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LOAD TEST OF THE BRIDGE ON OLD US-27 OVER HOLDEN CREEK, IN CLINTON COUNTY (B02-19031)

Report submitted to

The Michigan Department of Transportation

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Testing and Research Section
Construction and Technology Division
Research Project No. RC-1388

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16. Abstract

This Report documents the load tests performed on Bridge ID #B02-19031, carrying old US-27 over Holden Creek, In Clinton County. The objective of the load test was to verify the effect of a strengthening with carbon fibers on the behavior of a reinforced concrete deck slab. The tests were carried out prior to strengthening, on July 7, 2000, and after application of carbon fibers, on August 22, 2000. Carbon fiber reinforced polymer (CFRP) sheets were glued at the bottom of the deck slab to strengthen concrete in tension. The strains at the bottom of the slab and deflections were measured to find the effect of strengthening.

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1. INTRODUCTION

This Report documents the load tests performed on Bridge ID #B02-19031, carrying OLD US-27 over Holden Creek, in Clinton County. The bridge was selected by the Michigan DOT. The objective of the load test was to verify the effect of strengthening with carbon fibers on the behavior of a reinforced concrete deck slab. The tests were carried out prior to strengthening, on July 7, 2000, and after application of carbon fiber sheets, on August 22, 2000. Carbon fiber reinforced plastics (CFRP) sheets were glued at the bottom of the deck slab to strengthen concrete in tension. CFRP sheets were glued in strips in the longitudinal direction of the slab.

The load was applied in form a three axle truck, weighing about 170 kN. Strains were measured using strain transducers and deflections were measured using LVDT's and an optical (laser-based) device by Noptel. The strain transducers were attached to the bottom surface of the concrete slab. After the carbon fiber sheets were glued, some of the strain transducers were also attached to the surface of the carbon sheets, while others were attached to the concrete surface between the sheets. During the tests on July 7 and August 22, exactly the same truck was used and it was positioned in the same locations. Gages for strain and deflection measurements were also placed at exact the same location for pre and post testing.

2. CFRP APPLICATION DESCRIPTION

Application of carbon sheets to B02 of 19031

Master Builders materials used:

Mbrace CF130 carbon sheet, 508 mm wide

Mbrace Primer

Mbrace Saturant

Concresive 1490

Mbrace Topcoat ATX

Sequence of carbon sheet application:

July 5, 2000 – Location of five carbon sheet strips, centered in slow lane of southbound, old US 27 was marked on underside of bridge deck.

July 13, 2000 - Concrete fins and protrusions in carbon sheet locations were ground smooth.

July 14, 2000 – Concrete area at carbon sheet location was cleaned by water blasting using 21 MPa pressure.

July 18, 2000 - Mbrace Primer was applied to concrete.

July 19, 2000 – Concrete depressions were filled with Concresive 1490.

July 20, 2000 – Five carbon sheet strips were placed on the underside of bridge. Each strip eas a total of 5.16 m long, centered between abutments. Three pieces of carbon sheet 1.82 m, 1.97 m, and 1.67 m long with two 0.15 m laps comprise each 5.16 m strip. A layer of Mbrace Saturant was placed on the concrete before placing the carbon sheet. The carbon sheet was smoothed to remove air before removing the white backing paper, then rolled with a notched roller. A coat of Mbrace Saturant was placed on the carbon sheet.

July 27, 2000 – Carbon sheets were top coated with gray, acrylic paint after one week of saturant curing.

3. TEST DESCRIPTION

The tested bridge is located on Old US-27 over Holden Creek, in Clinton County, Michigan. The span length is 7.62 m, with no skew, and the total width of the bridge is 28.8 m. The bridge was originally built in 1923, and widened in 1932, and again in 1949. The tested span was built in 1932, with 510 mm thick slab. The width of the tested span is 9 m.

Prior to the installation of the CFRP sheets, a bridge test was performed on July 7, 2000. The test was repeated on August 22, 2000, after the installation of CFRP sheets, to determine the effect of the CFRP sheets. The test performed on July 7, 2000 is denoted by "PRE" test, and the test on August 22, 2000 is denoted by "POST" test in this study.

The test truck, which weighs about 170 kN, used in both tests, was provided by the University of Michigan Transportation Research Institutes (UMTRI). The gross vehicle weight and the truck axle configuration are shown in Figure 1.

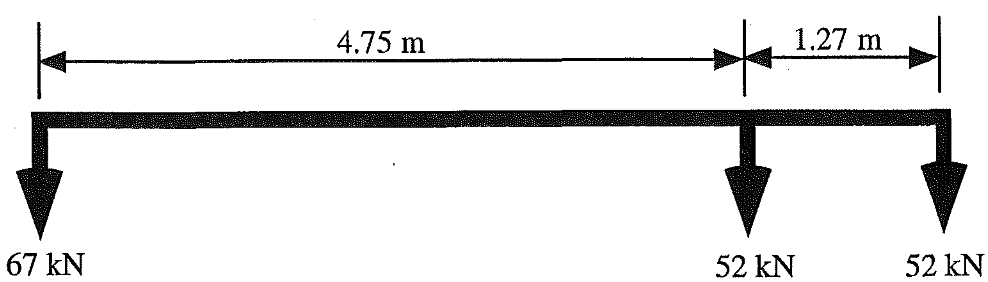


Figure 1. Truck Load Configuration.

4. INSTRUMENTATION

Strain transducers were attached to the bottom surface of the deck slab at midspan, and close to the supports. Linear Variable Differential Transformers (LVDT's) were installed to measure deflections at the midspan (Figure 2), and at quarter point of the span. Figure 5 shows the detail of the testing equipment. Ten strain transducers (Figures 3 and 4) were used (numbered from 1 to 10) and they were placed so that during the second test, any odd number was located on the CFRP sheet strips after strengthening. During the first test, the odd numbers were placed in the same positions, but on the concrete surface.

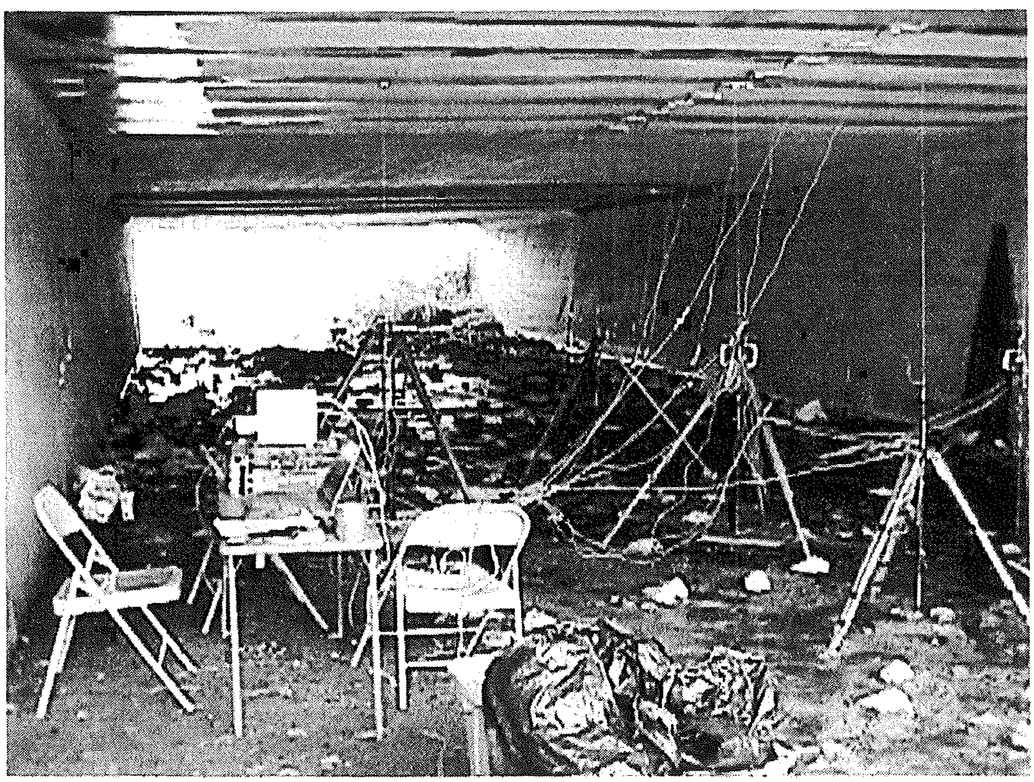


Figure 2. LVDT's installed in the midspan.

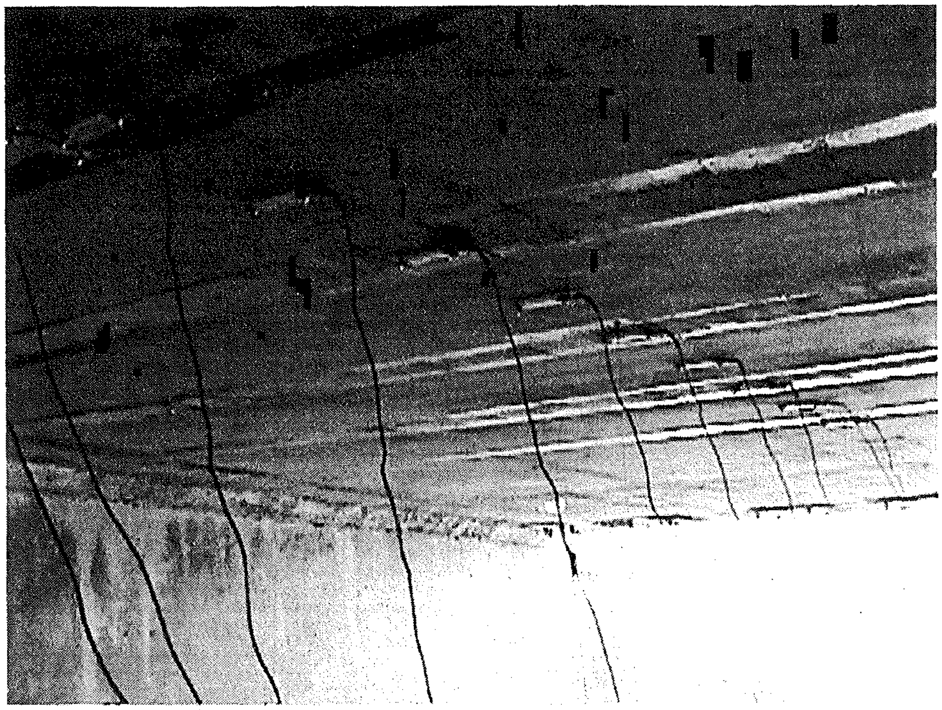


Figure 3. Strain transducers installed at the midspan.

