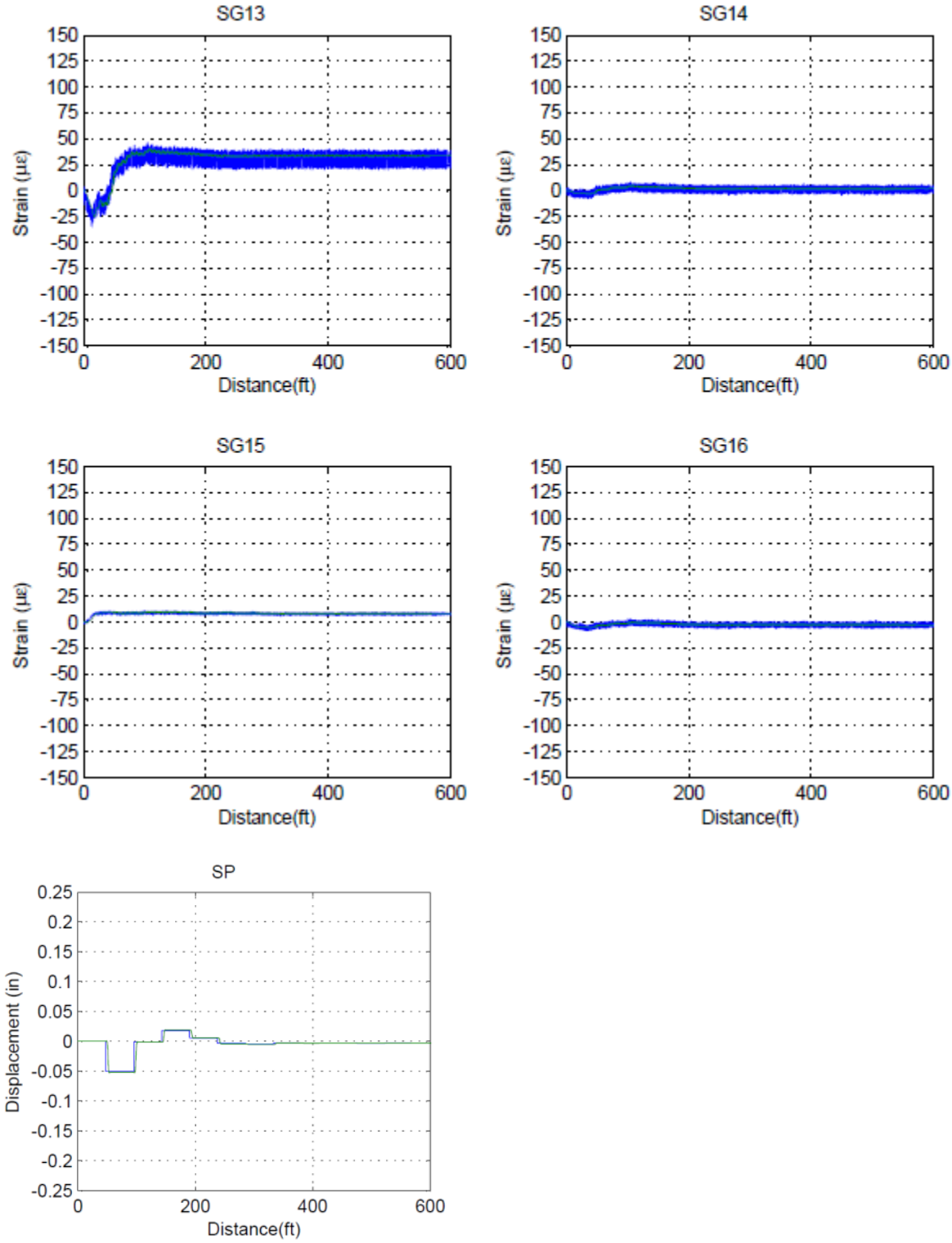


Figure C. 18: East Truck Load Placement 105-121 kph (65-75 mph).



After Retrofit

Figure C. 19: West Truck Load Placement 8-16 kph (5-10 mph).

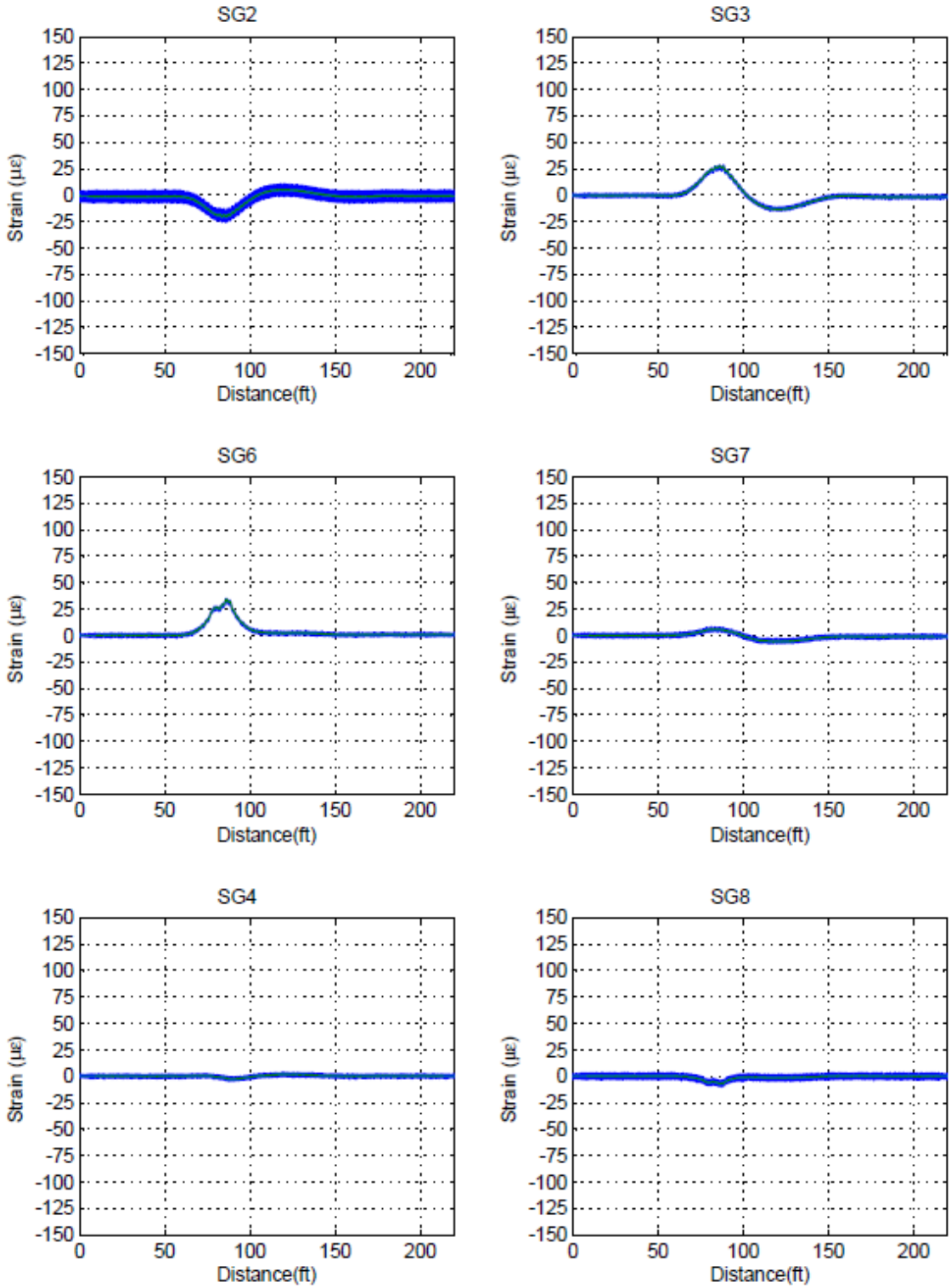


Figure C. 20: West Truck Load Placement 8-16 kph (5-10 mph).

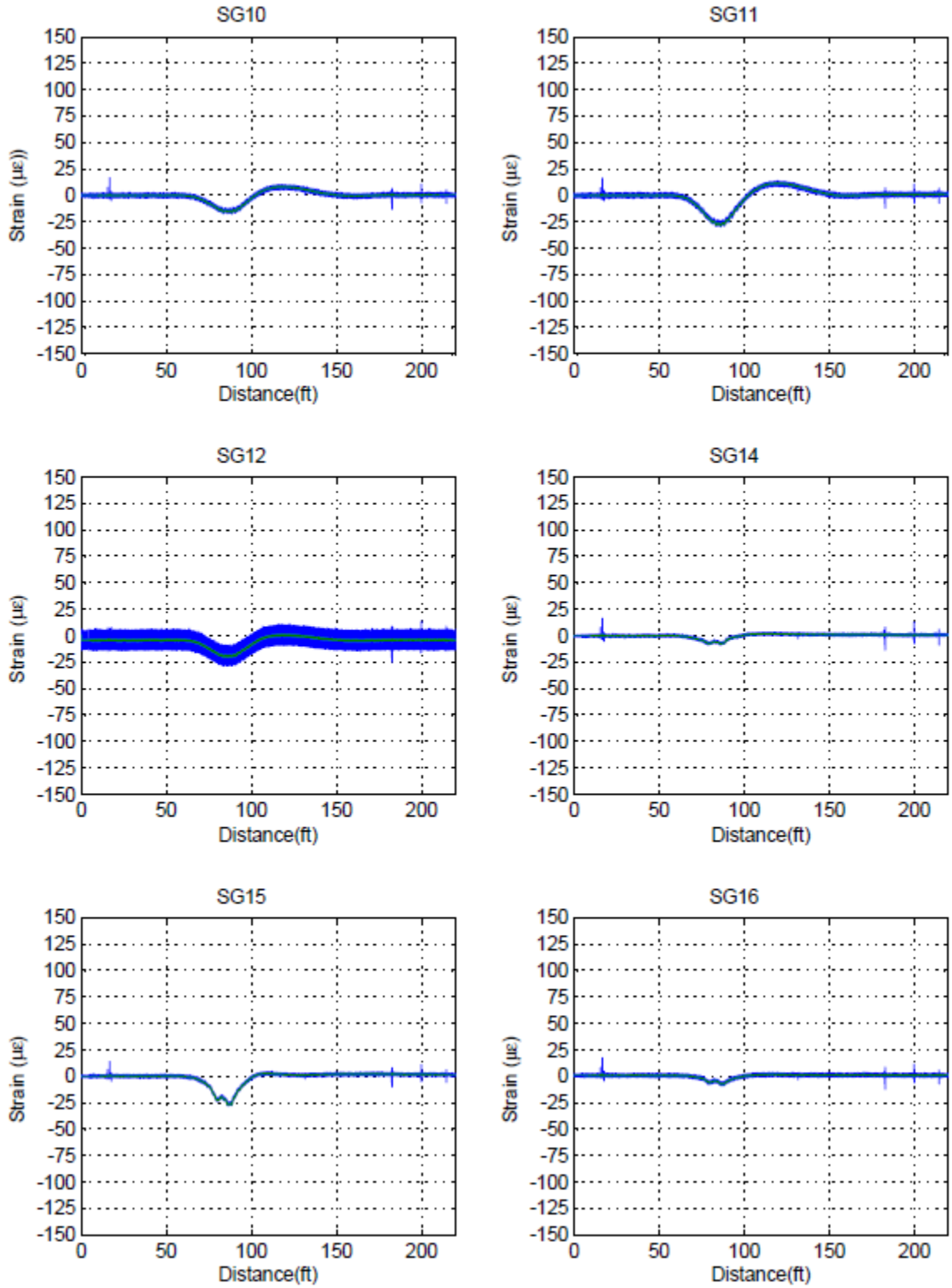


Figure C. 21: West Truck Load Placement 8-16 kph (5-10 mph).

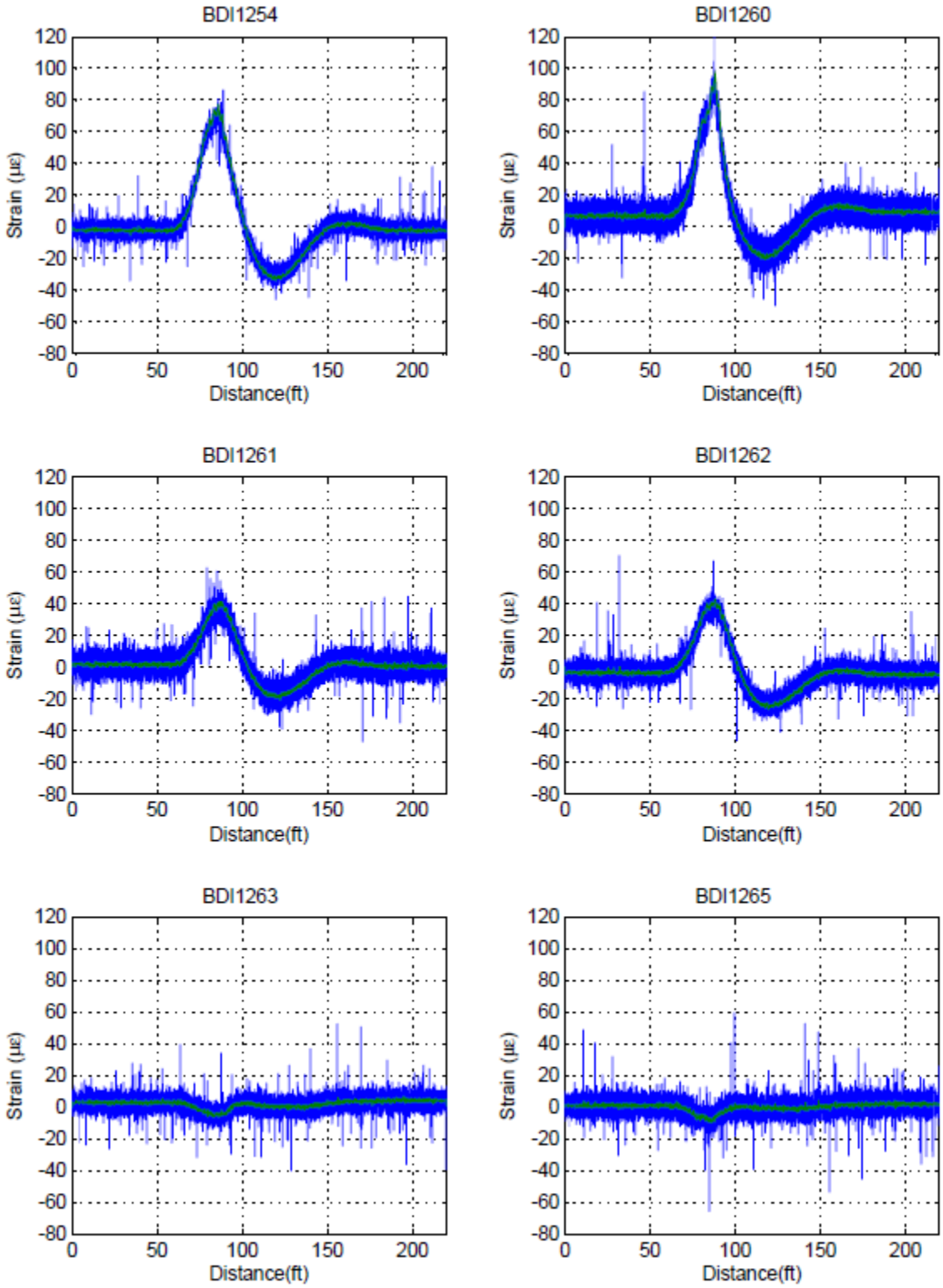


Figure C. 22: West Truck Load Placement 8-16 kph (5-10 mph).

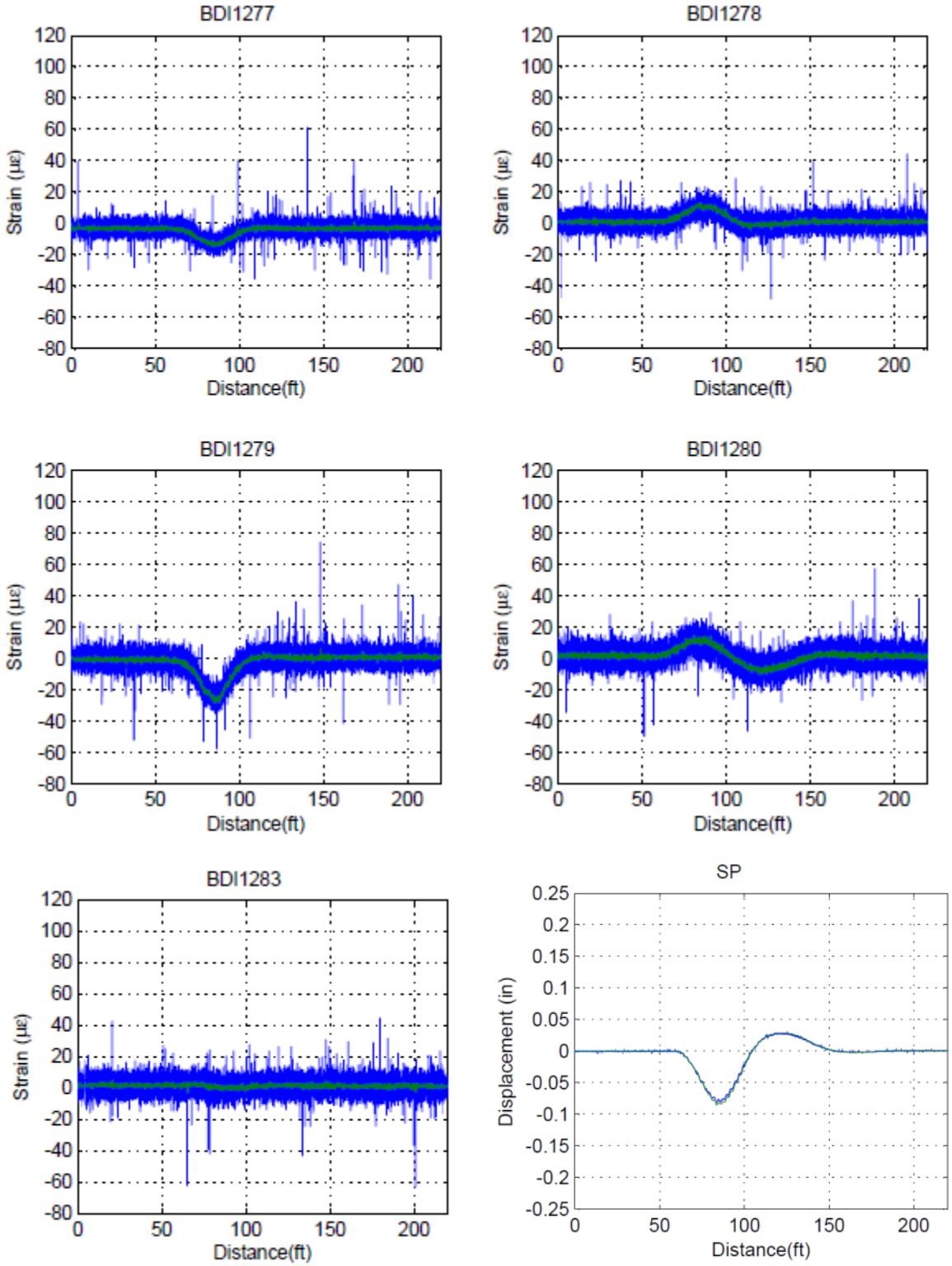


Figure C. 23: West Truck Load Placement 105-121 kph (65-75 mph).