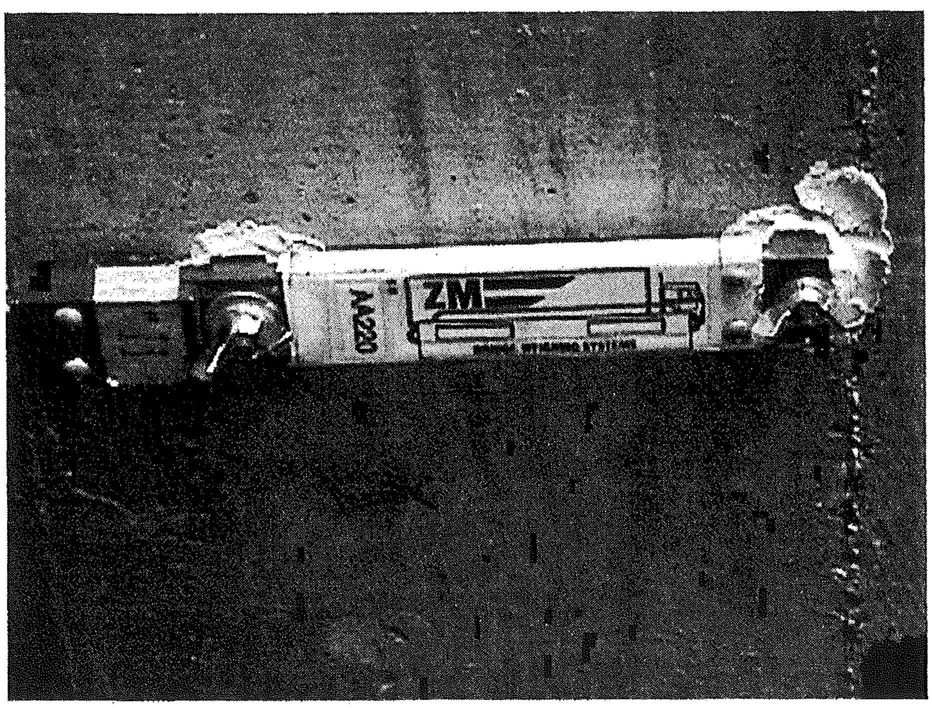


Figure 4. The strain transducer attached to the concrete surface.

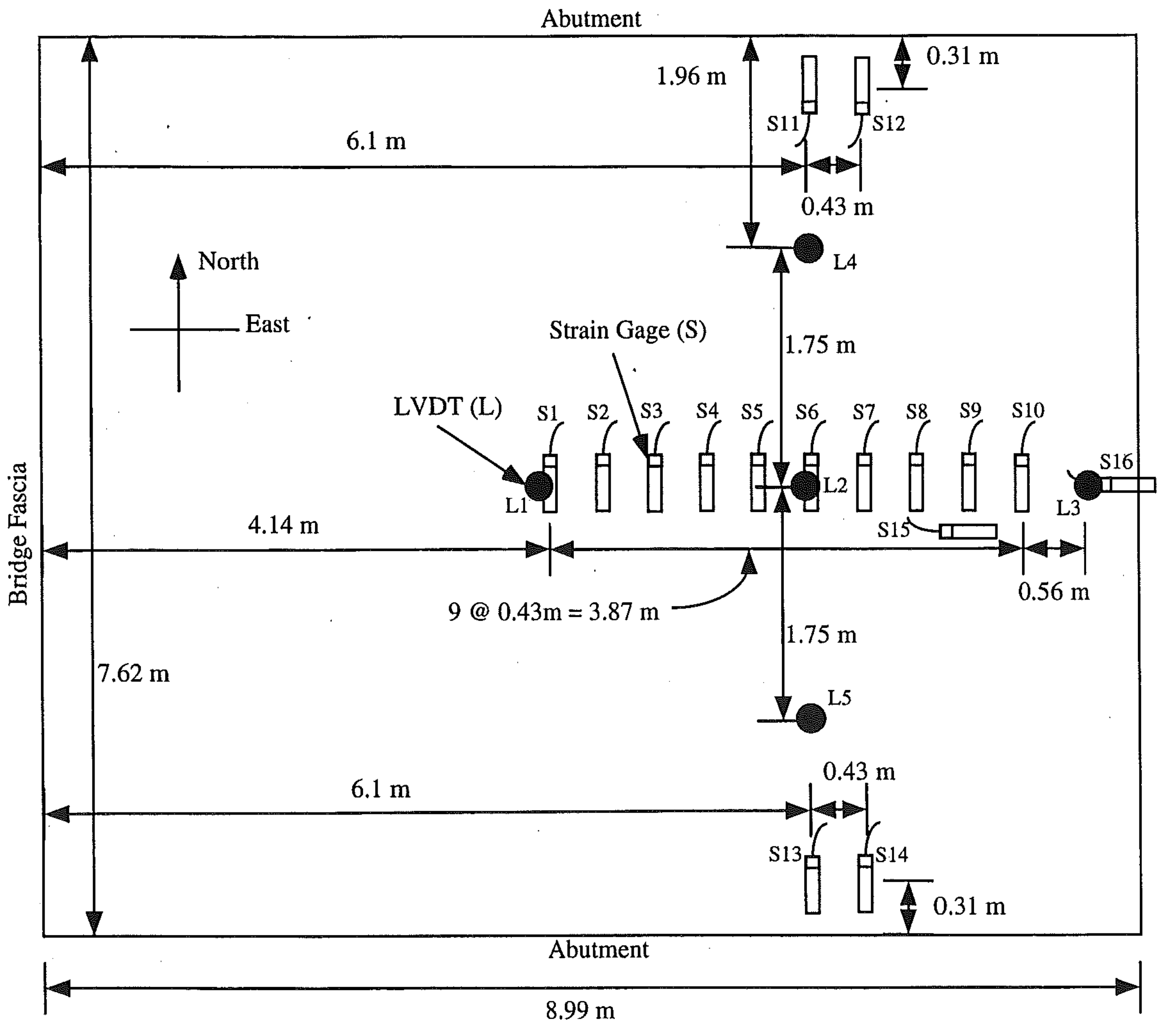


Figure 5. Location of the Strain Gages and LVDT's.

5. LOAD CASES

The total of 5 different runs were considered. For run 1 to 4, trucks were positioned at predetermined locations statically. For each static run, two load cases were considered. First, the center of the rear axles was positioned at the midspan (load case A), and then the front axle was located at the midspan (load case B). The different transverse positions are shown in Figure 6. For run 5, the truck was driven in the center of the traffic lane at 30 mph, which is a normal traffic speed at that location.

The truck positions were exactly the same for the two bridge tests, on July 7 and August 22..

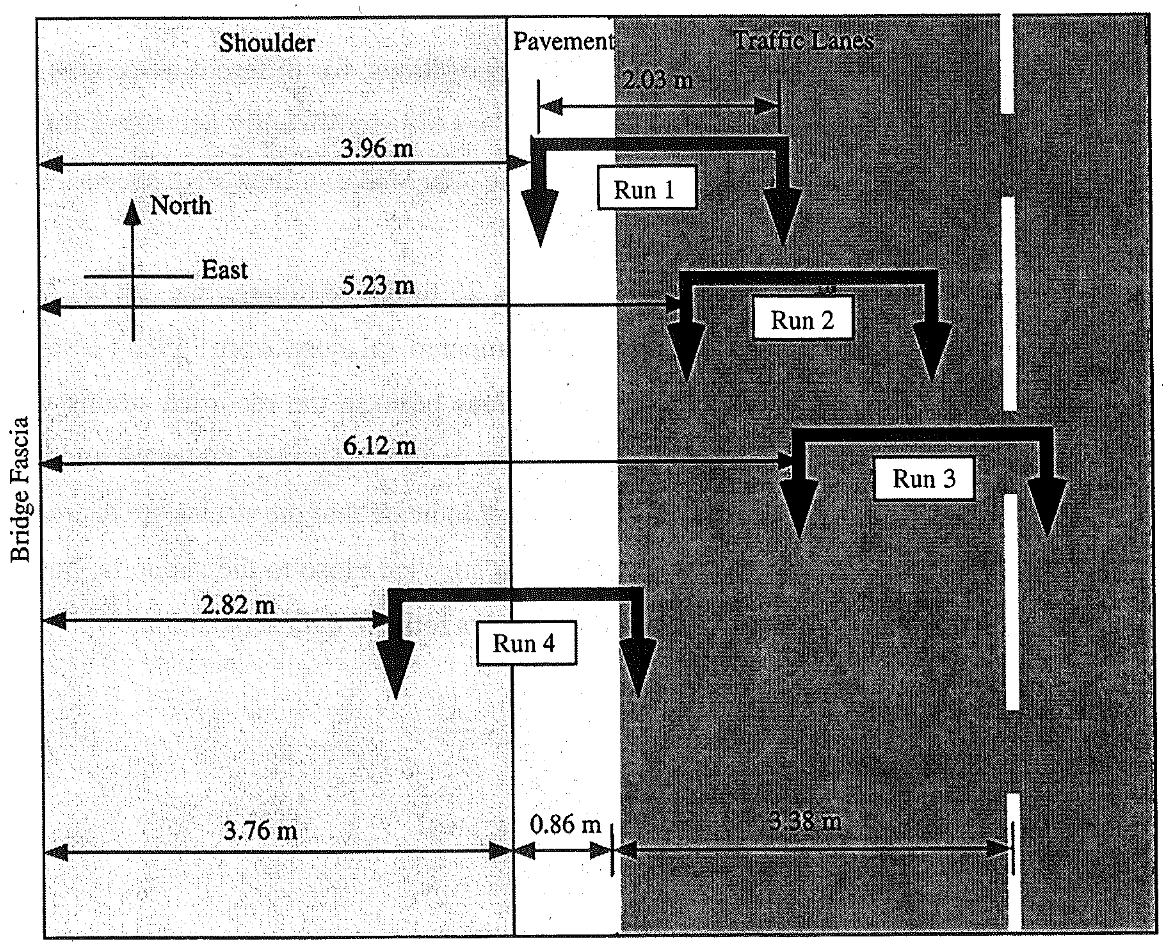


Figure 6. Location of the Truck Load, Runs 1 – 4.

6. TEST RESULTS

The measured strains and deflections are shown in graphical format (Figures 7 to 33). Position A corresponds to the center of rear axles placed at the midspan of the bridge, and position B corresponds to the front axle placed at the midspan.

Deflections are shown in Figures 7 to 15, for different transverse and longitudinal load positions, for static and regular speed tests. The locations of the LVDT's are shown in Figure 5. As can be seen in the figures, deflection values are significantly decreased for the "POST" test compared to the "PRE" test, due to the attachment of the CFRP sheets, even considering the slight load positioning error for two separate bridge tests.

Figures 16 to 24 present the longitudinal deflections, for different transverse and longitudinal load positions. Again, deflection values are significantly decreased for the "POST" test compared to the "PRE" test, due to the attachment of the CFRP sheets.

The resulting strains are shown in Figures 25 to 33. Although the "POST" test results show some reduction in strain values compared to those from "PRE" test, the strain values are not as reliable as deflection values because the recorded strains were very small, in relation to the accuracy of the reading device. However, the peaks and lows in the strain values recorded during the "POST" test indicate that the strains are decreased on the CFRP sheets. Strain transducers were also attached close to the supports, but the magnitudes of the readings were too small to ensure a reliable data acquisition.

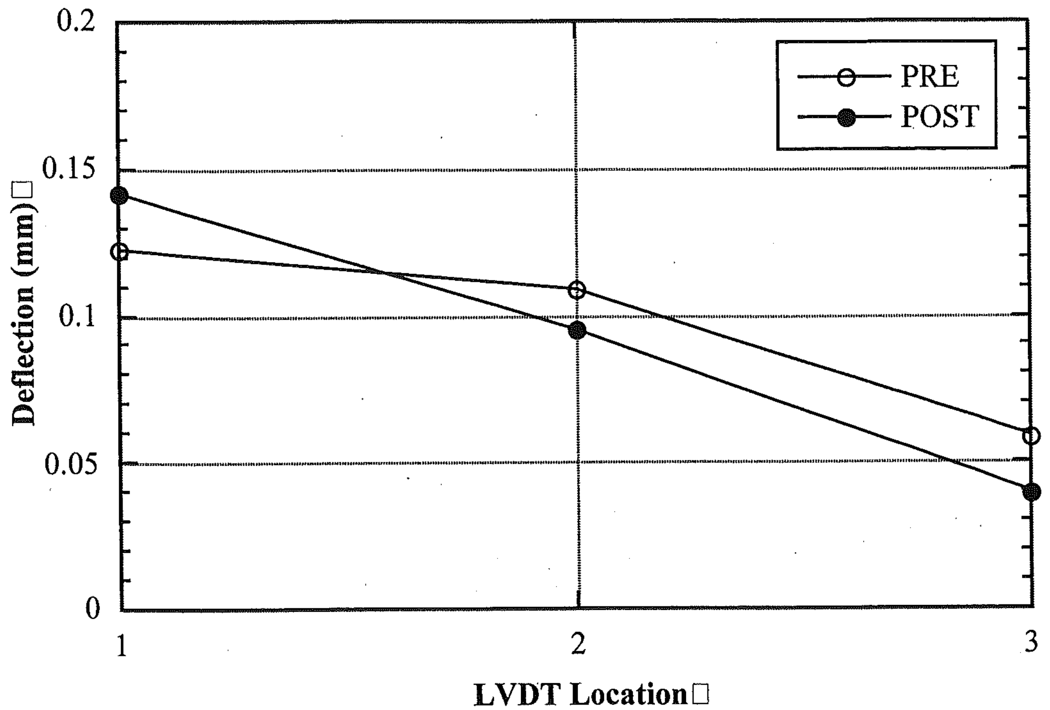


Figure 7. Transverse Deflection, Run 1A

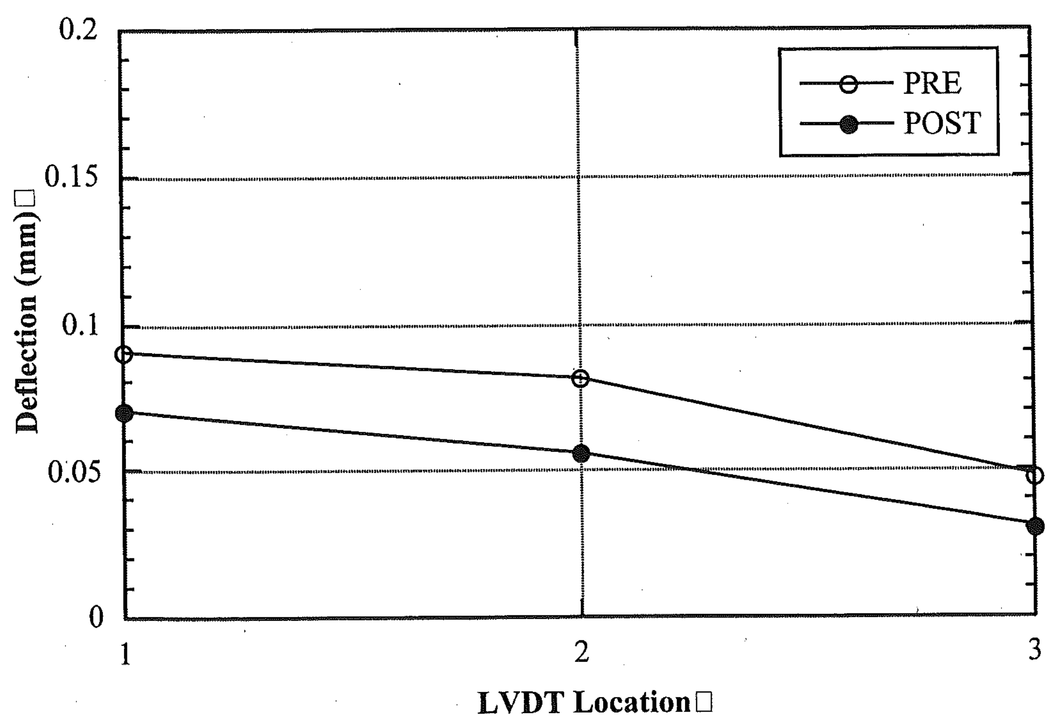


Figure 8. Transverse Deflection, Run 1B

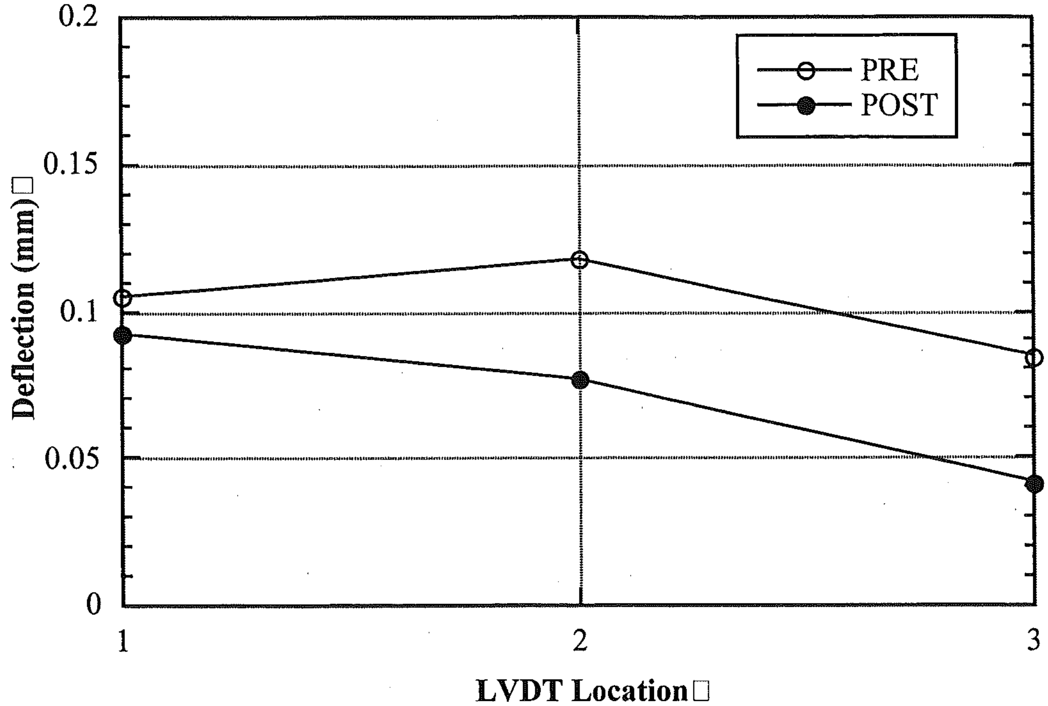


Figure 9. Transverse Deflection, Run 2A

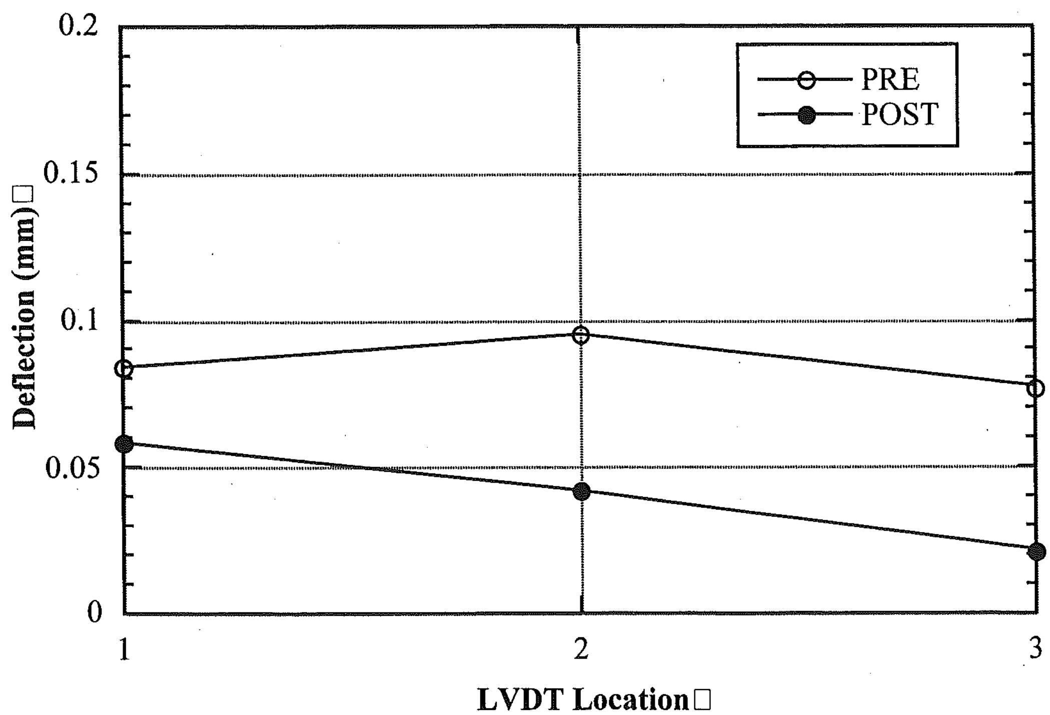


Figure 10. Transverse Deflection, Run 2B