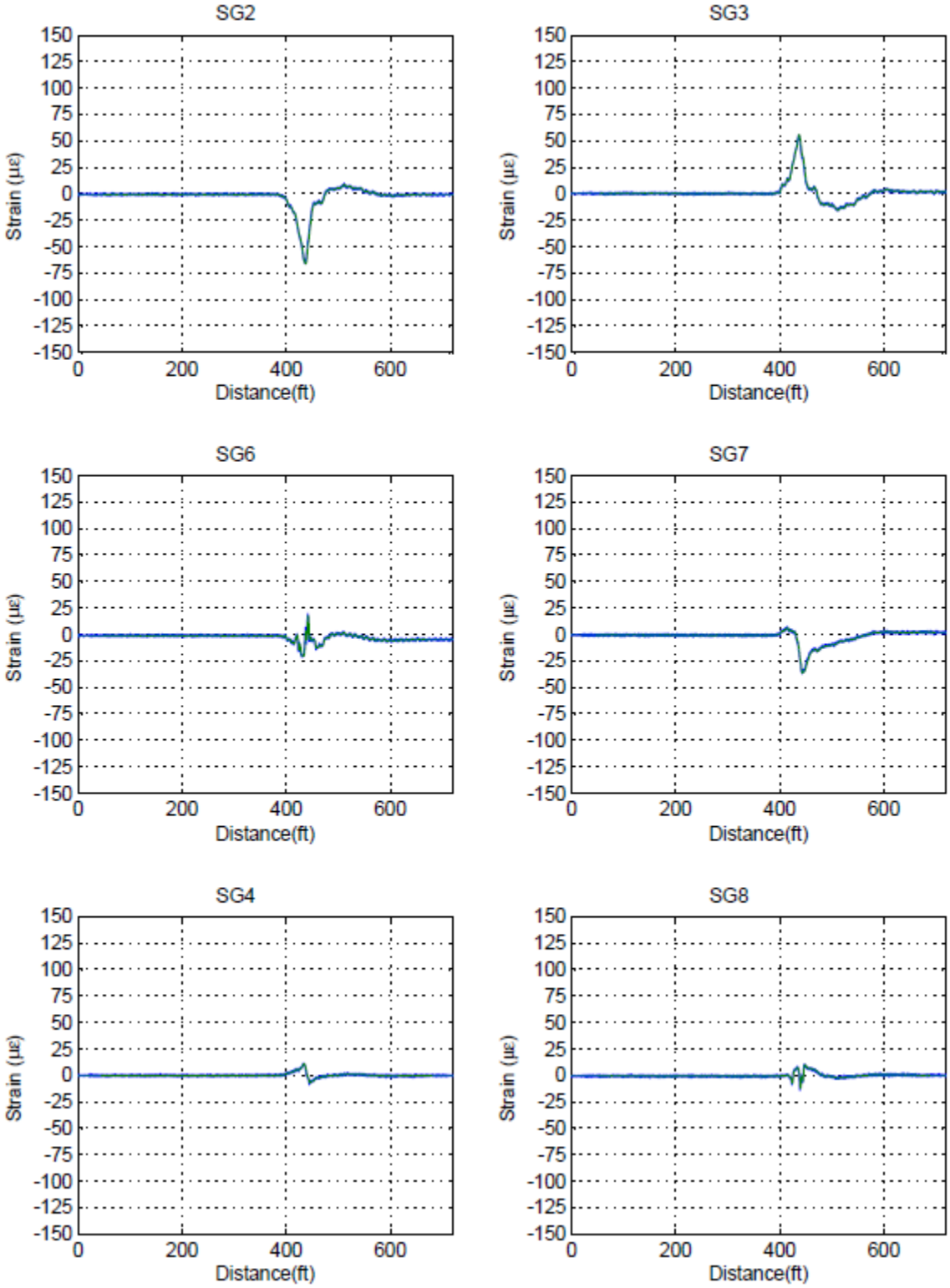


Figure C. 24: West Truck Load Placement 105-121 kph (65-75 mph).

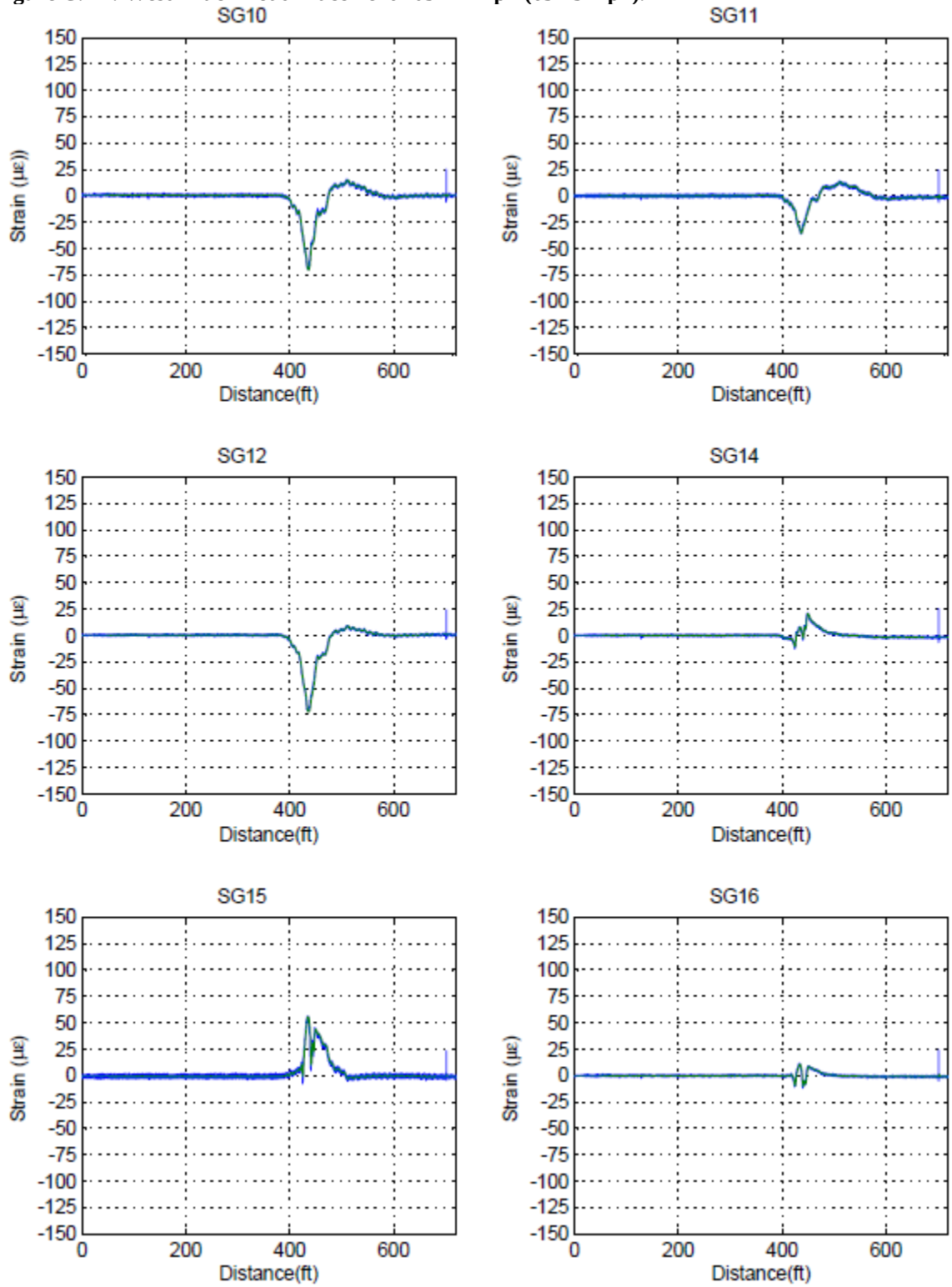


Figure C. 25: West Truck Load Placement 105-121 kph (65-75 mph).

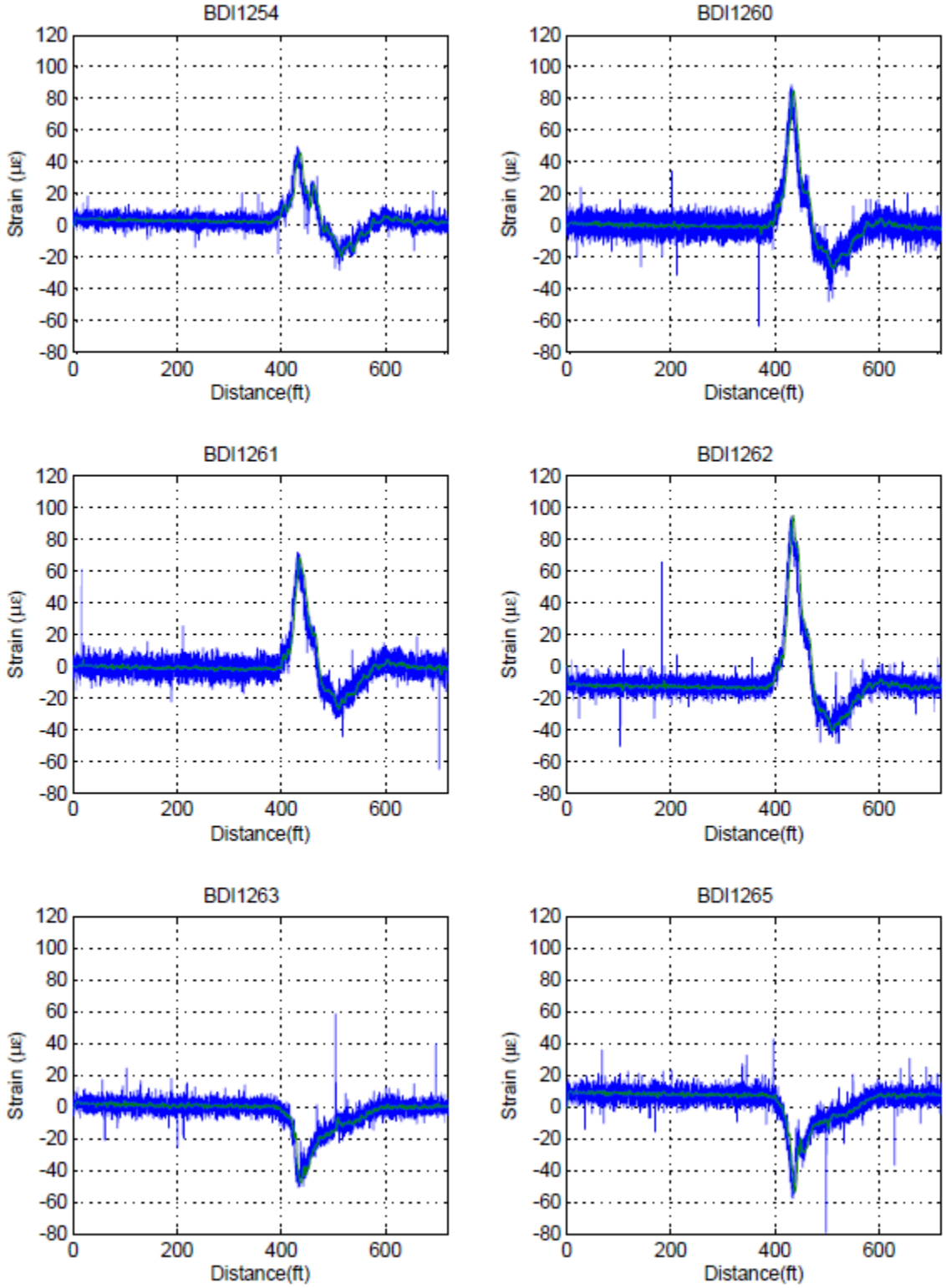


Figure C. 26: West Truck Load Placement 105-121 kph (65-75 mph).

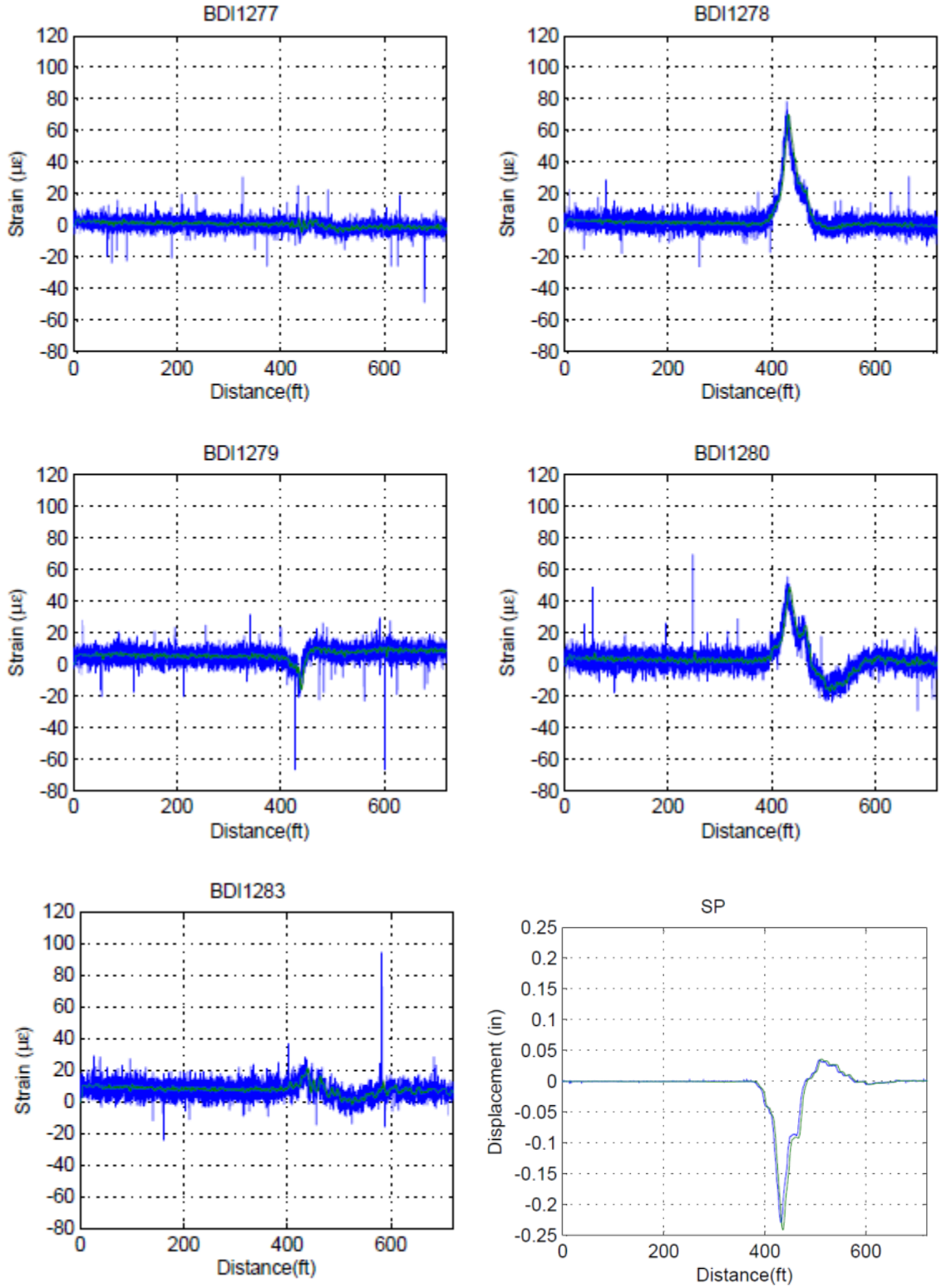


Figure C. 27: Center Truck Load Placement 8-16 kph (5-10 mph).

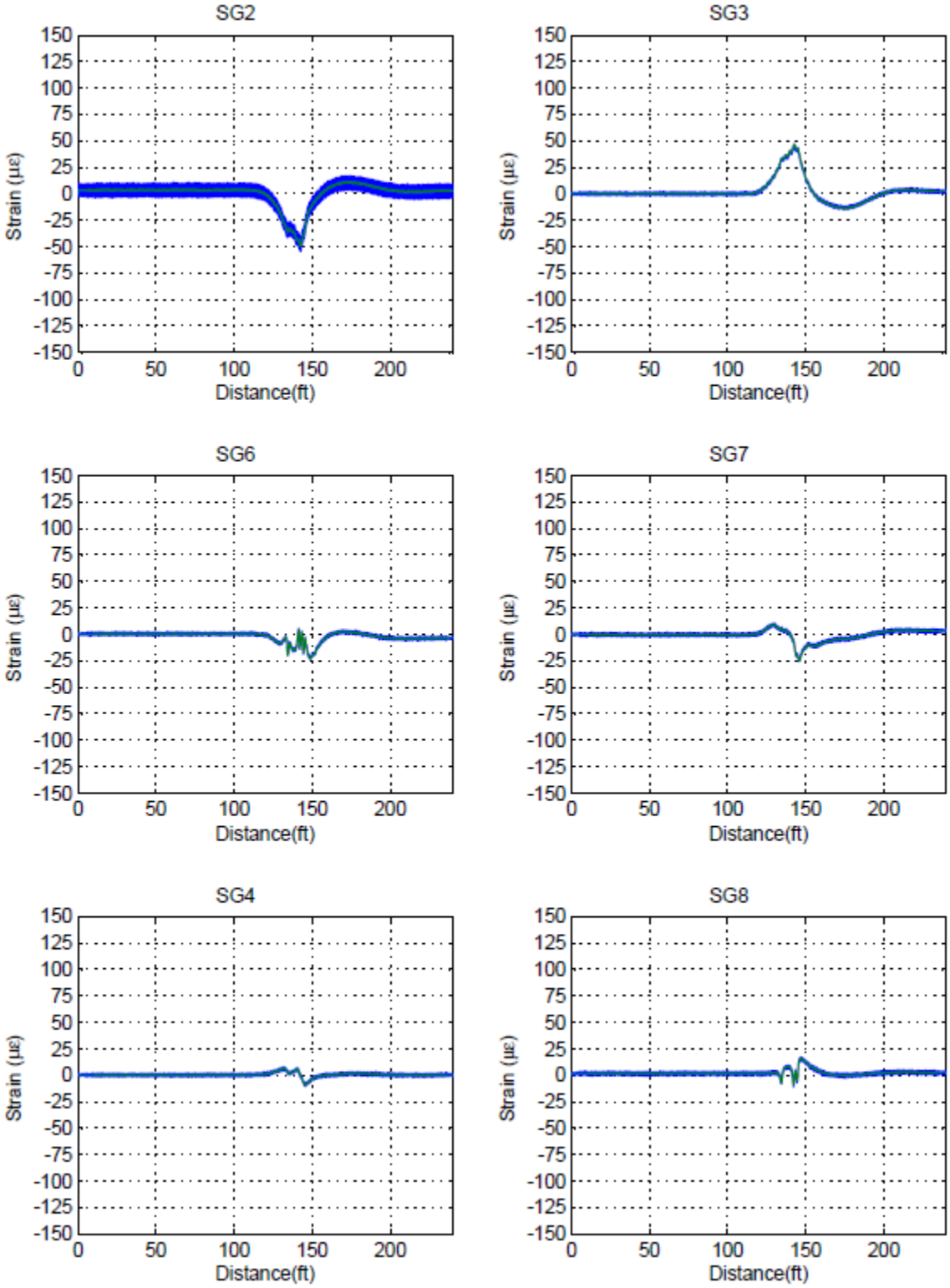


Figure C. 28: Center Truck Load Placement 8-16 kph (5-10 mph).