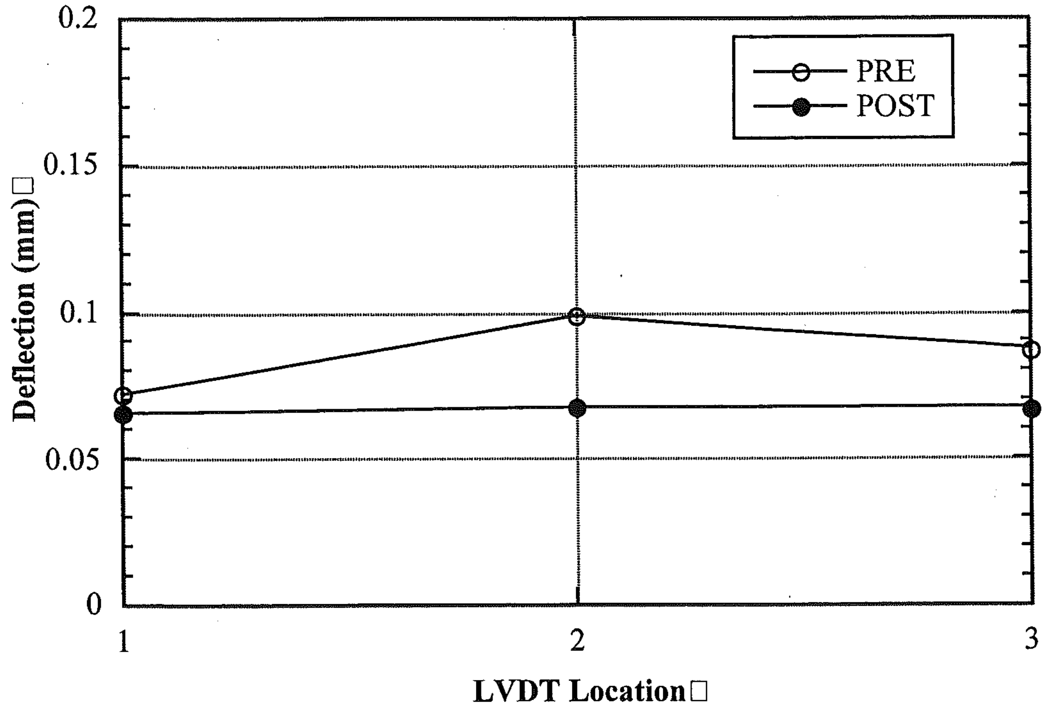


Figure 11. Transverse Deflection, Run 3A

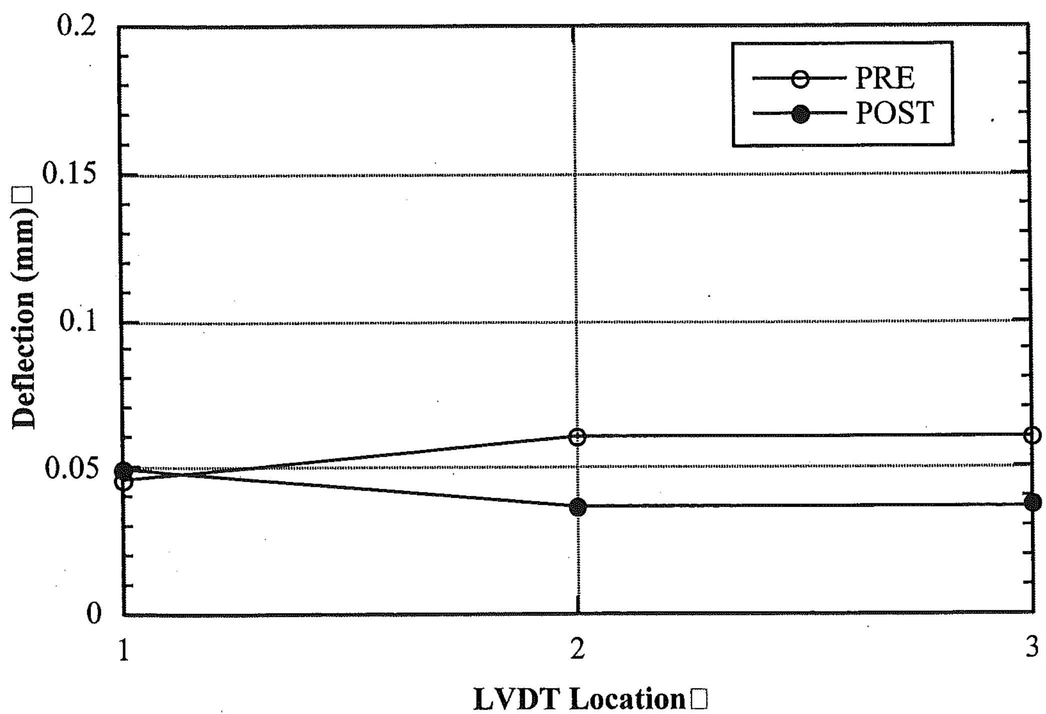


Figure 12. Transverse Deflection, Run 3B

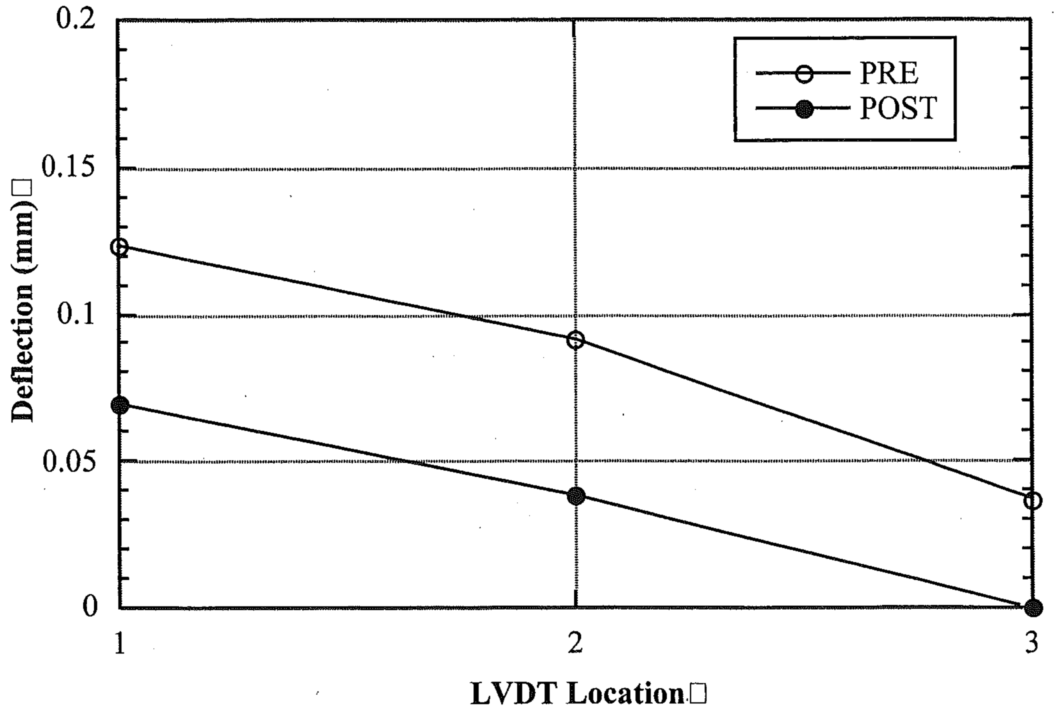


Figure 13. Transverse Deflection, Run 4A

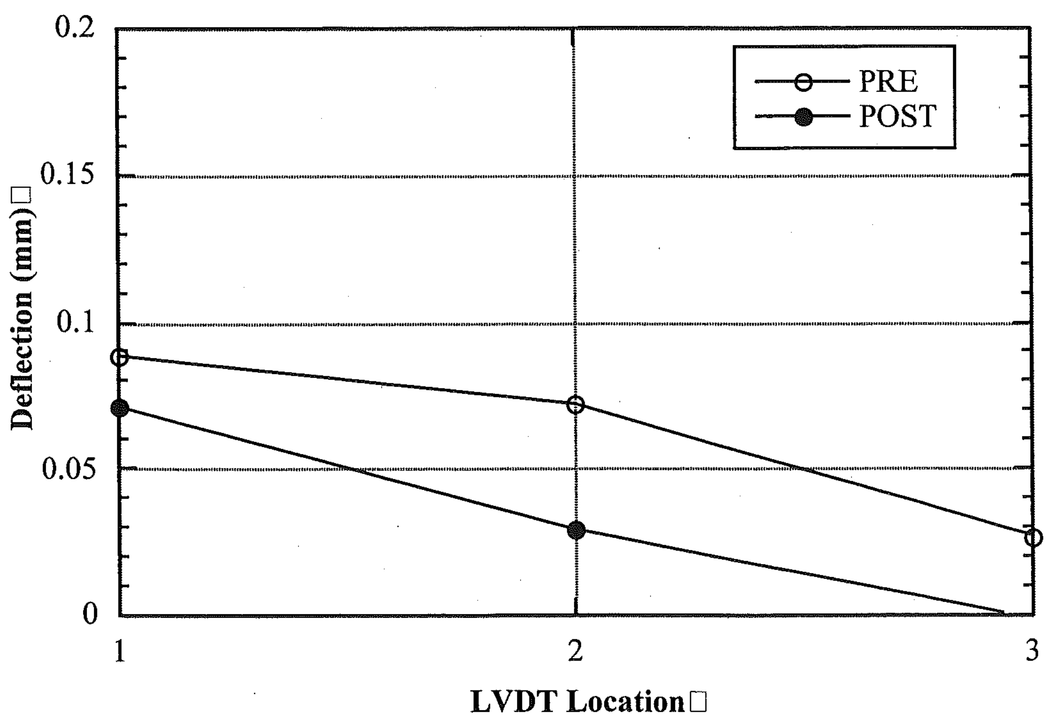


Figure 14. Transverse Deflection, Run 4B

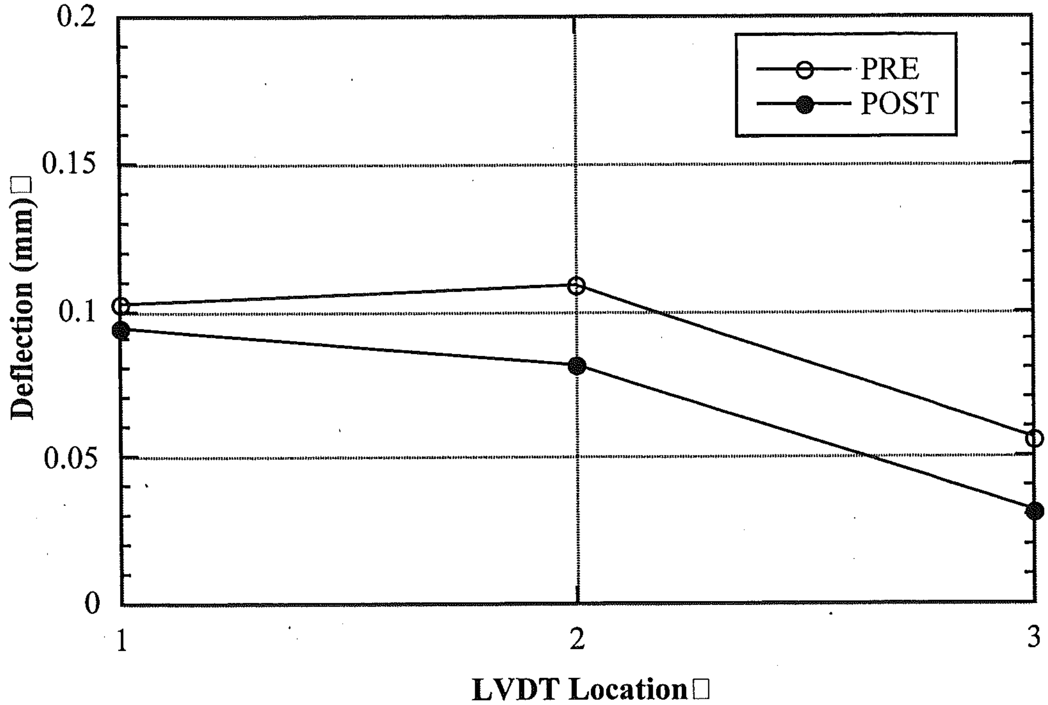


Figure 15. Transverse Deflection, Run 5

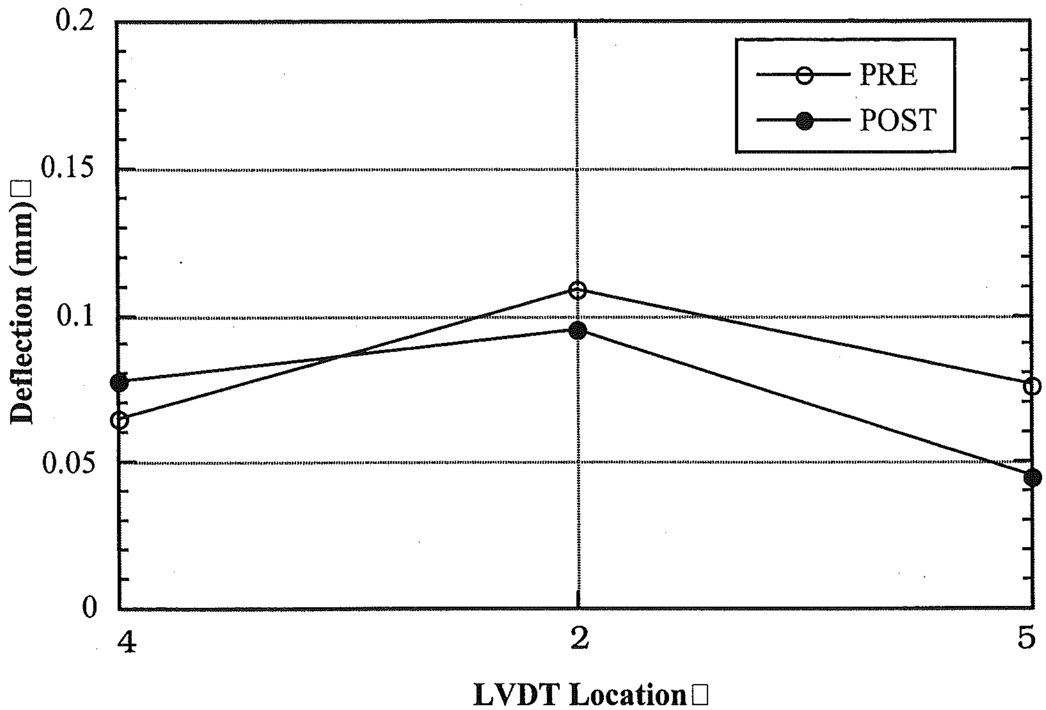


Figure 16. Longitudinal Deflection, Run 1A

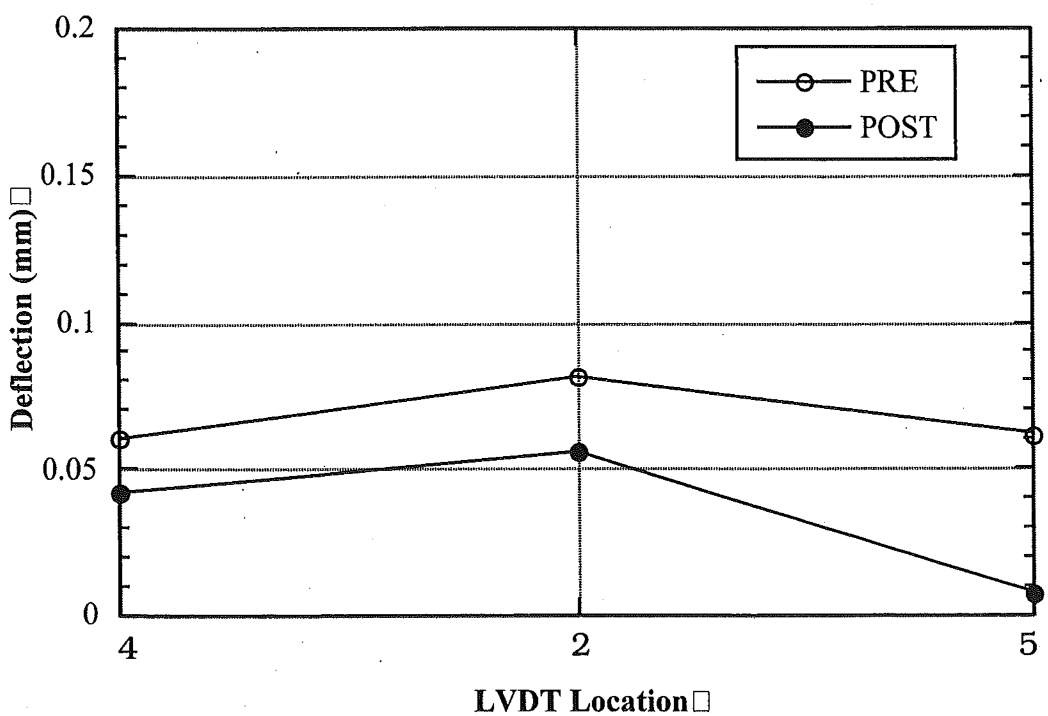


Figure 17. Longitudinal Deflection, Run 1B

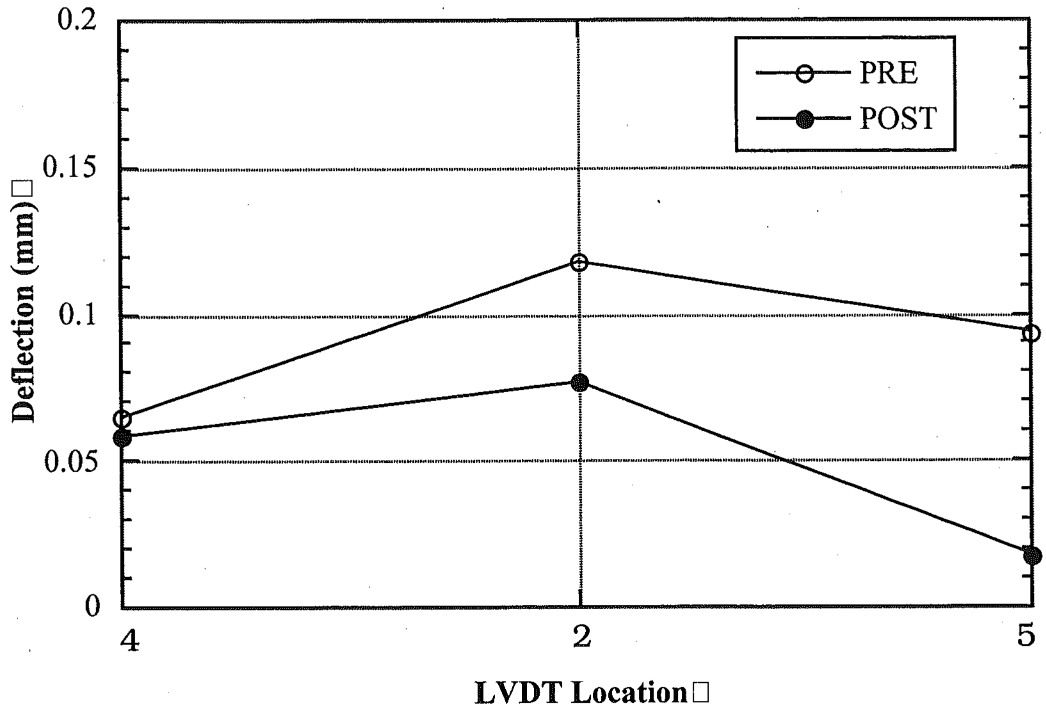


Figure 18. Longitudinal Deflection, Run 2A

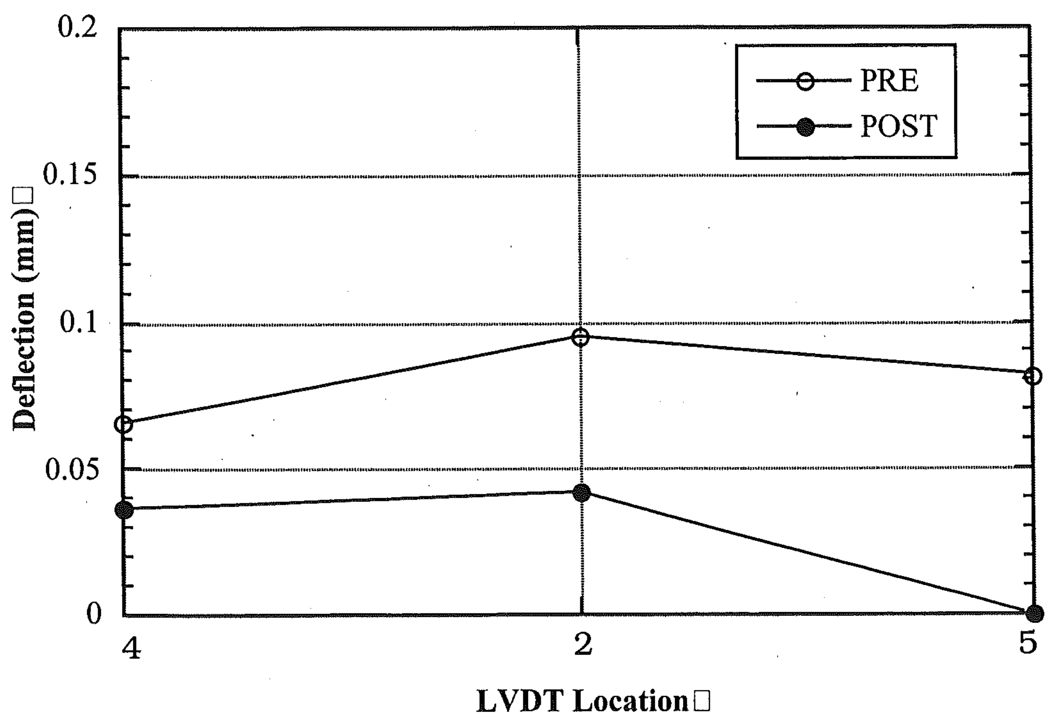


Figure 19. Longitudinal Deflection, Run 2B

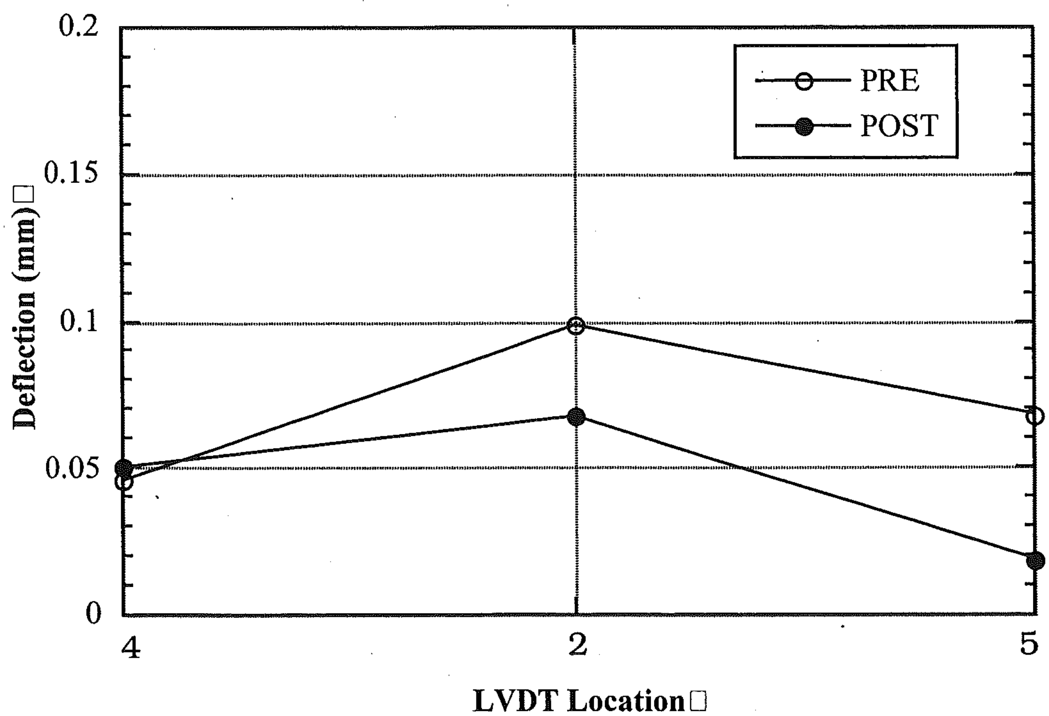


Figure 20. Longitudinal Deflection, Run 3A

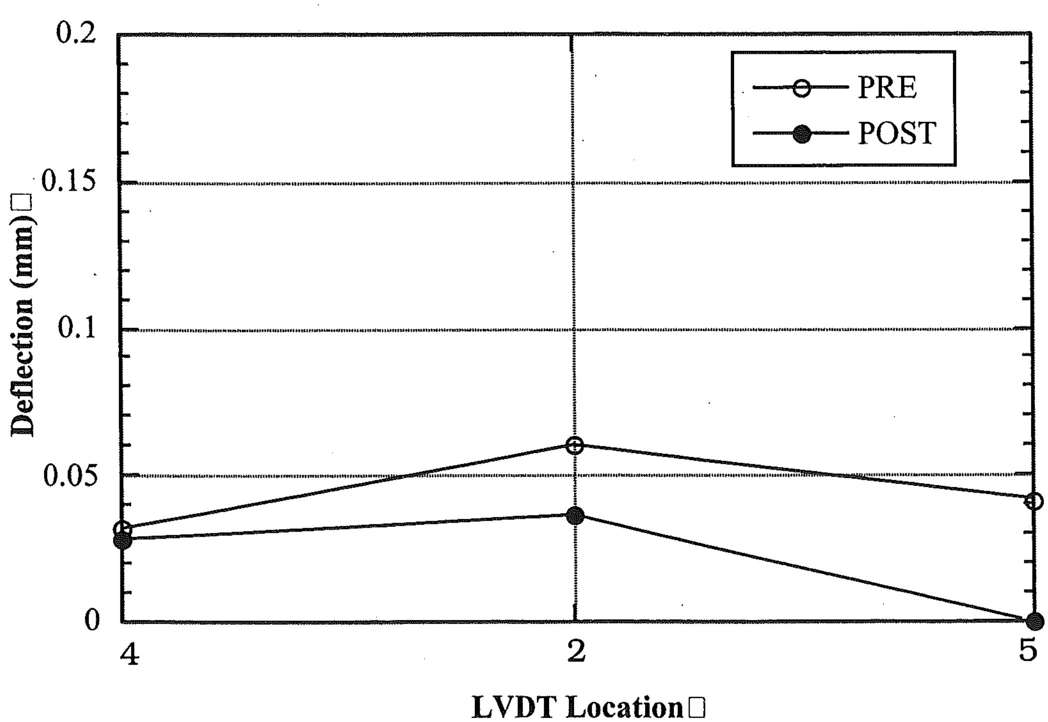


Figure 21. Longitudinal Deflection, Run 3B