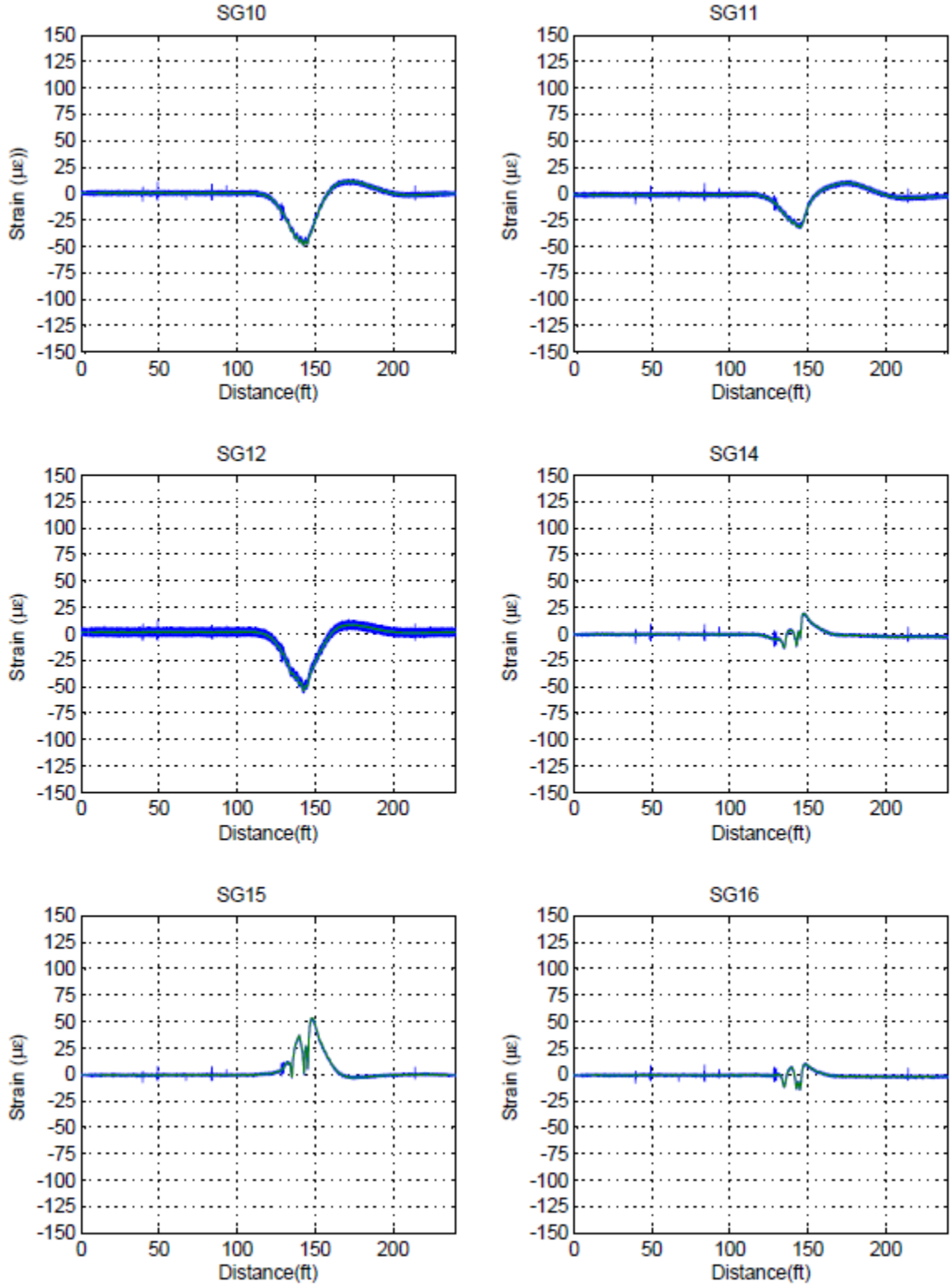


Figure C. 29: Center Truck Load Placement 8-16 kph (5-10 mph).

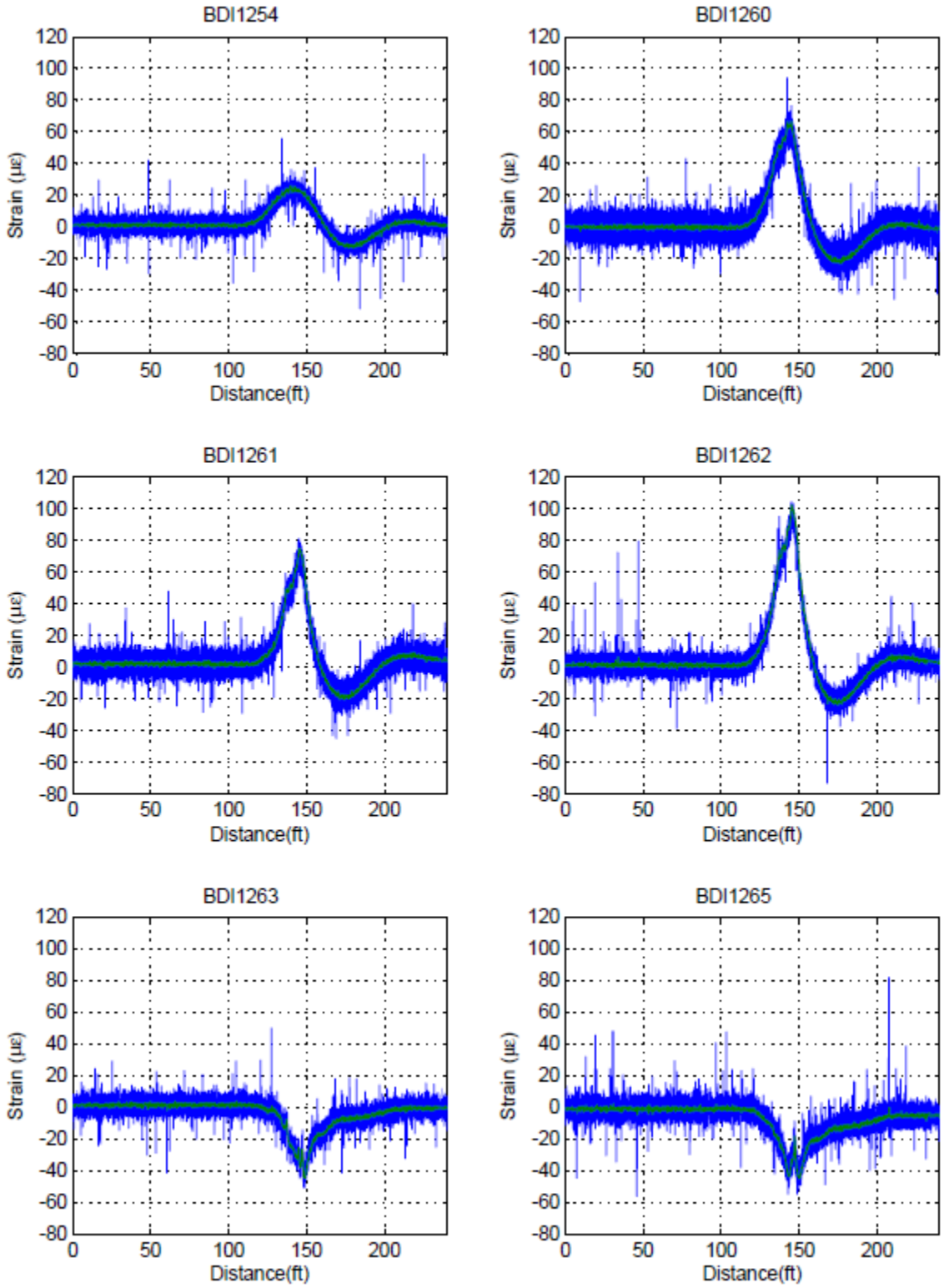


Figure C. 30: Center Truck Load Placement 8-16 kph (5-10 mph).

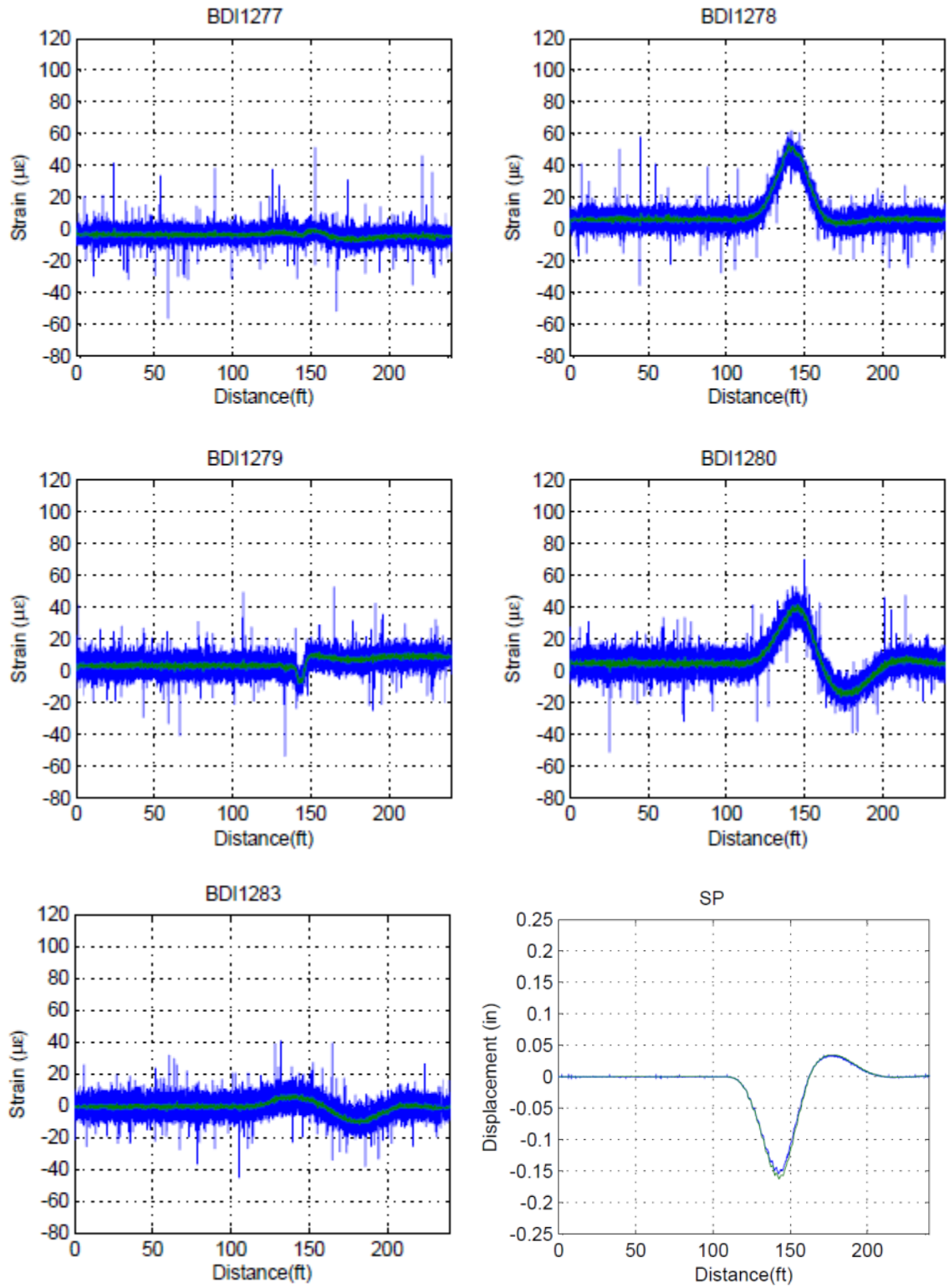


Figure C. 31: Center Truck Load Placement 105-121 kph (65-75 mph).

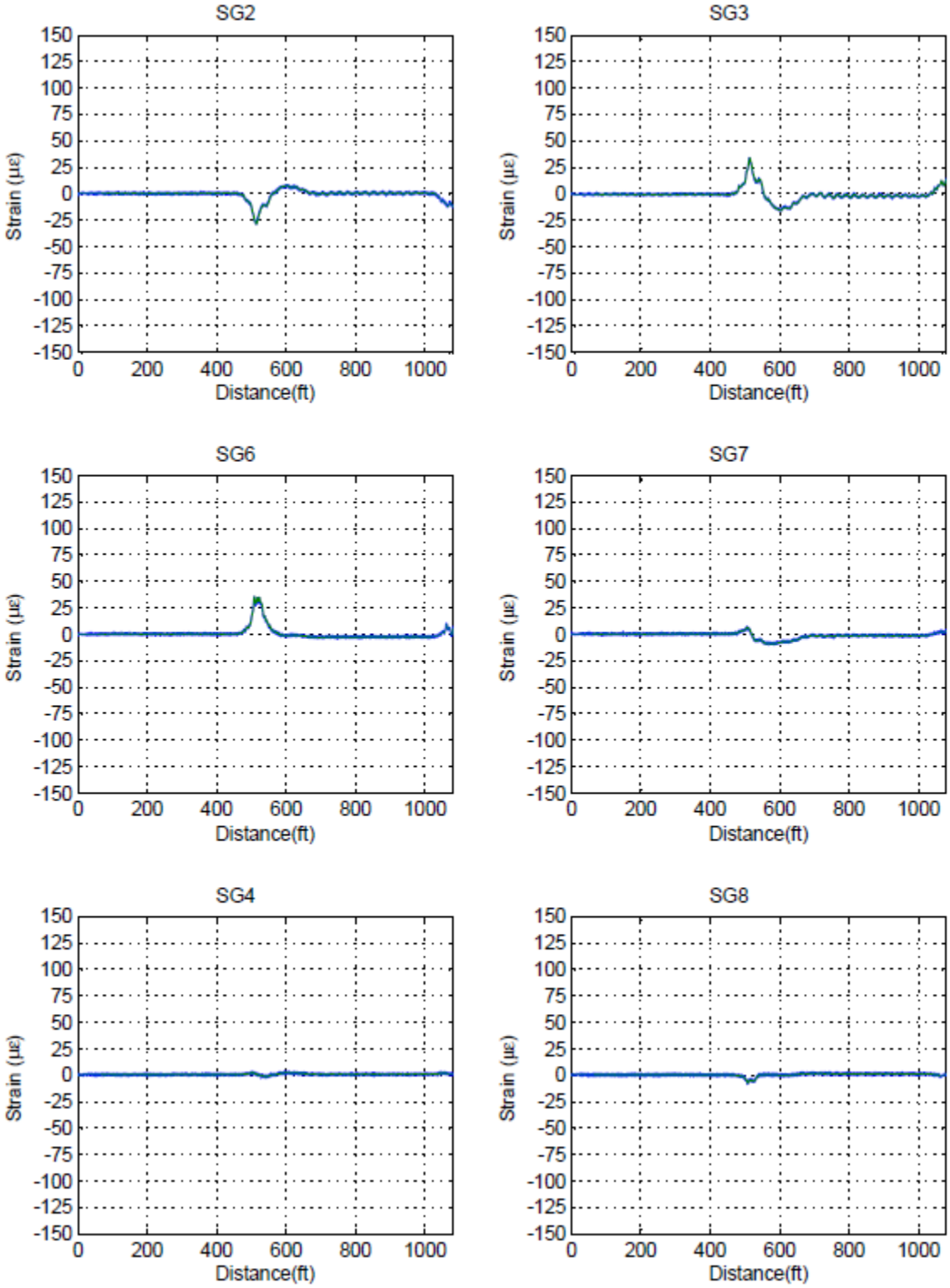


Figure C. 32: Center Truck Load Placement 105-121 kph (65-75 mph).

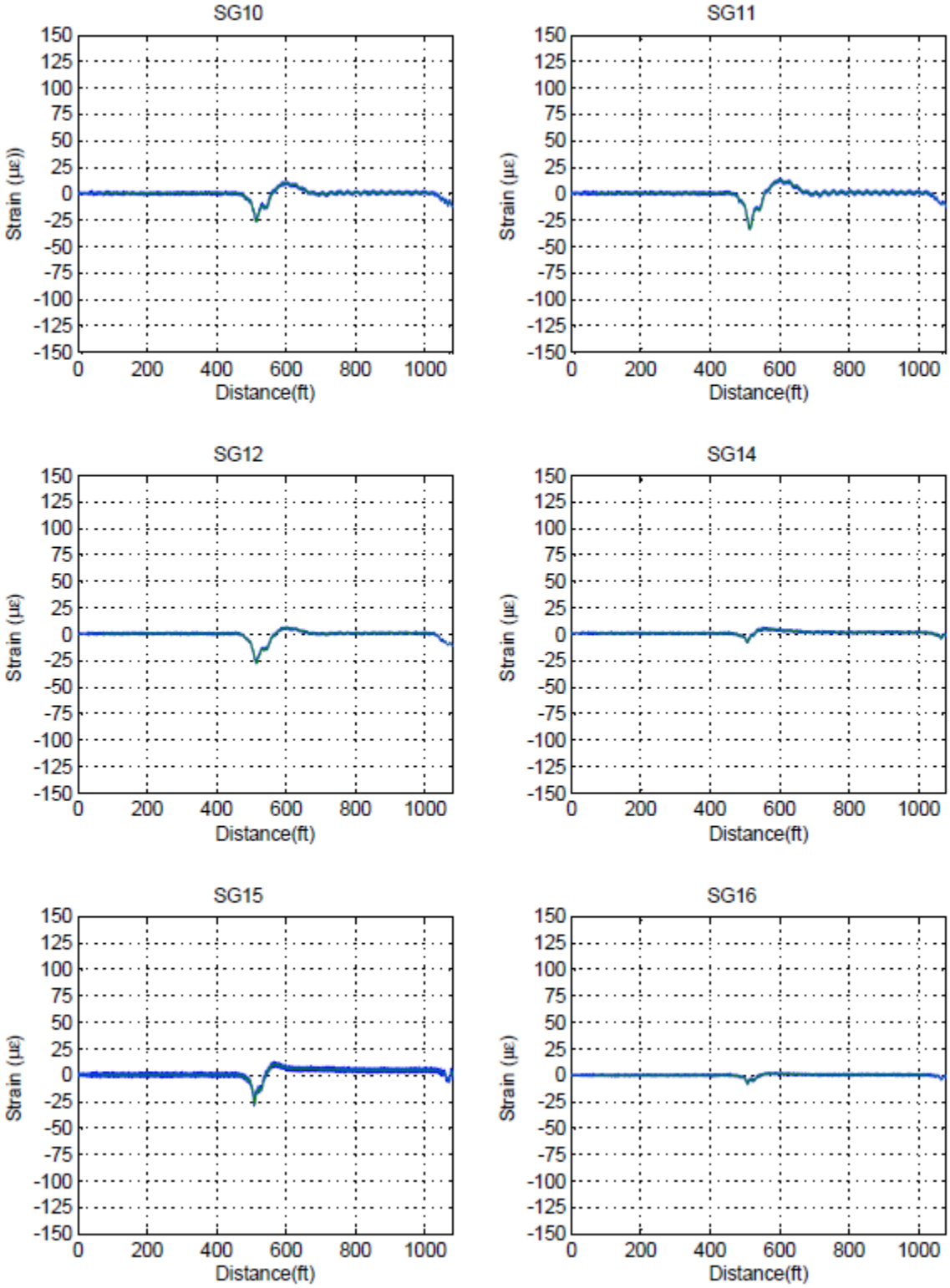


Figure C. 33: Center Truck Load Placement 105-121 kph (65-75 mph).

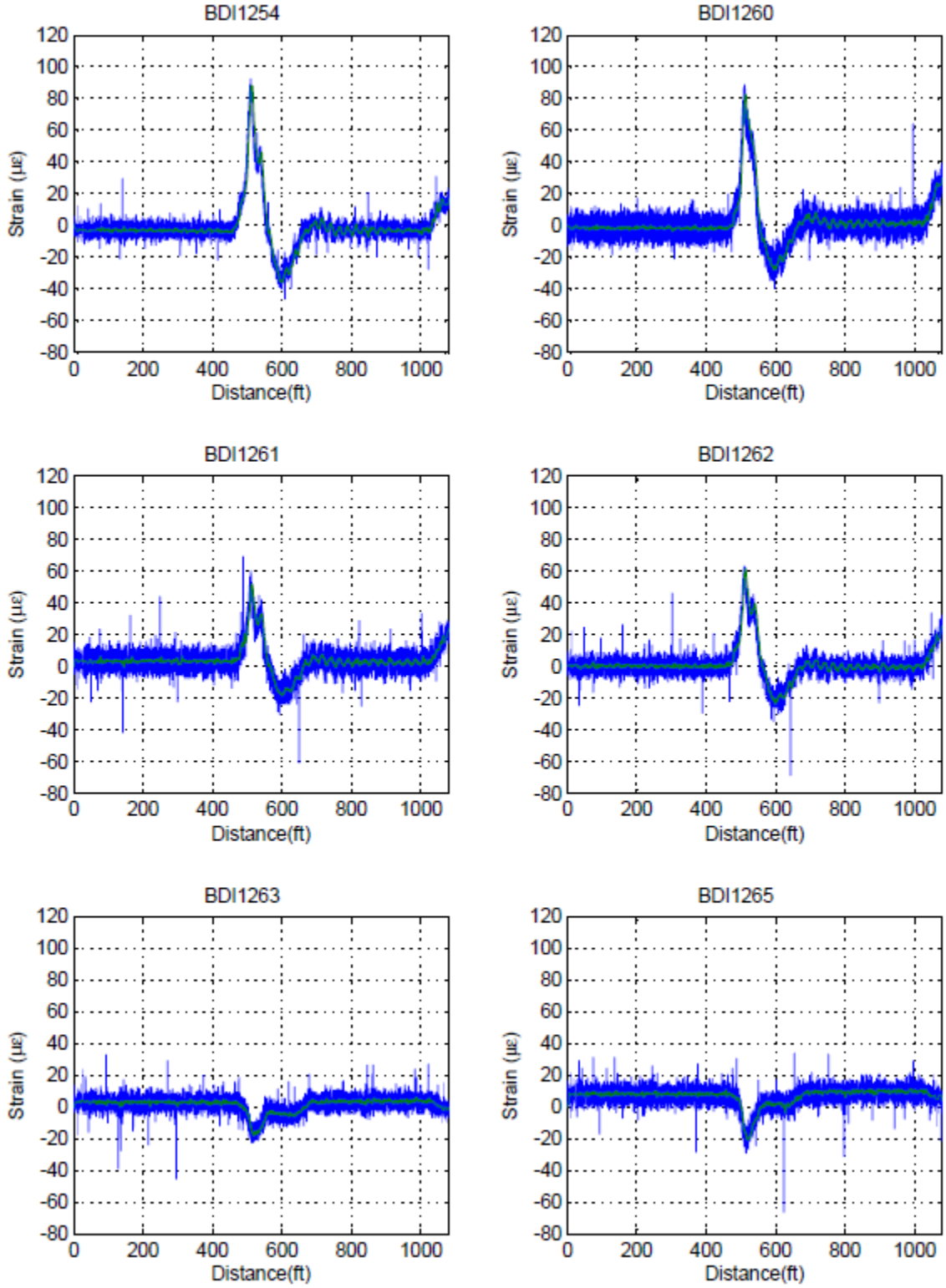


Figure C. 34: Center Truck Load Placement 105-121 kph (65-75 mph).

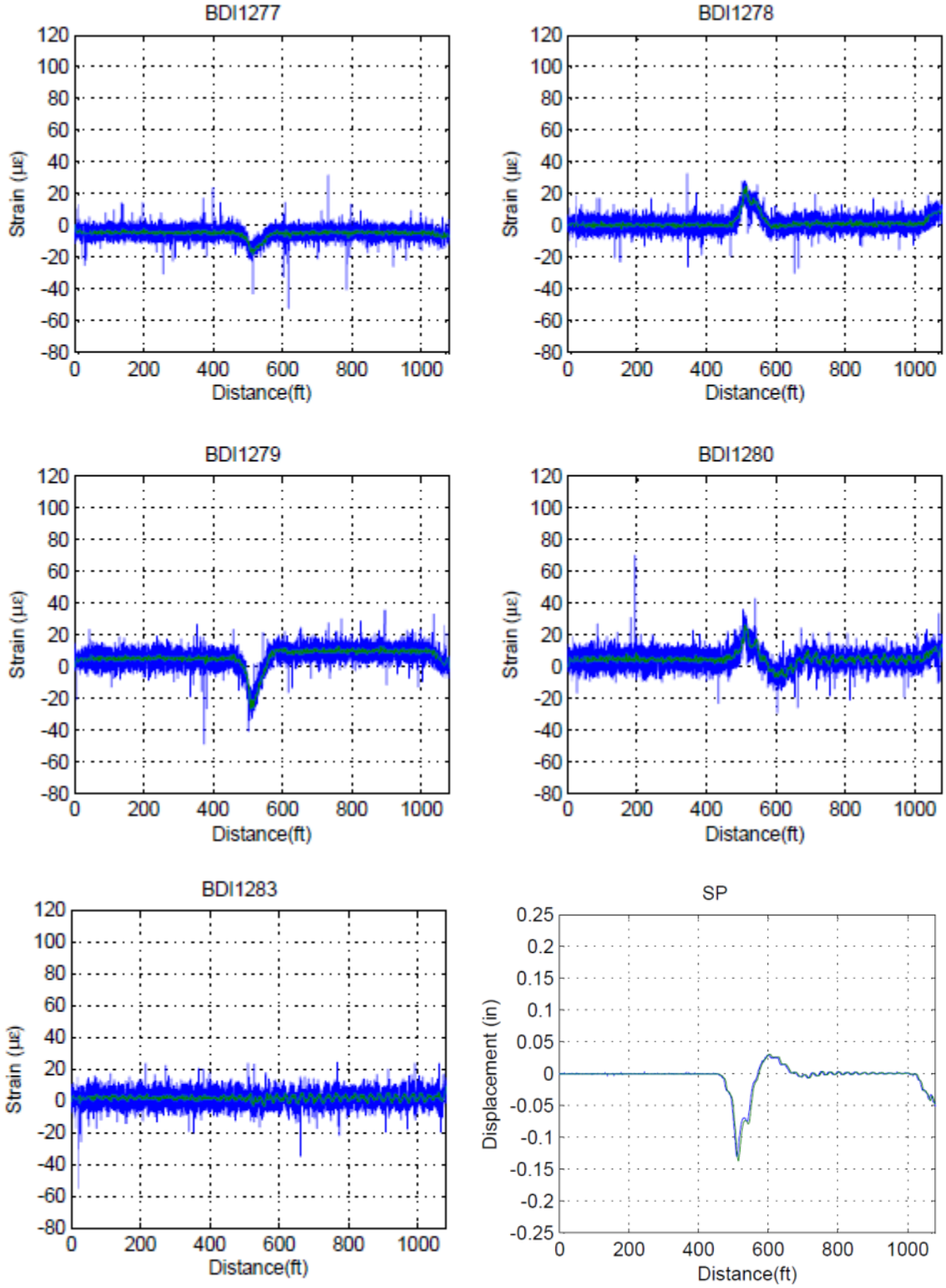


Figure C. 35: East Truck Load Placement 8-16 kph (5-10 mph).

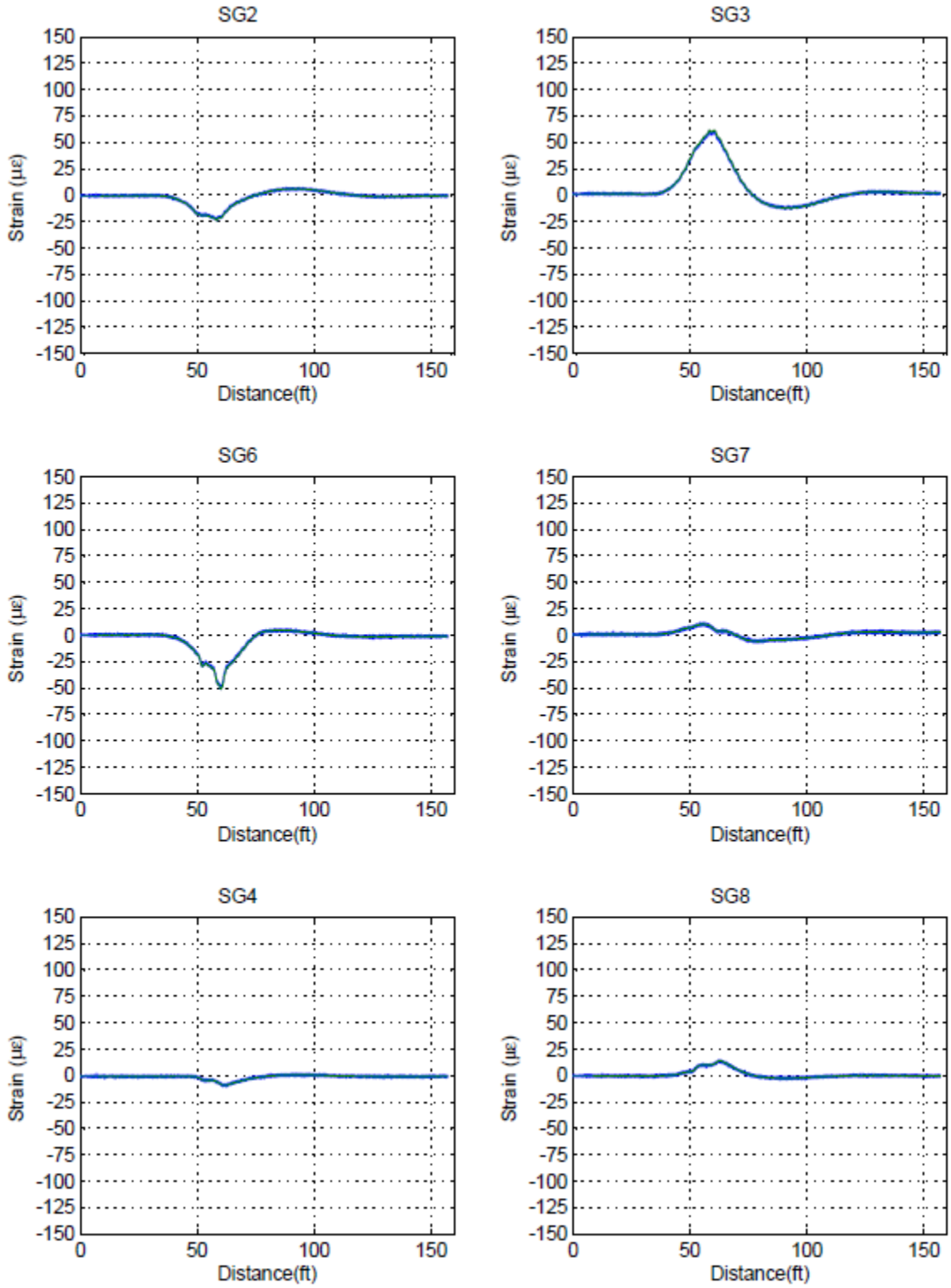


Figure C. 36: East Truck Load Placement 8-16 kph (5-10 mph).

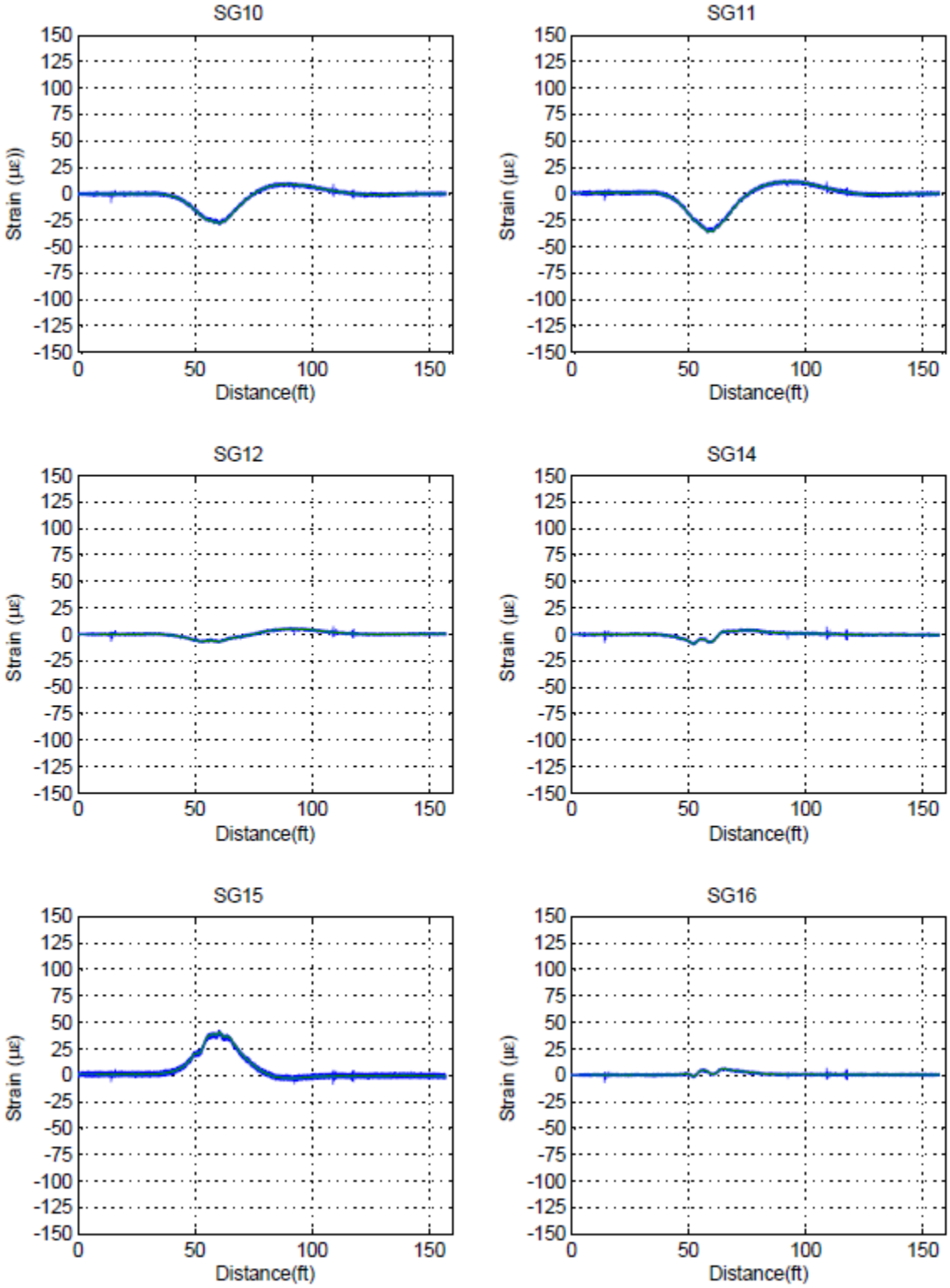


Figure C. 37: East Truck Load Placement 8-16 kph (5-10 mph).