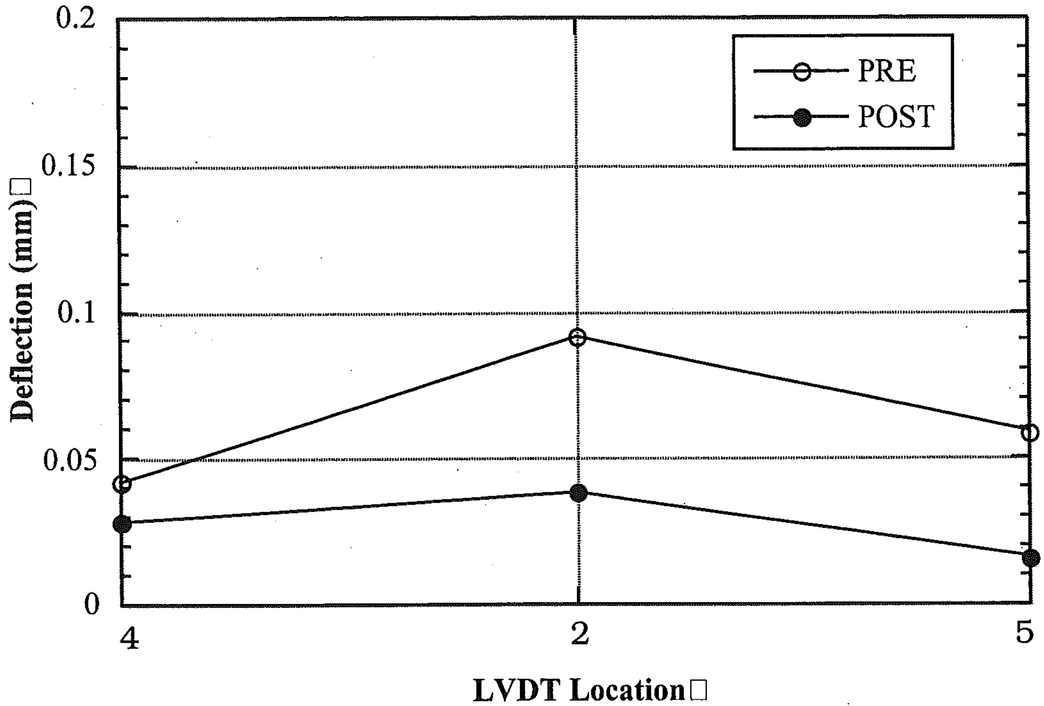


Figure 22. Longitudinal Deflection, Run 4A

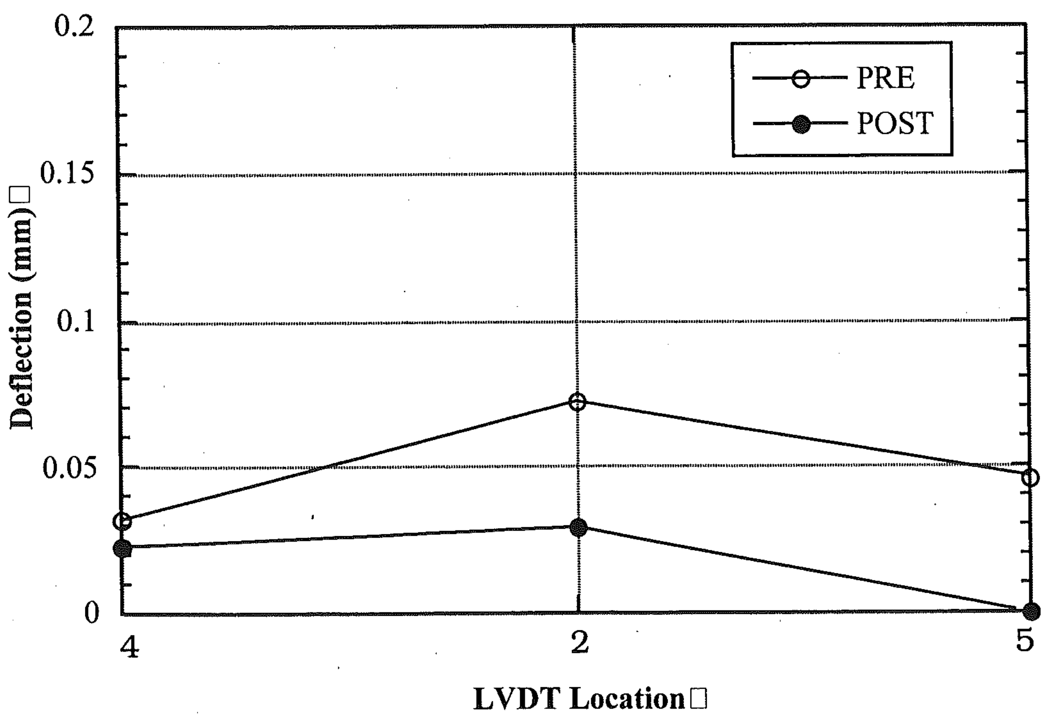


Figure 23. Longitudinal Deflection, Run 4B

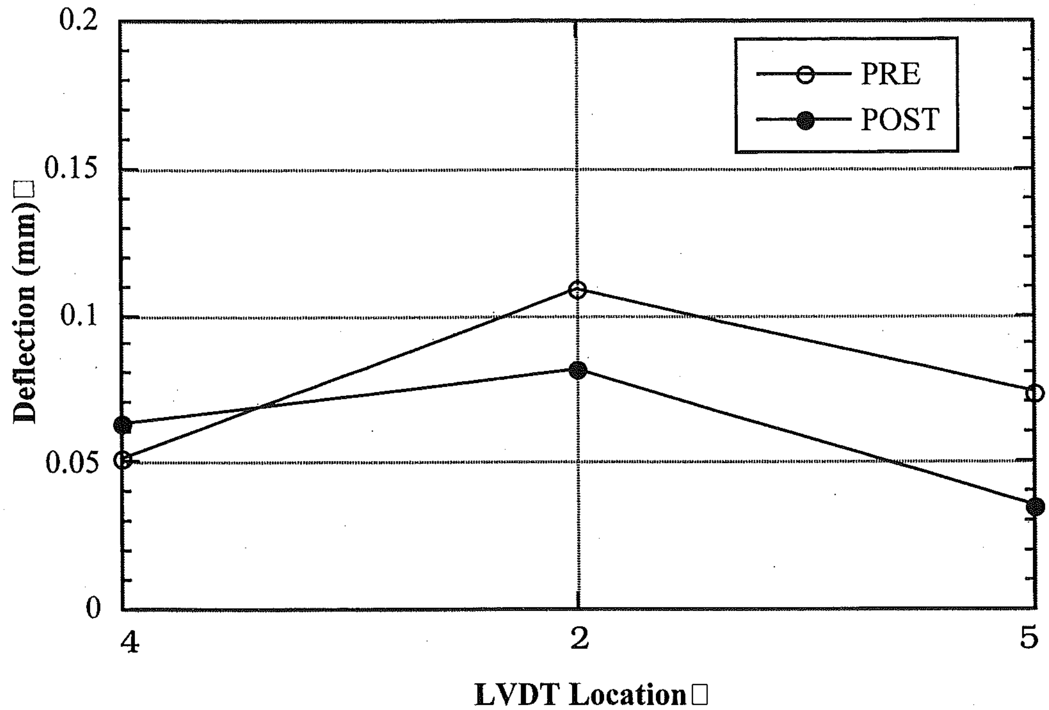


Figure 24. Longitudinal Deflection, Run 5

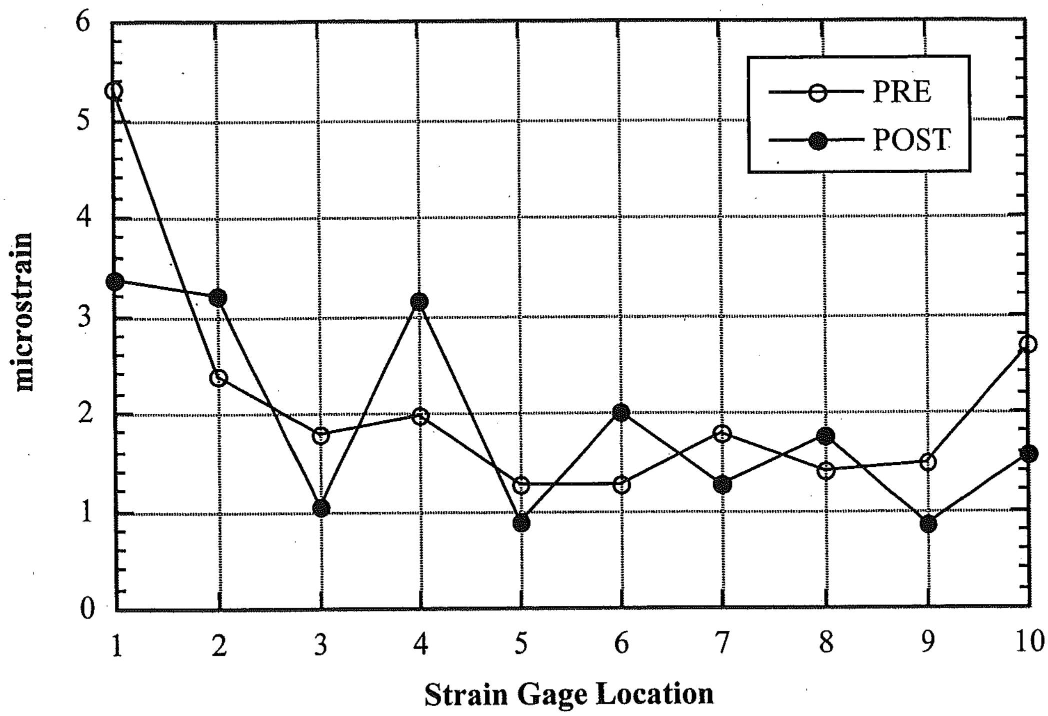
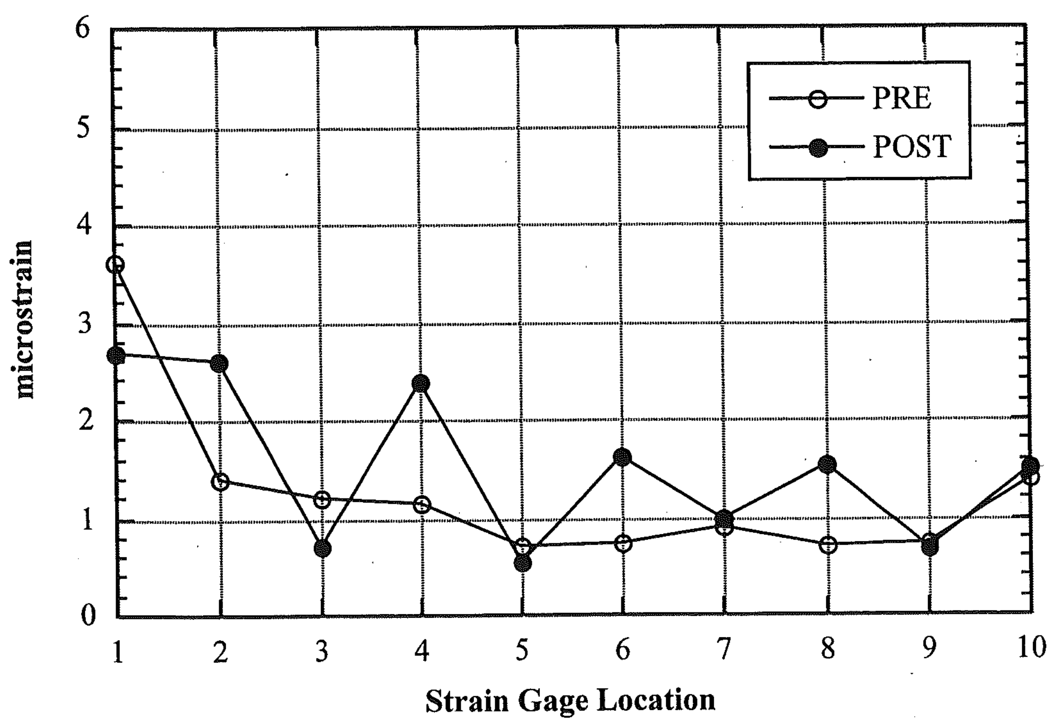


Figure 25. Strain, Run 1A



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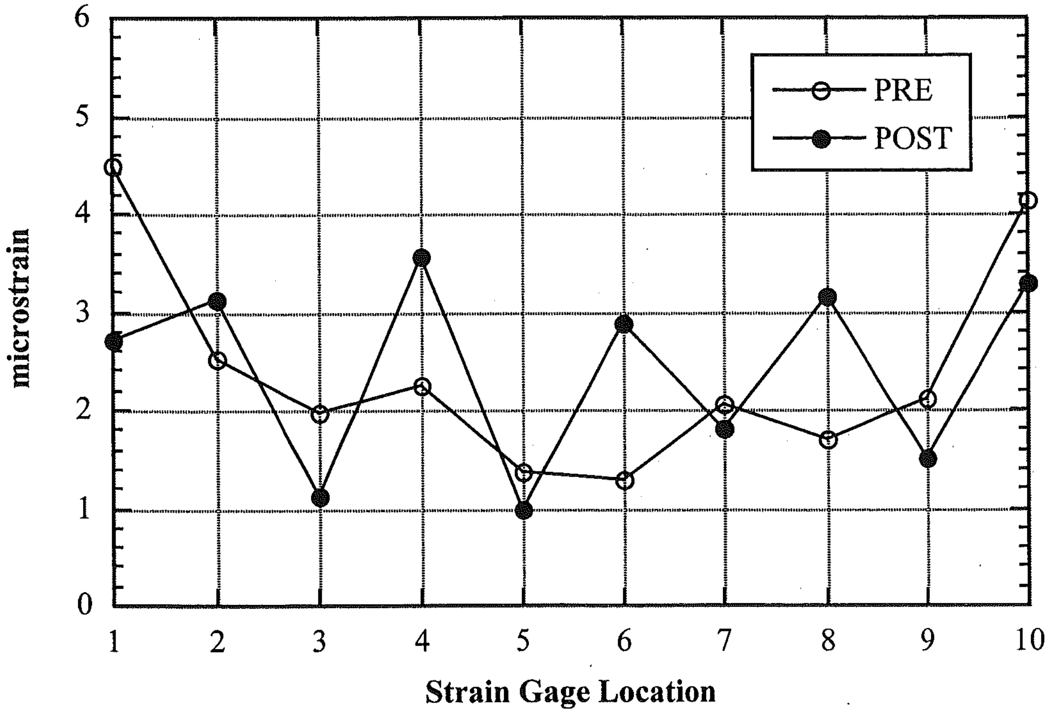