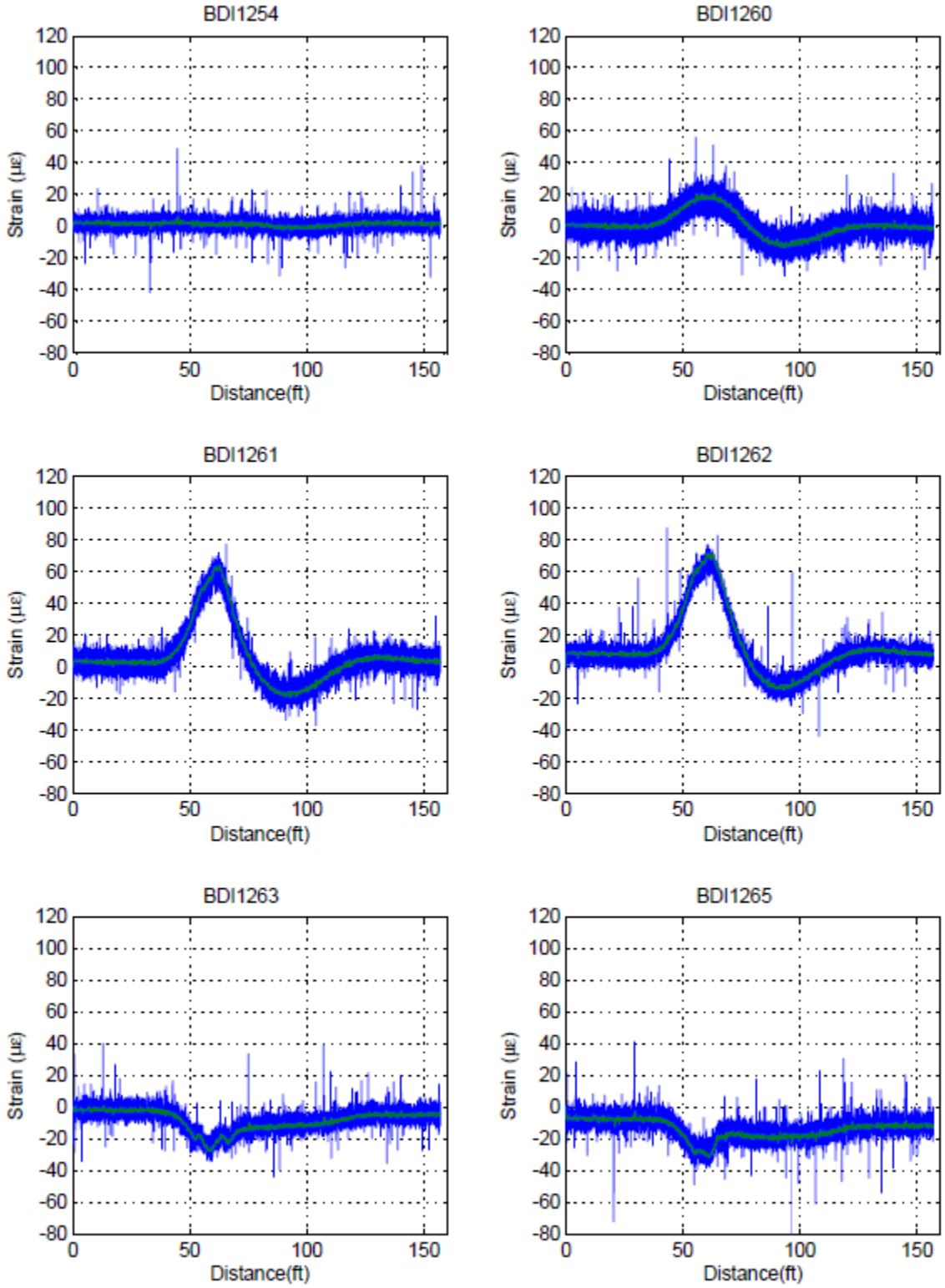


Figure C. 38: East Truck Load Placement 8-16 kph (5-10 mph).

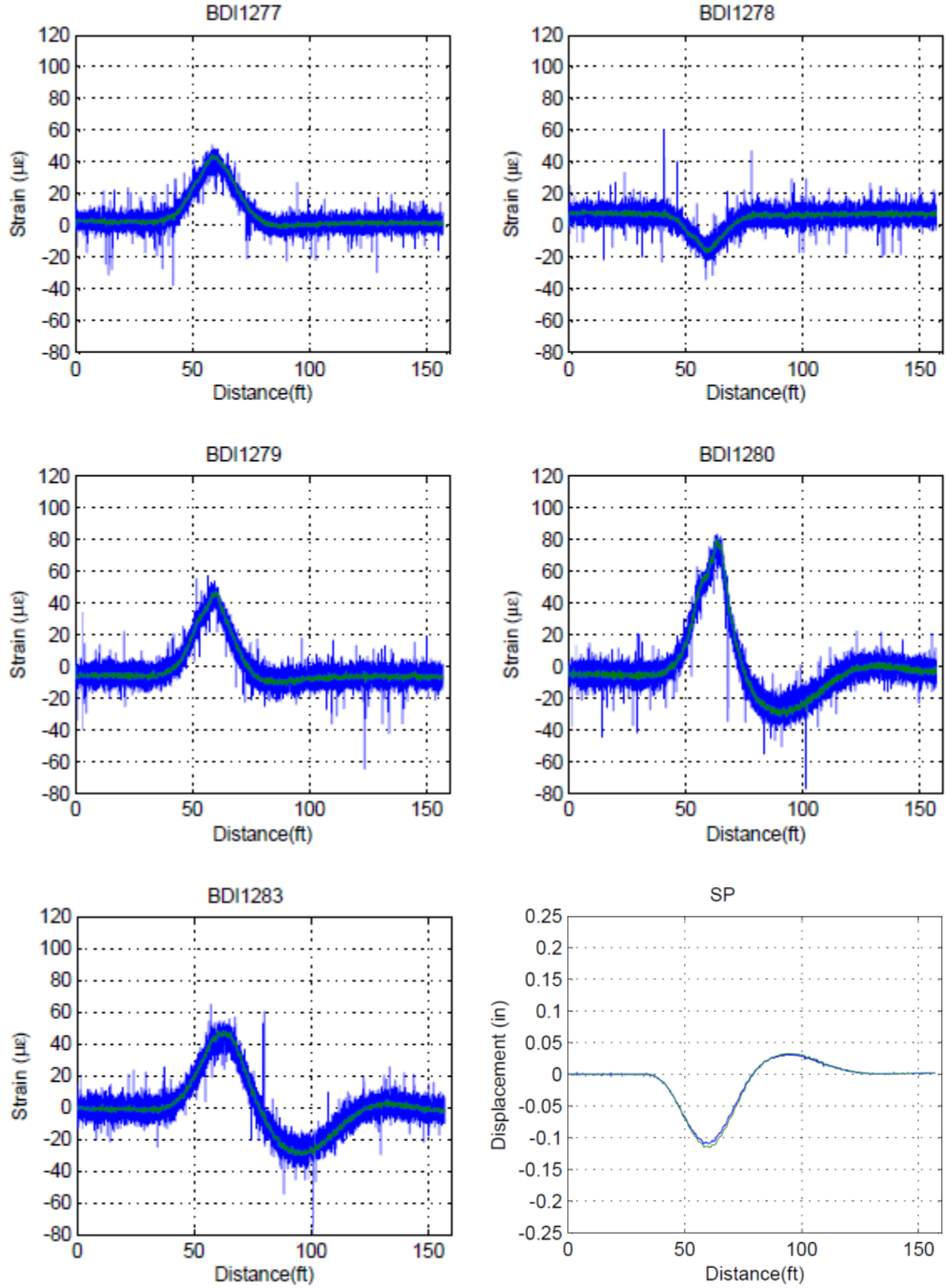


Figure C. 39: East Truck Load Placement 105-121 kph (65-75 mph).

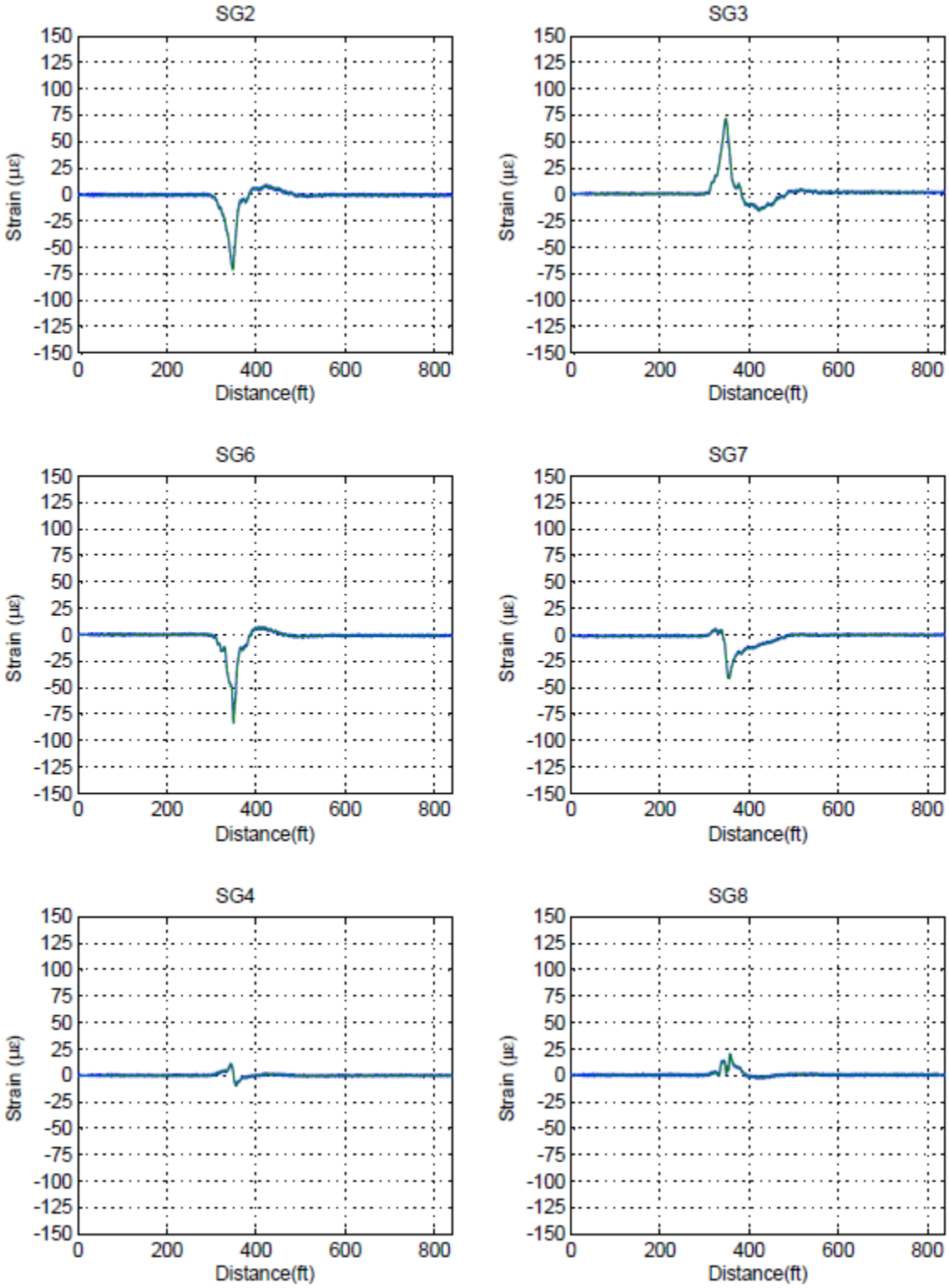


Figure C. 40: East Truck Load Placement 105-121 kph (65-75 mph).

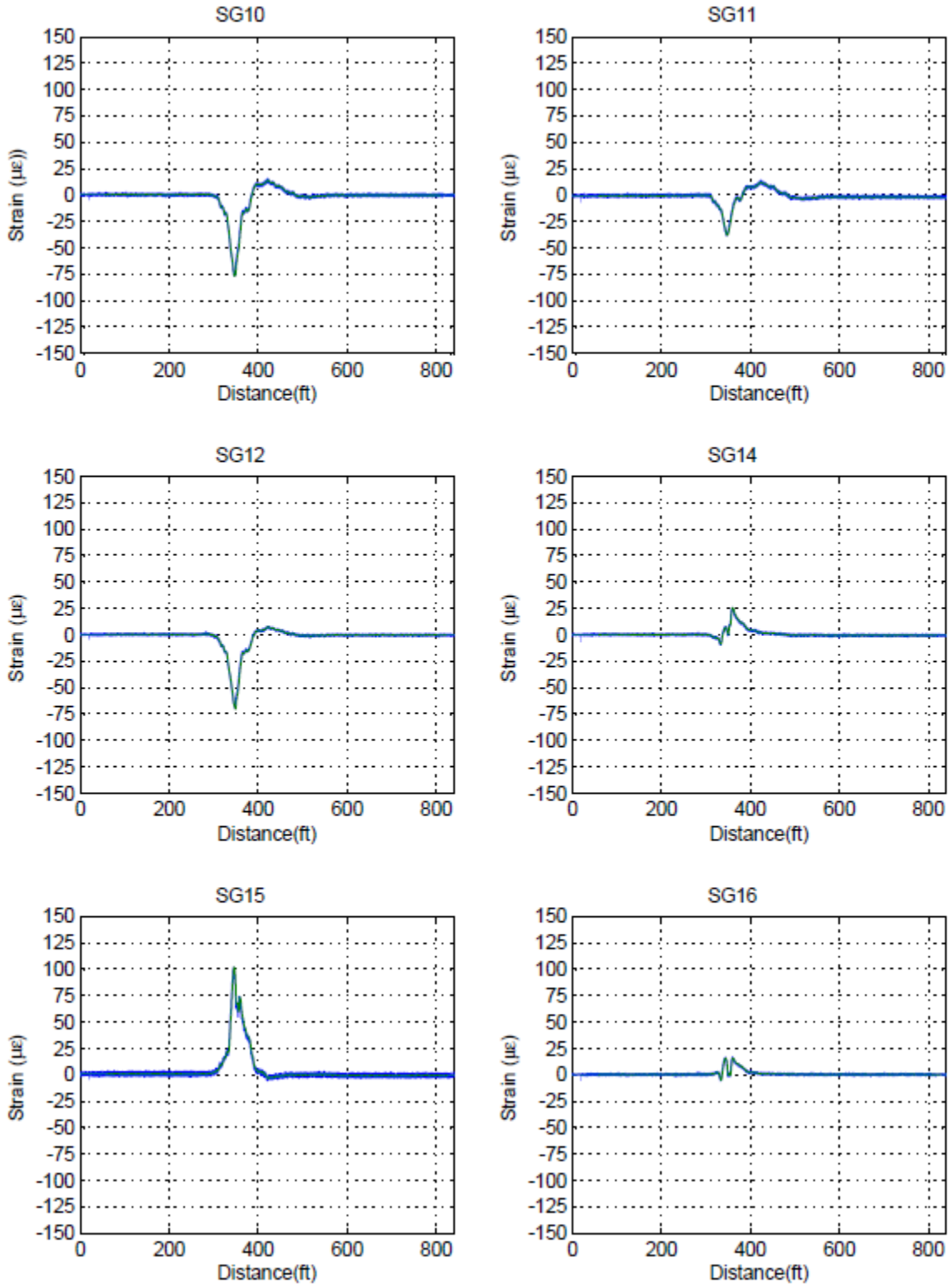


Figure C. 41: East Truck Load Placement 105-121 kph (65-75 mph).

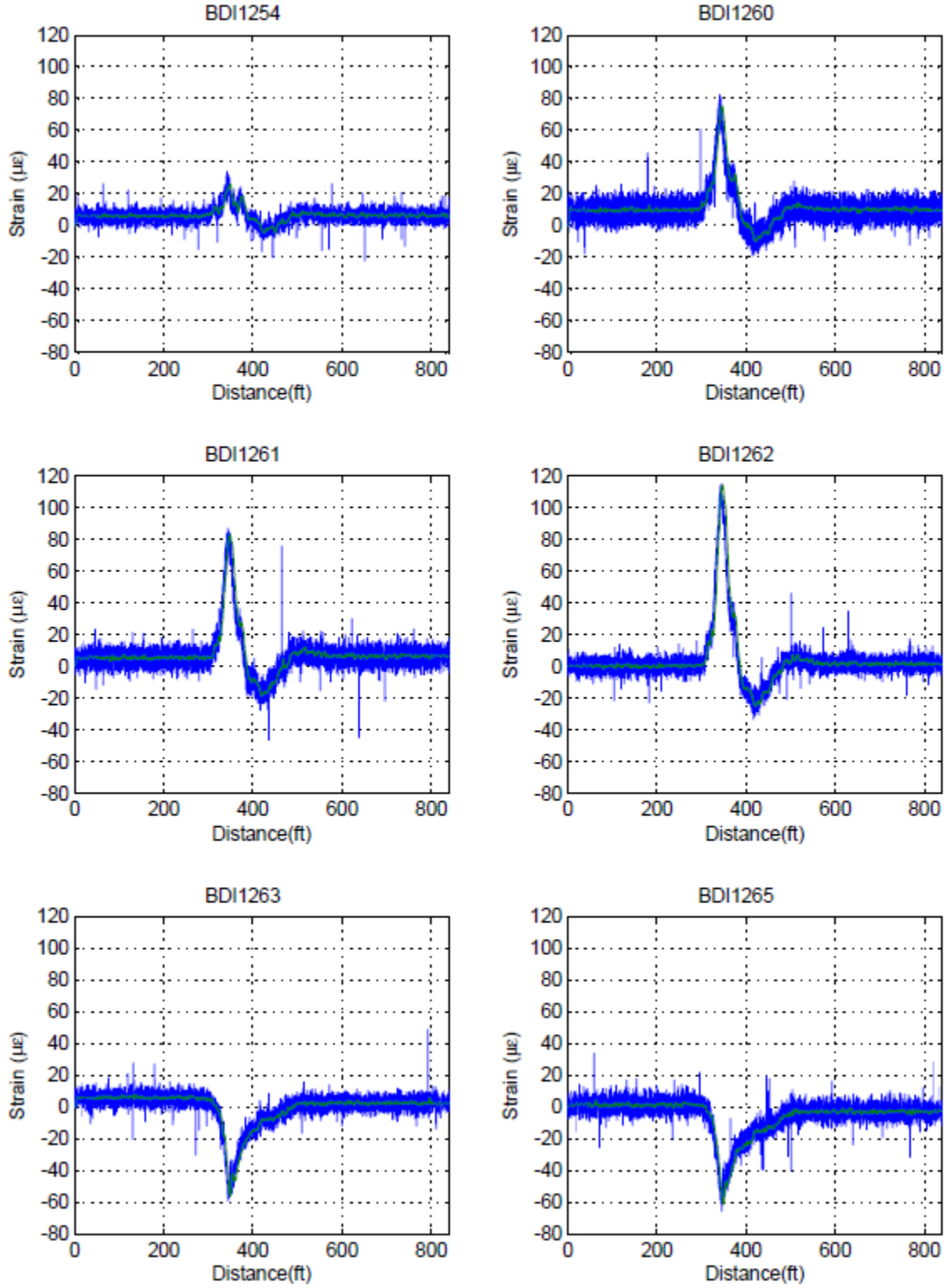
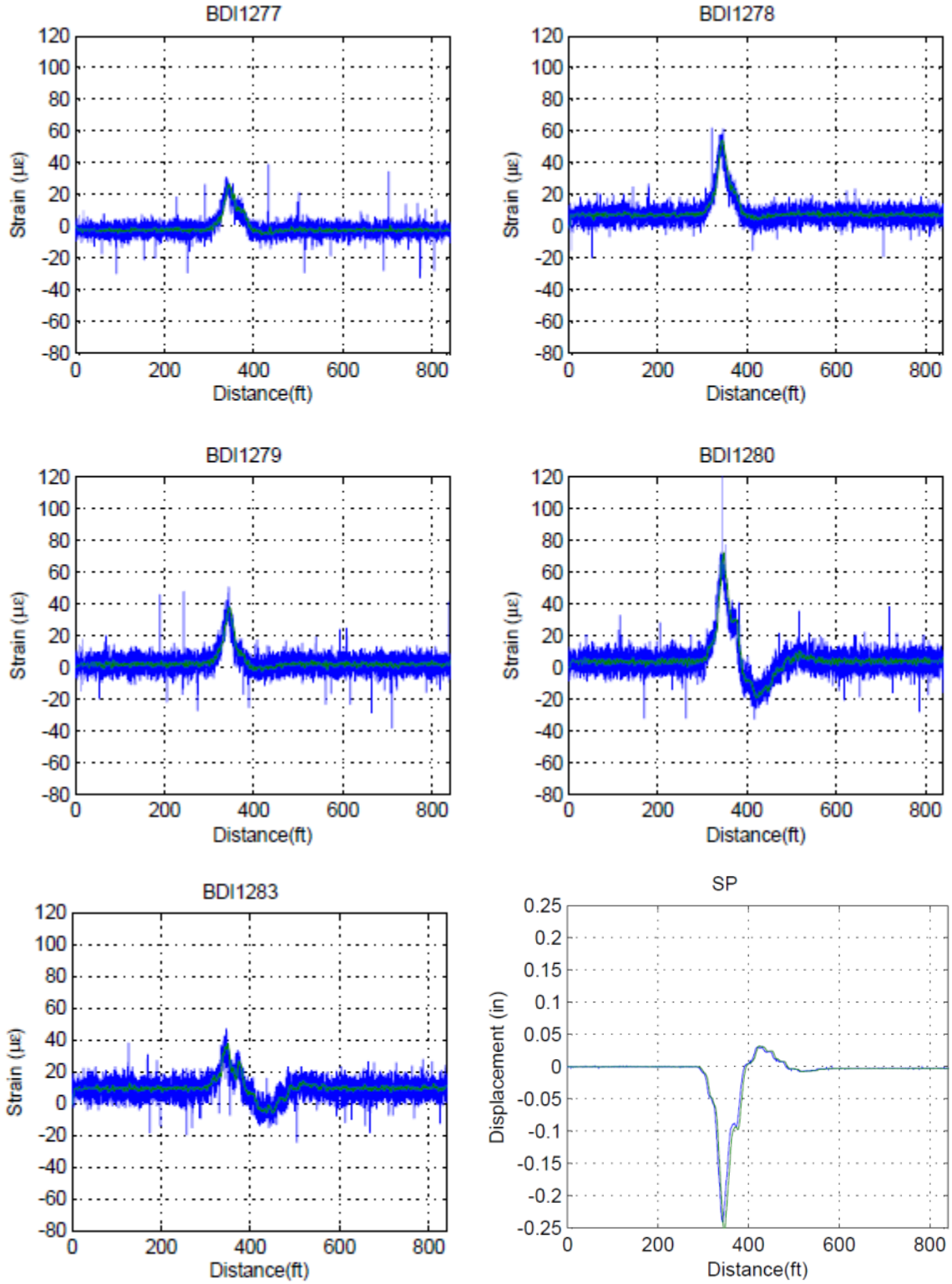


Figure C. 42: East Truck Load Placement 105-121 kph (65-75 mph).



Appendix D: Field Test and Finite Element Analyses Results

Field Test and Complementary Finite Element Analyses

Figure D. 1: West Truck Load Placement Maximum Principal Web Gap Stresses Before and After Retrofit.

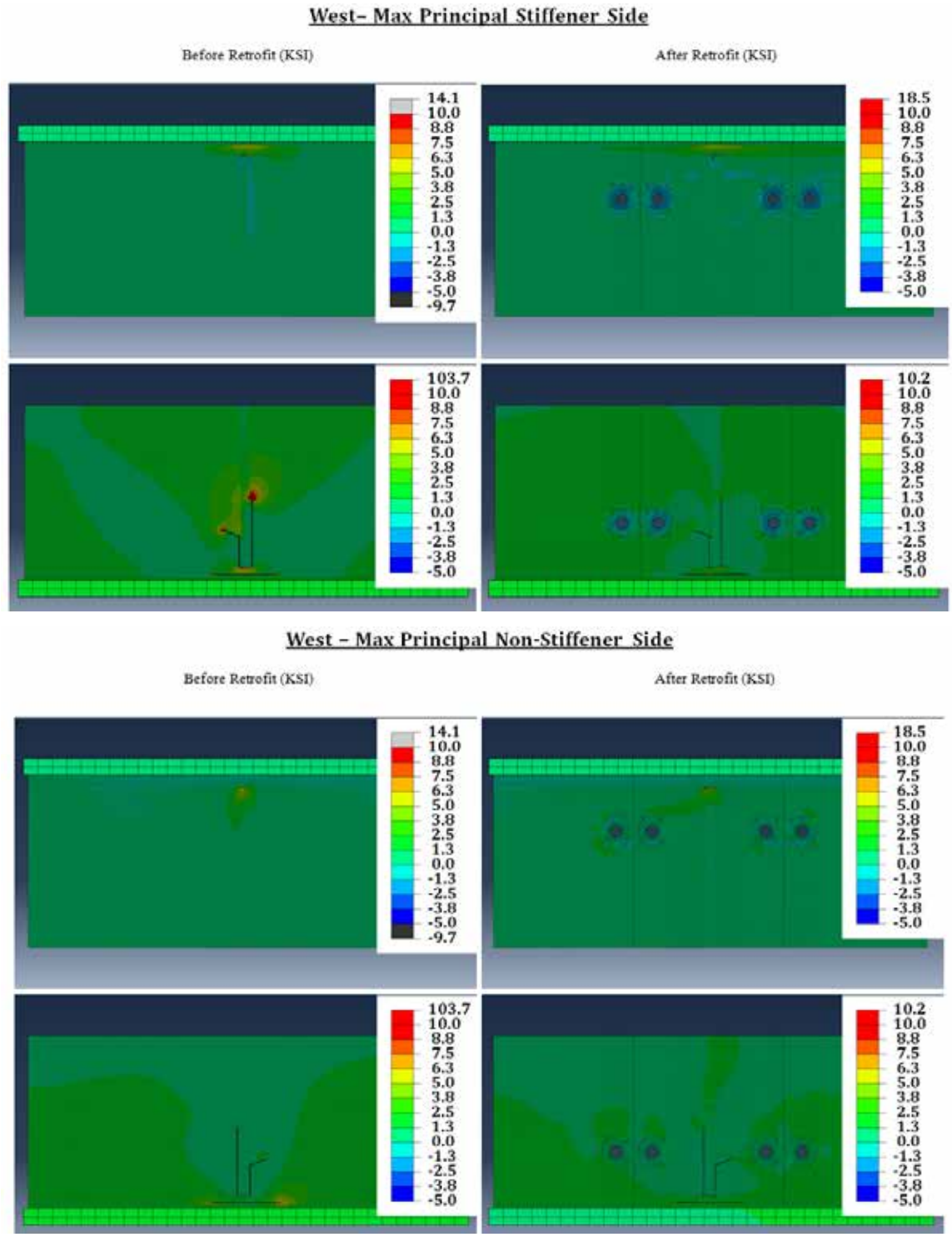


Figure D. 2: West Truck Load Placement Directional Web Gap Stresses Before and After Retrofit.

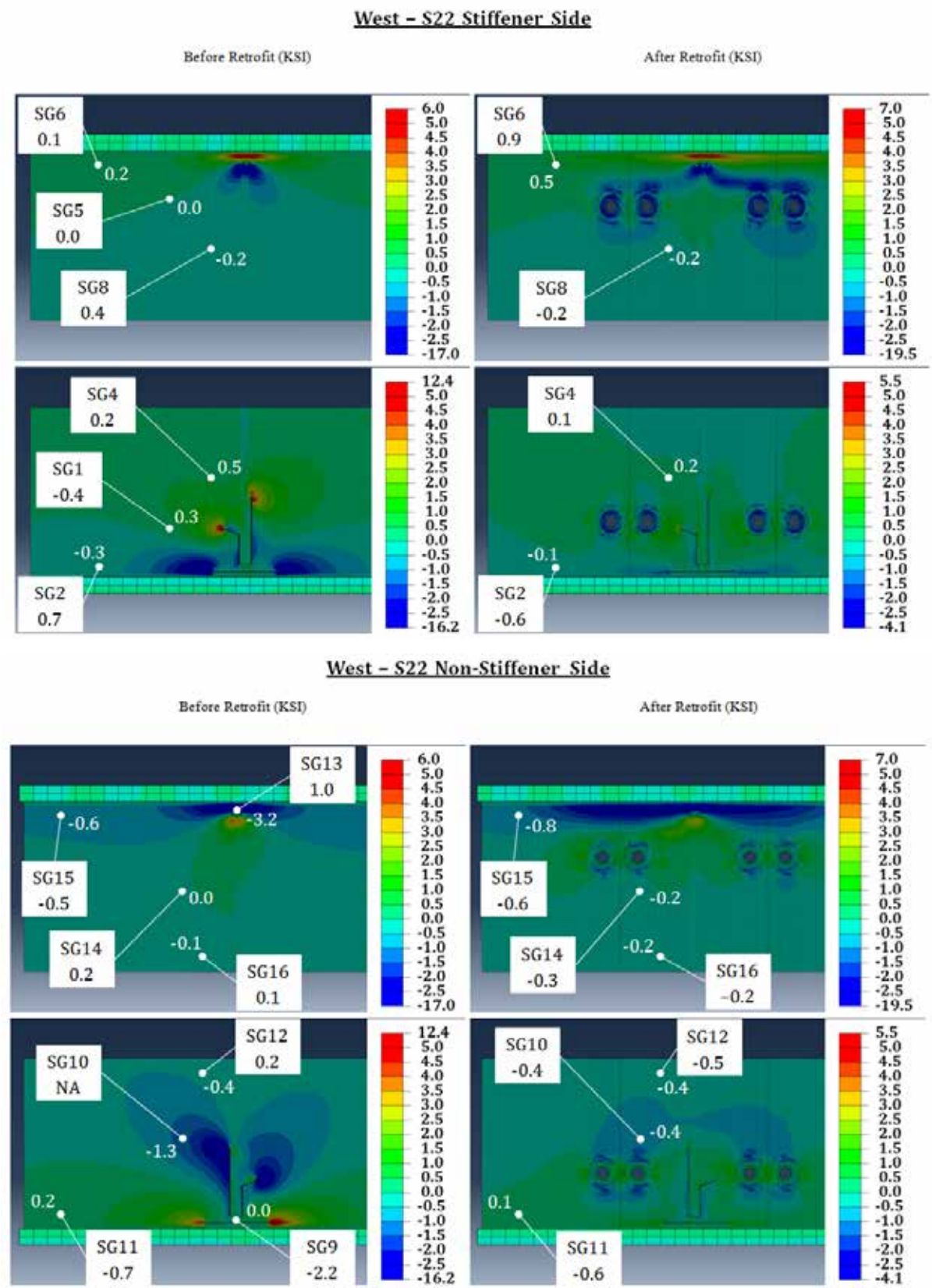


Figure D. 3: West Truck Load Placement Directional Web Gap Stresses Before and After Retrofit.

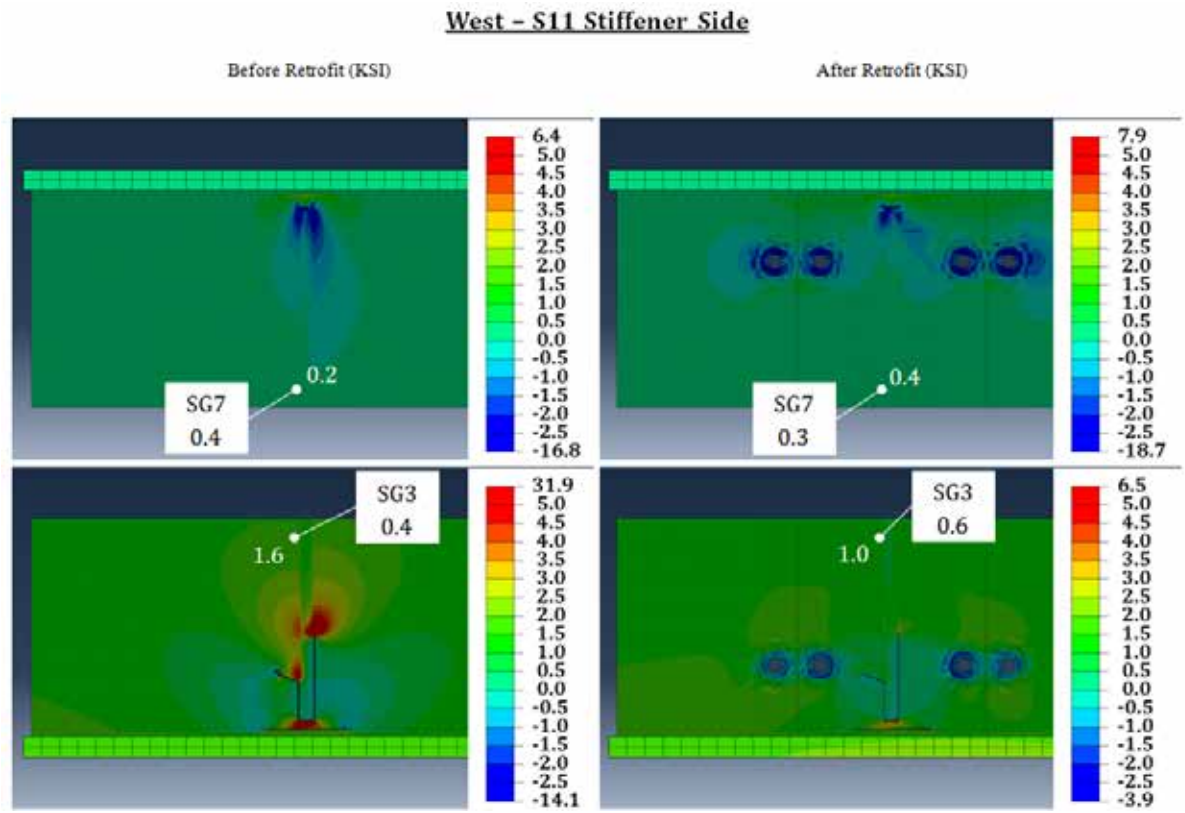


Figure D. 4: Center Truck Load Placement Maximum Principal Web Gap Stresses Before and After Retrofit.

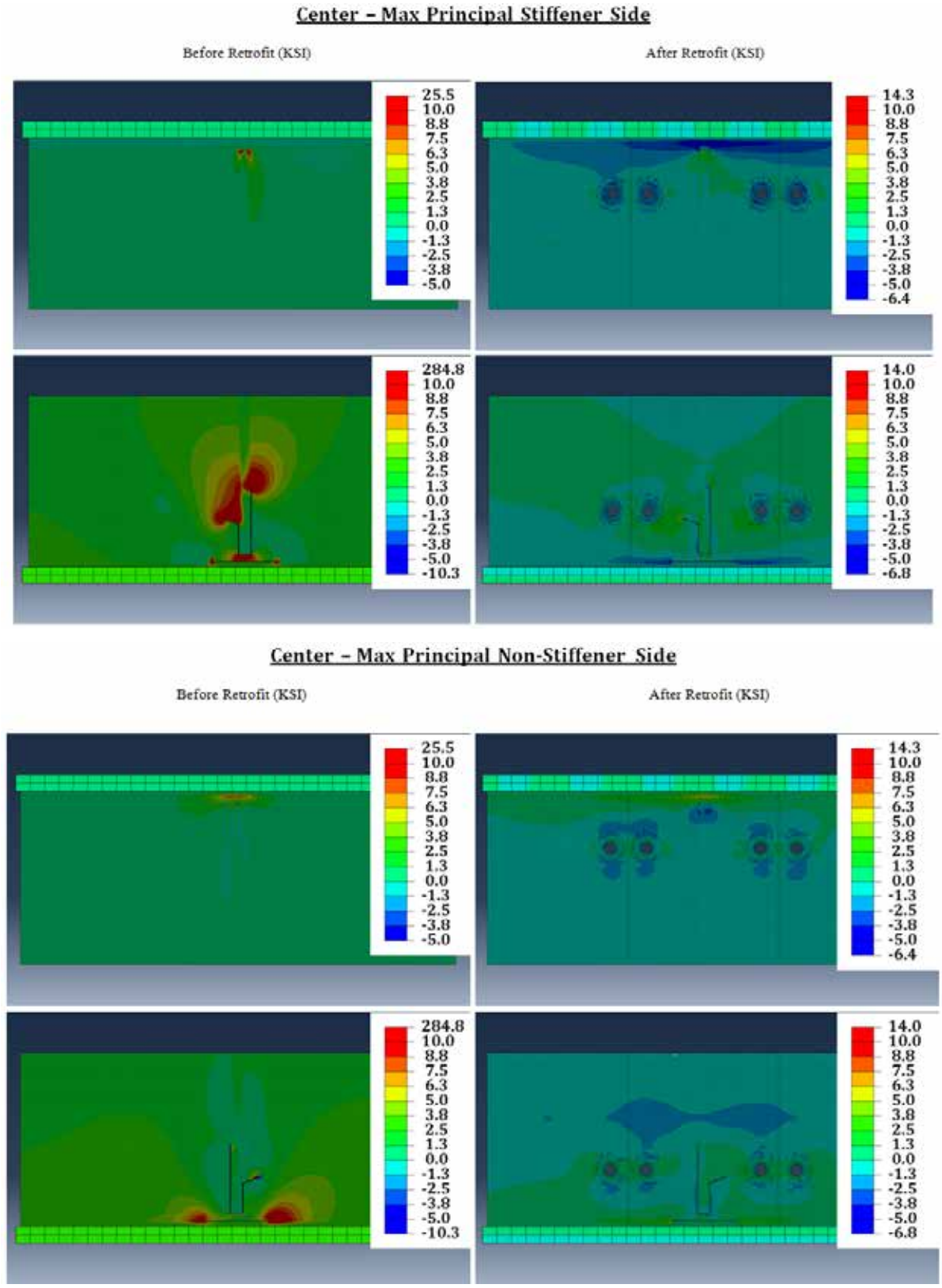


Figure D. 5: Center Truck Load Placement Directional Web Gap Stresses Before and After Retrofit.

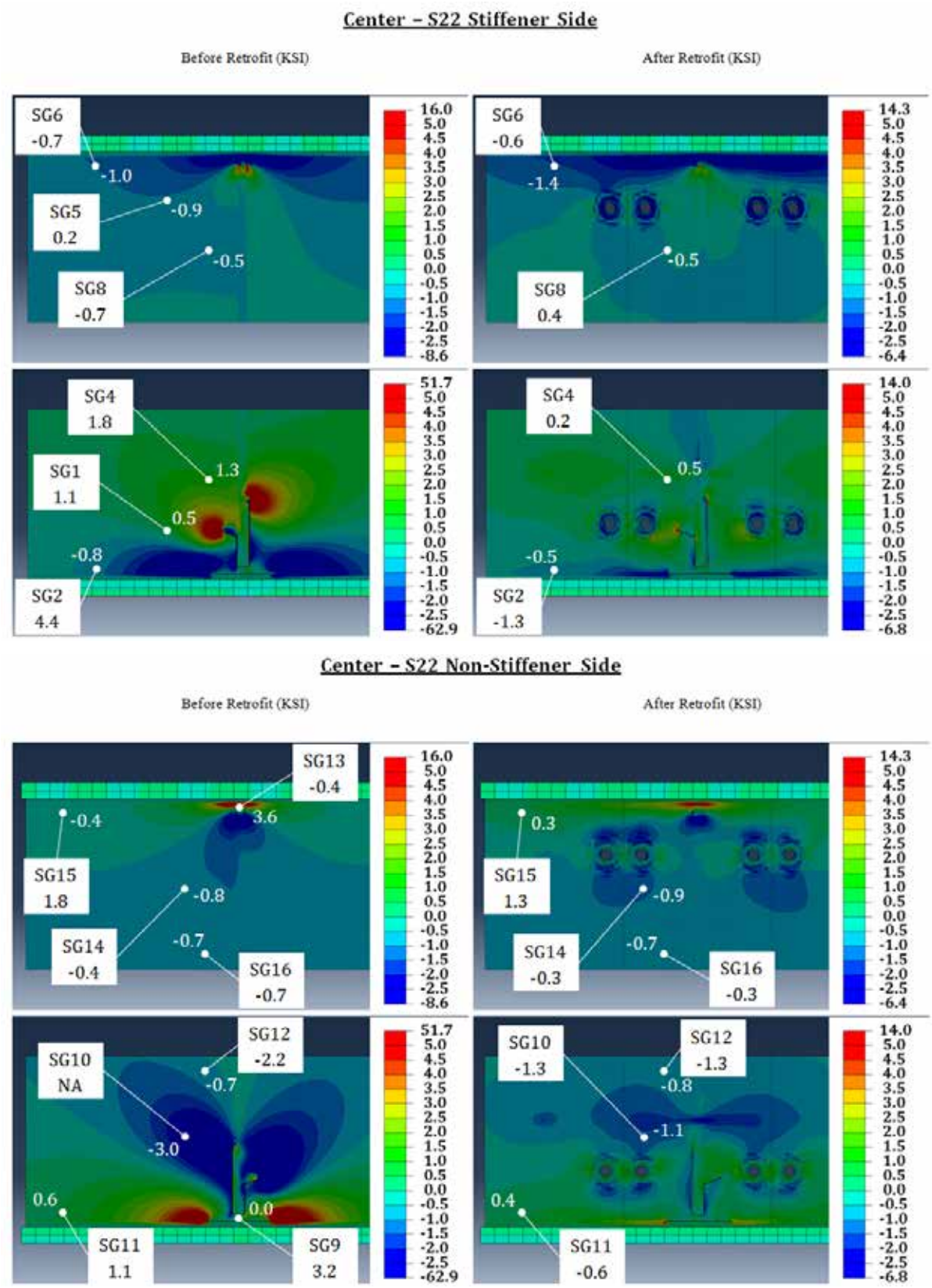


Figure D. 6: Center Truck Load Placement Directional Web Gap Stresses Before and After Retrofit.

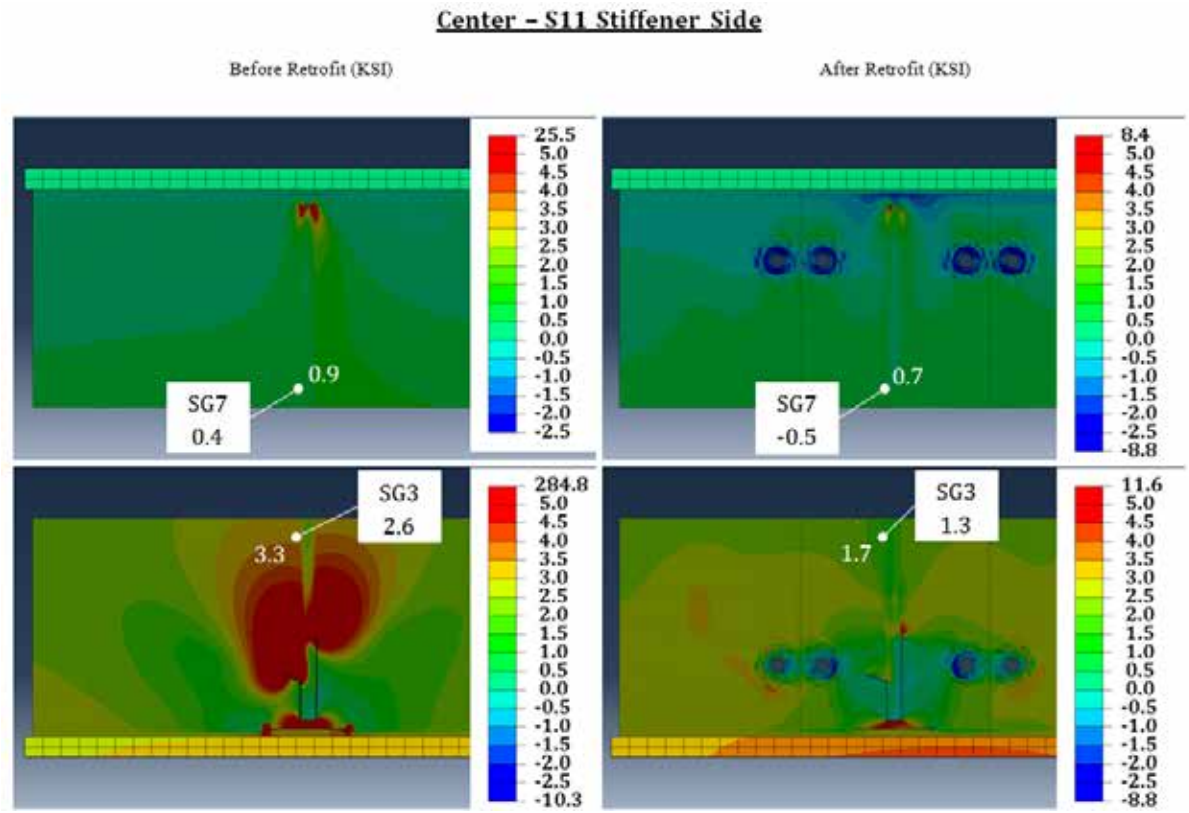


Figure D. 7: East Truck Load Placement Maximum Principal Web Gap Stresses Before and After Retrofit.

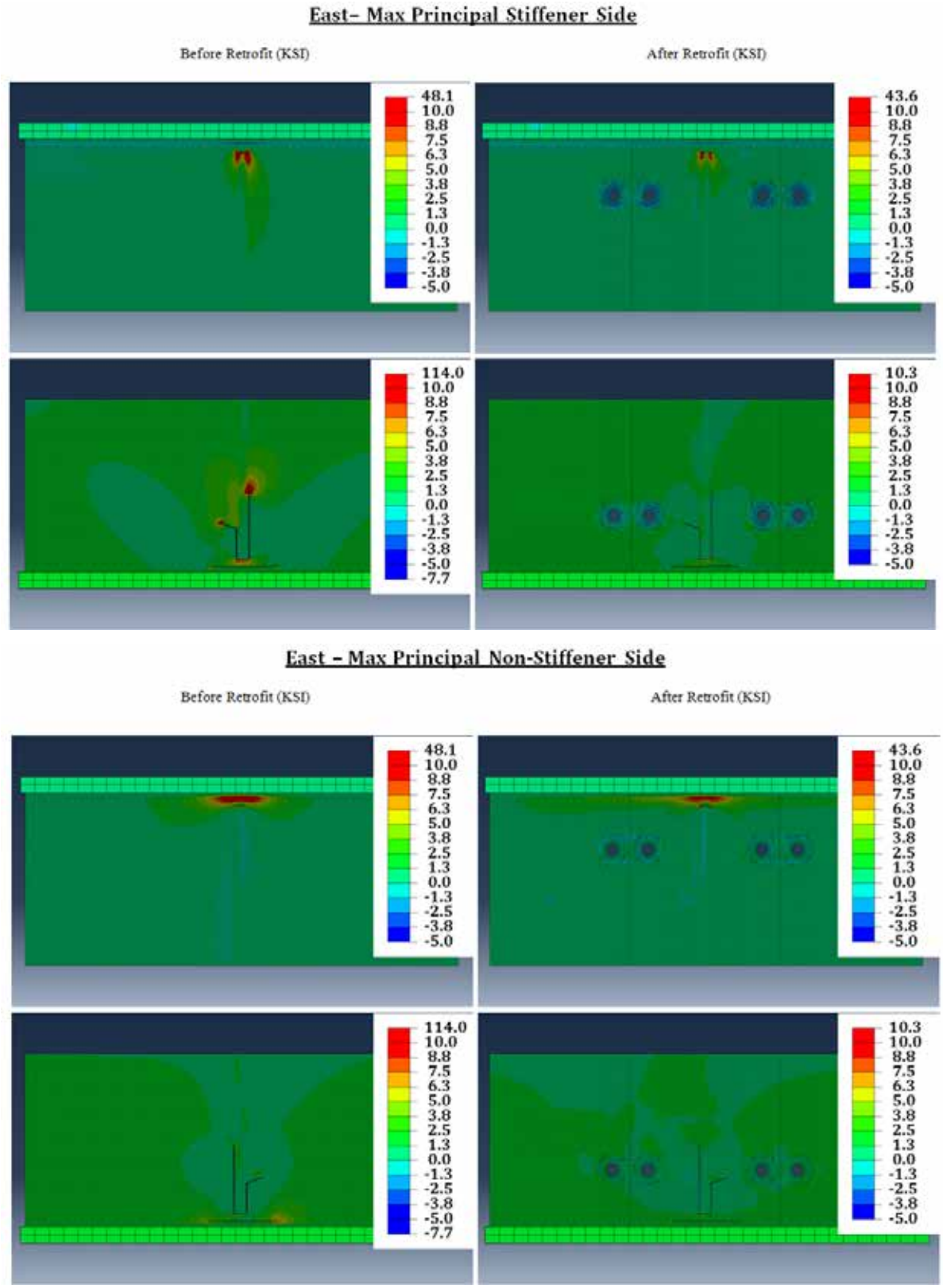


Figure D. 8: East Truck Load Placement Directional Web Gap Stresses Before and After Retrofit.

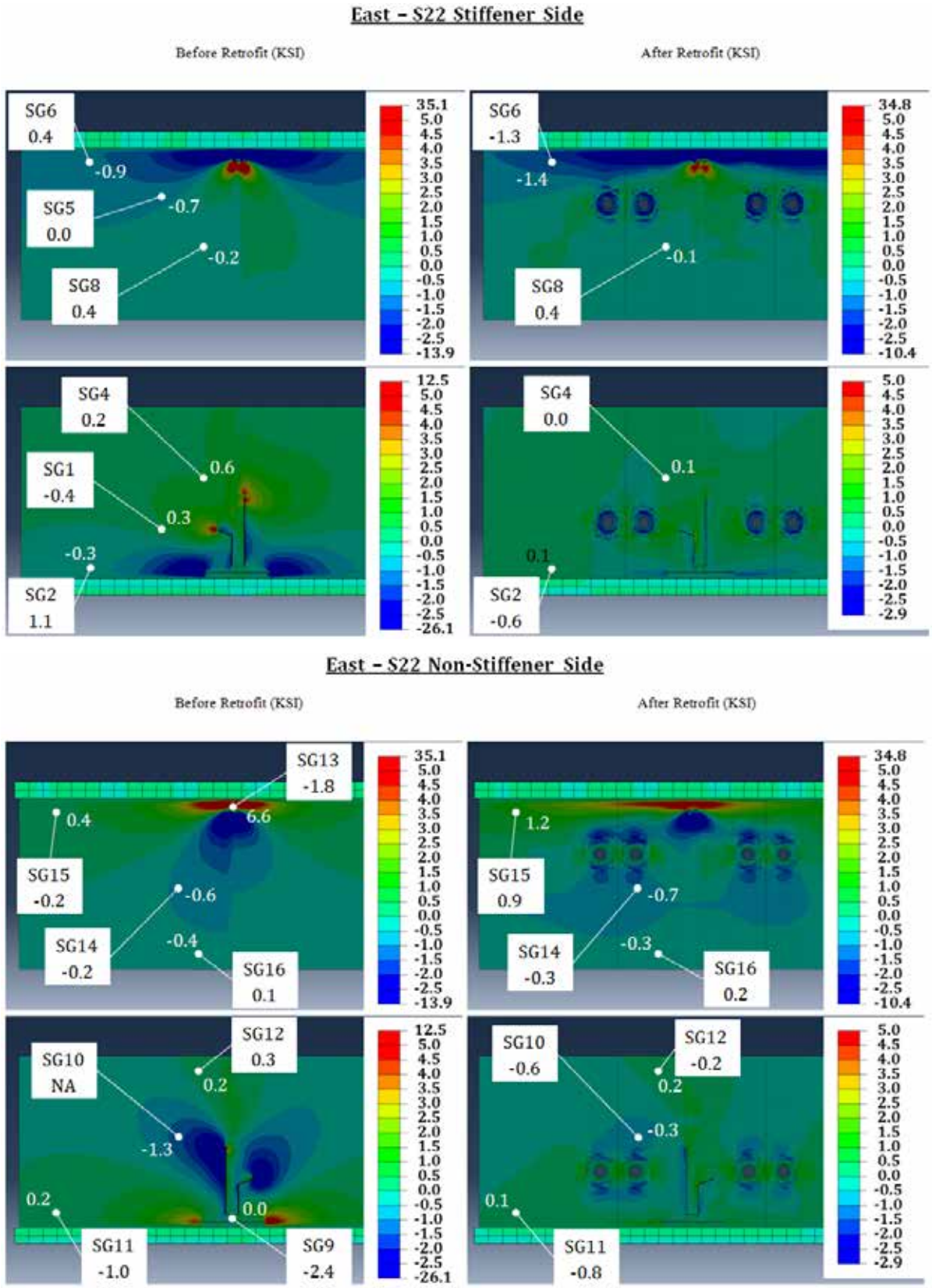
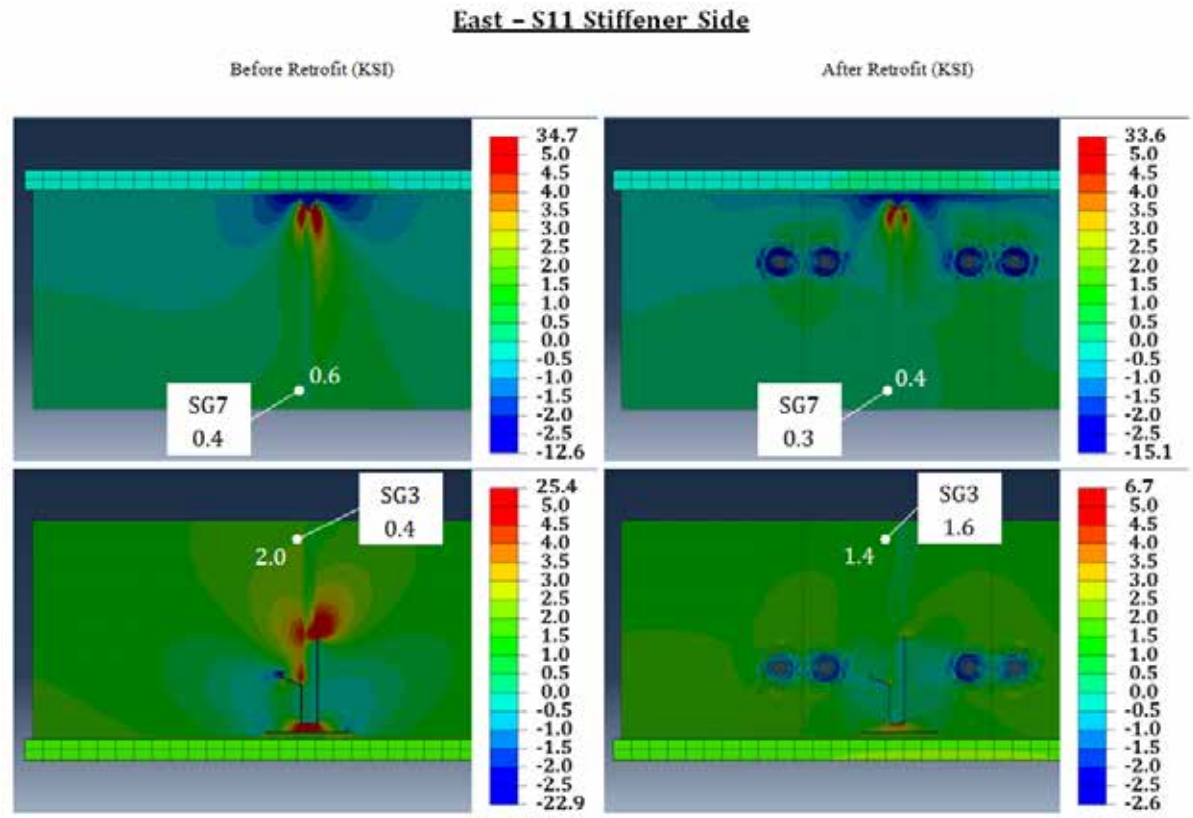


Figure D. 9: East Truck Load Placement Directional Web Gap Stresses Before and After Retrofit.



Top Web Gap Behavior Finite Element Analyses

Figure D. 10: Maximum Principal Stresses at Top Web Gap for West Load Truck Placement with Connection Plate-To-Web and Flange-To-Web Weld Cracks Present.

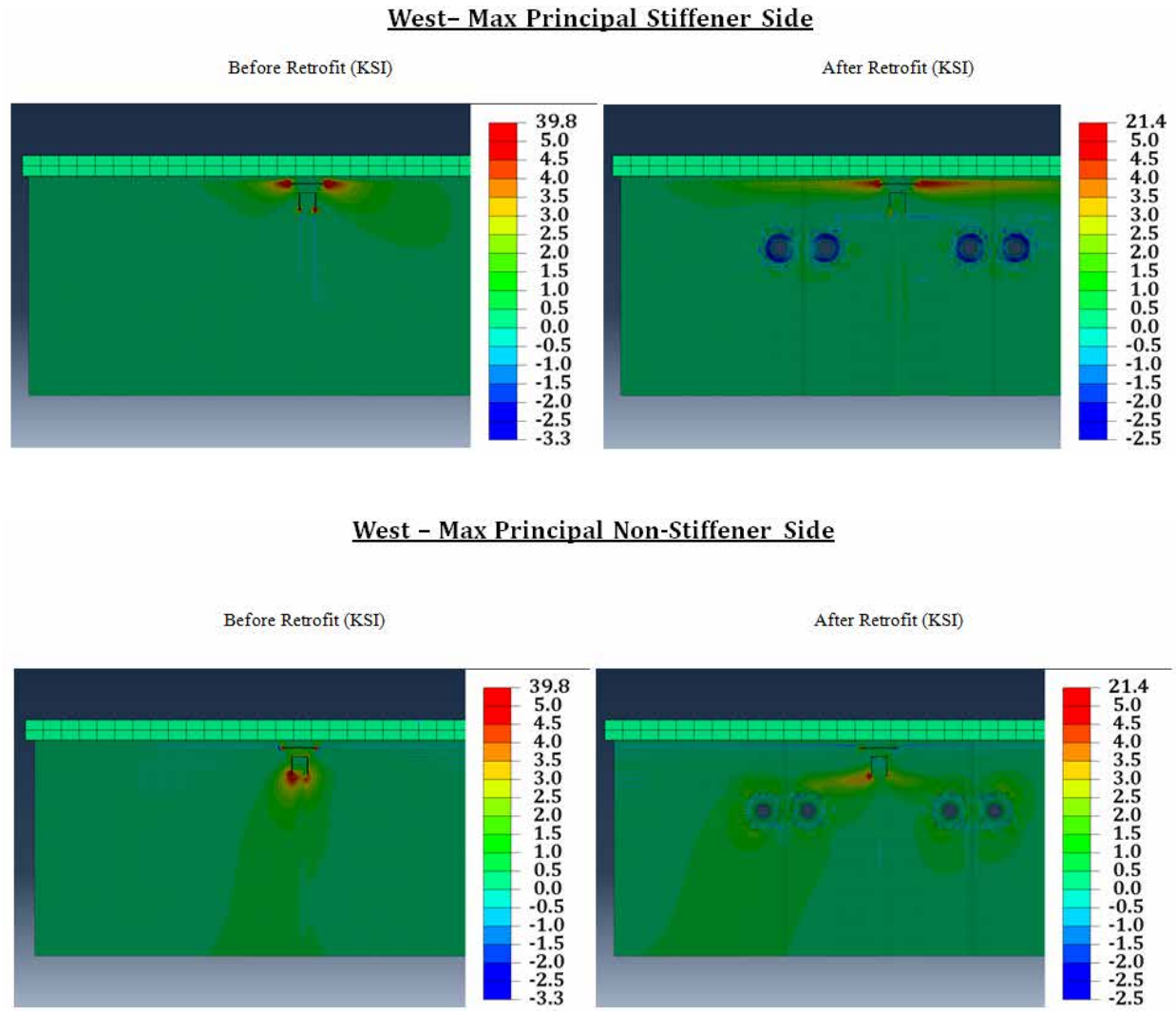


Figure D. 11: Maximum Principal Stresses at Top Web Gap for Center Load Truck Placement with Connection Plate-To-Web and Flange-To-Web Weld Cracks Present.

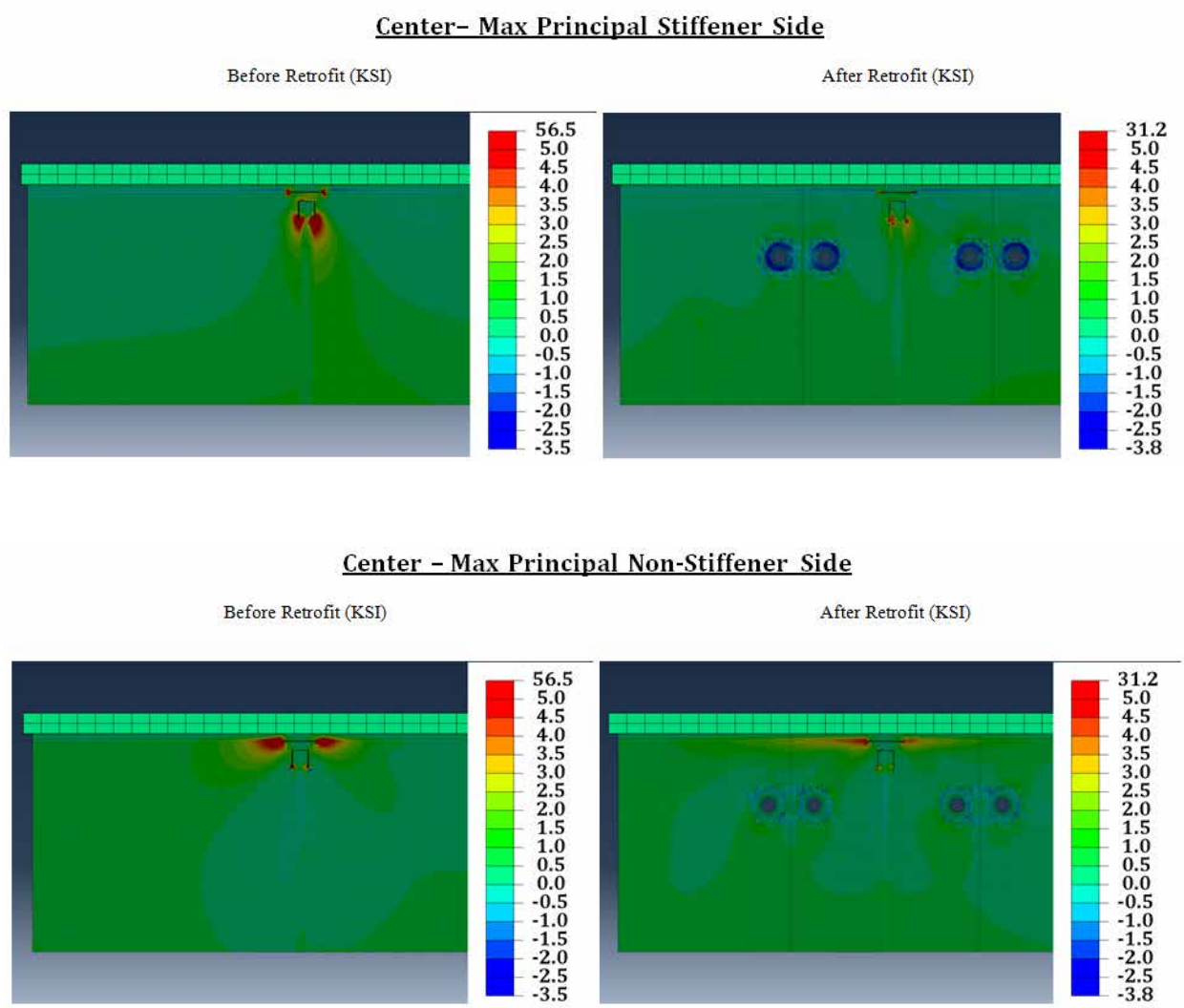


Figure D. 12: Maximum Principal Stresses at Top Web Gap for East Load Truck Placement with Connection Plate-To-Web and Flange-To-Web Weld Cracks Present.

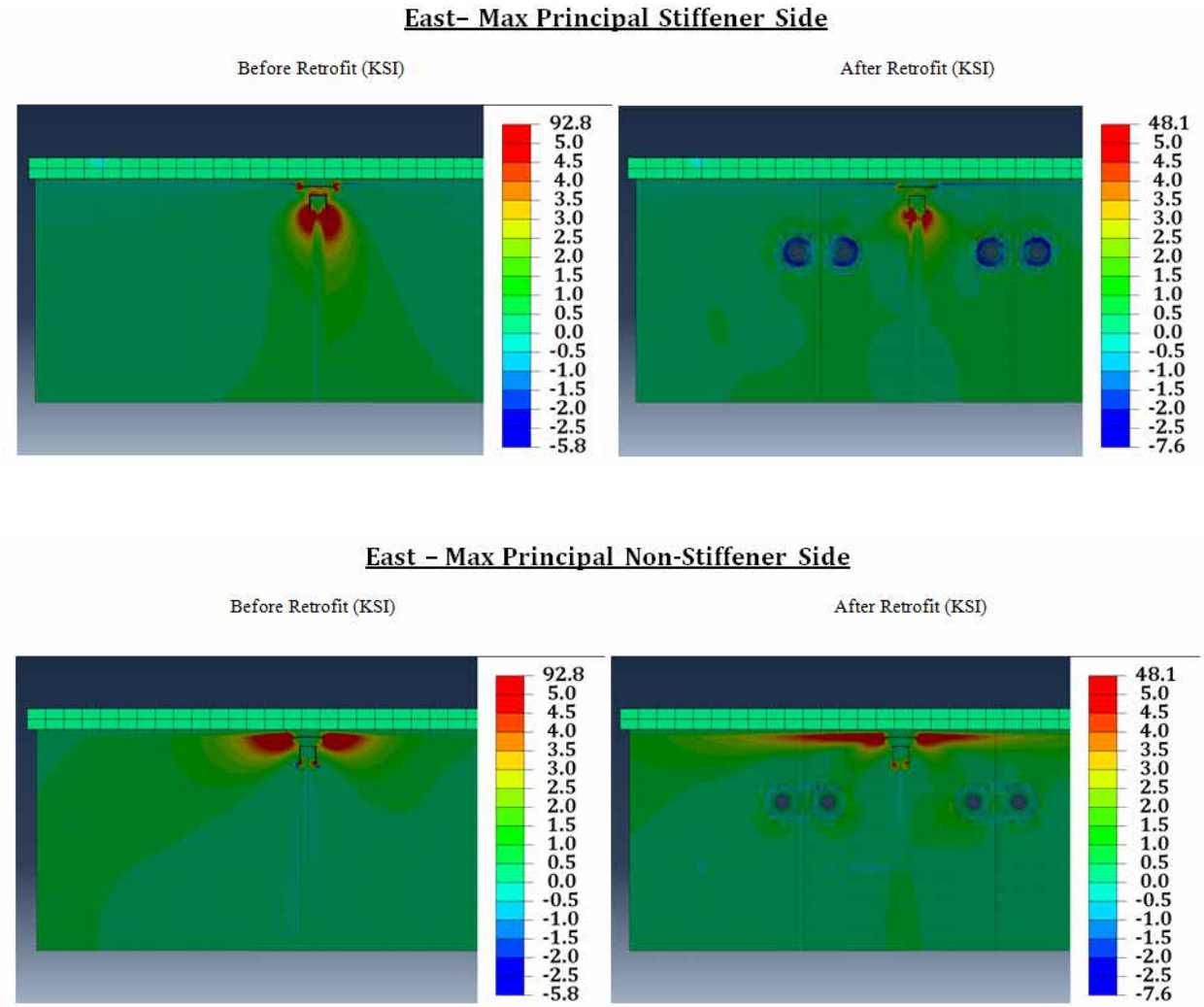


Figure D. 13: Maximum Principal Stresses at Top Web Gap for All Load Truck Placements with Only Connection Plate-To-Web Weld Crack Present.

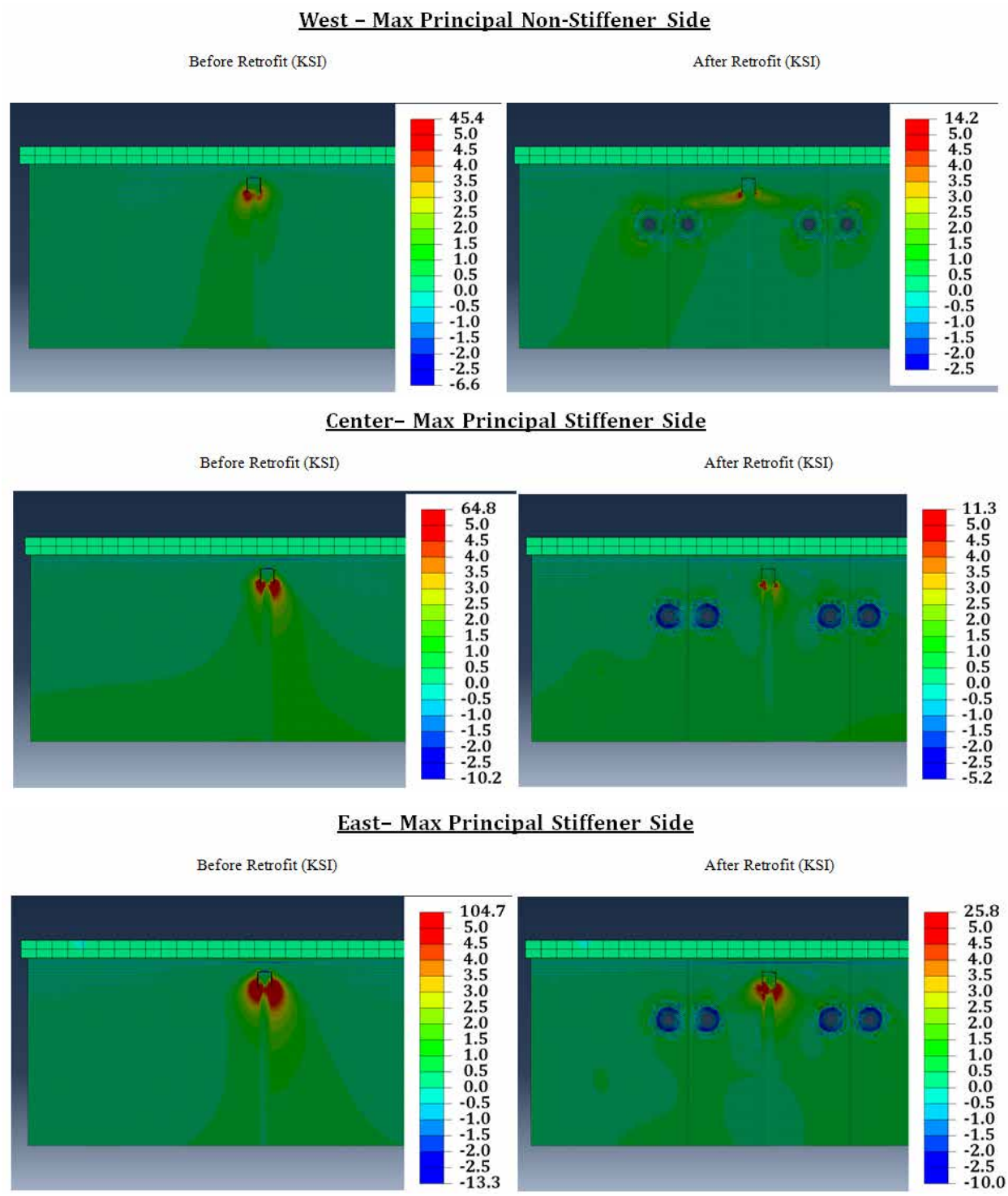
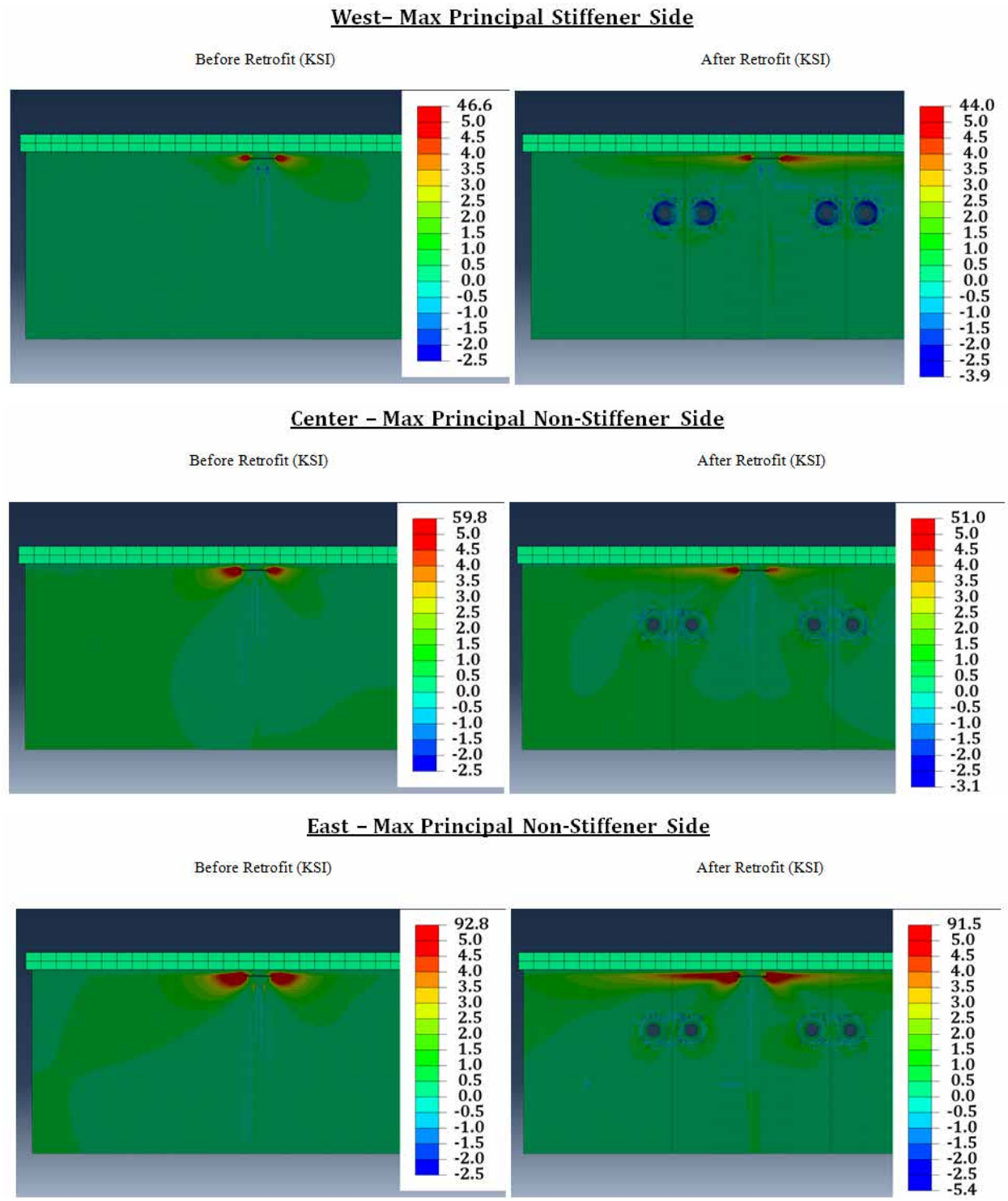


Figure D. 14: Maximum Principal Stresses at Top Web Gap for All Load Truck Placements with Only Flange-To-Web Weld Crack Present.



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