Figure 27. Strain, Run 2A

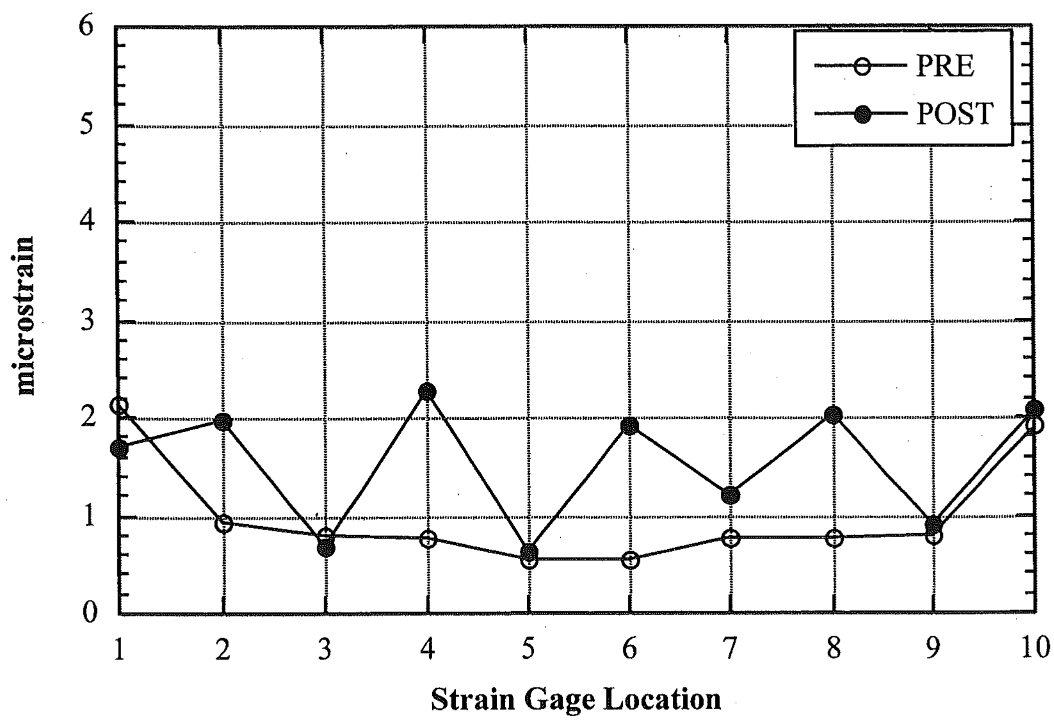

Figure 28. Strain, Run 2B

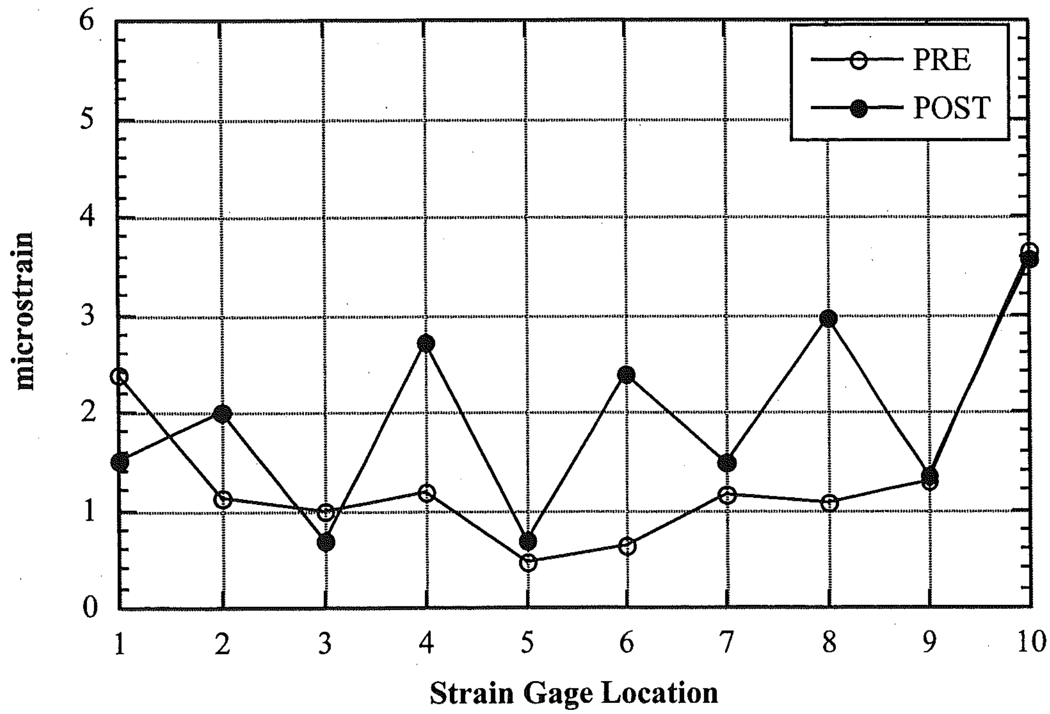

Figure 29. Strain, Run 3A

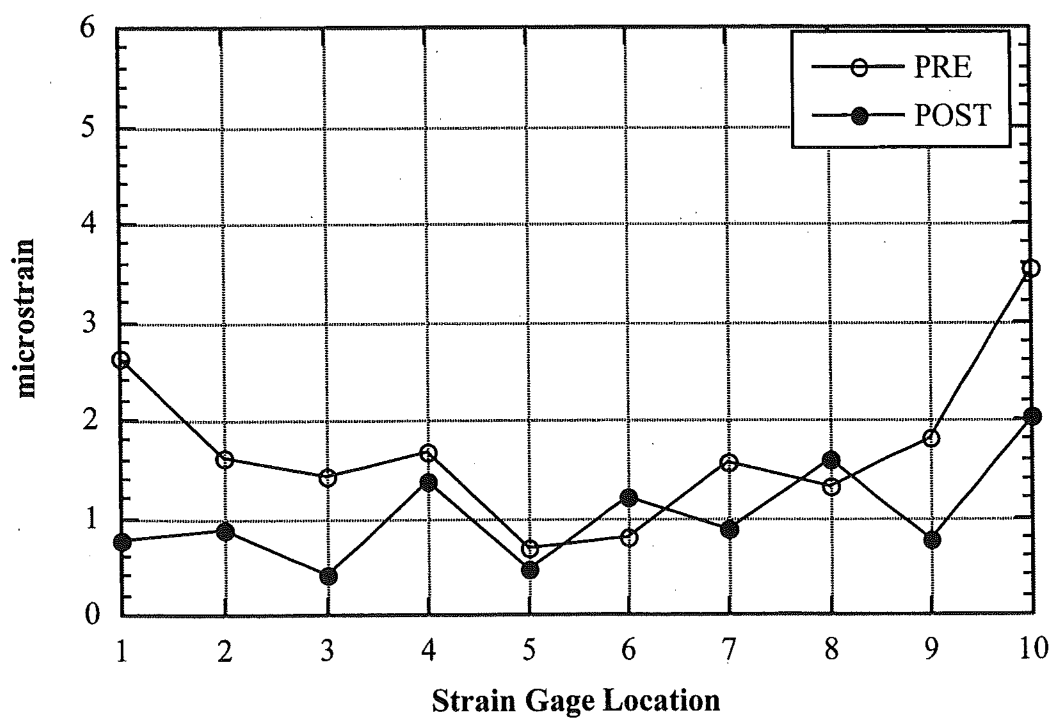

Figure 30. Strain, Run 3B

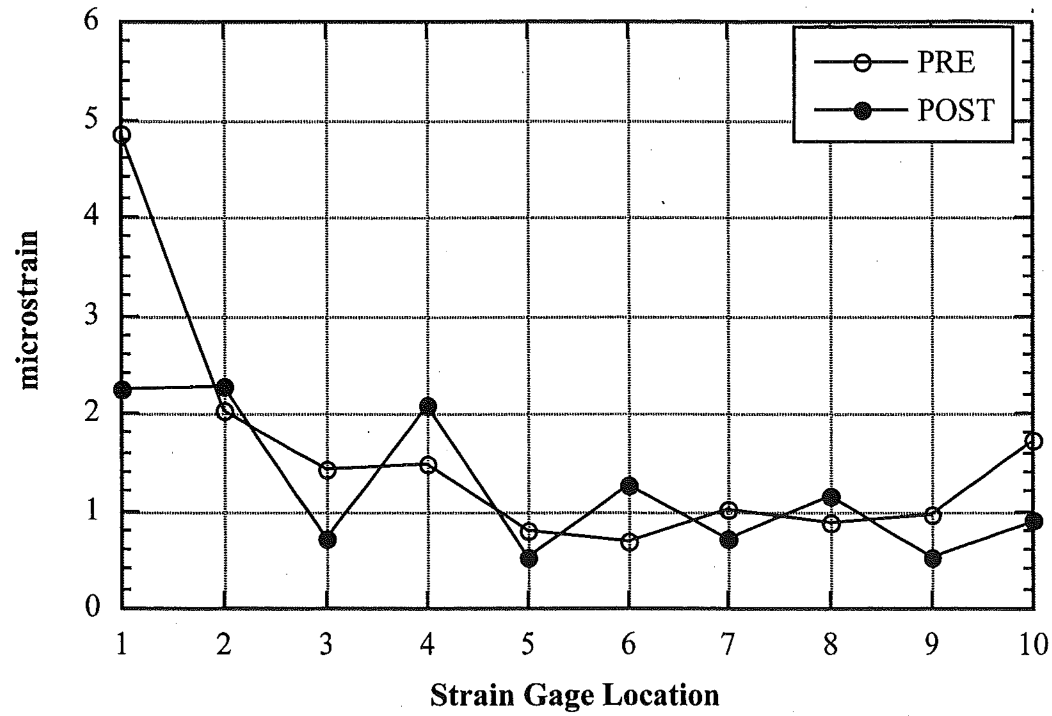

Figure 31. Strain, Run 4A

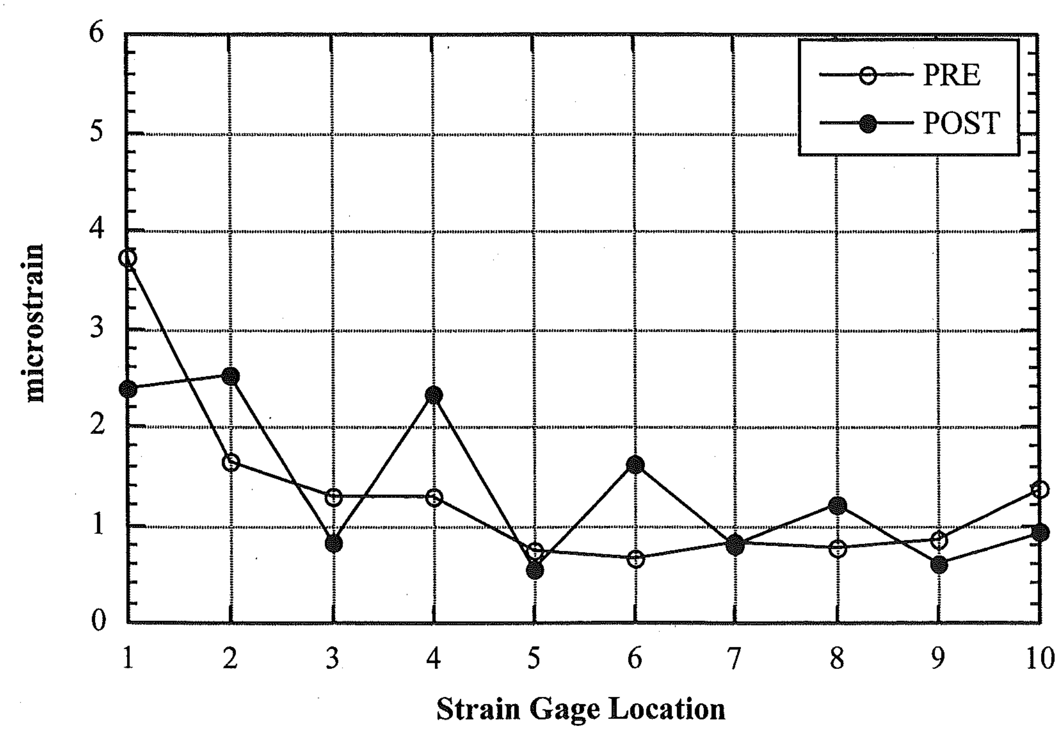

Figure 32. Strain, Run 4B

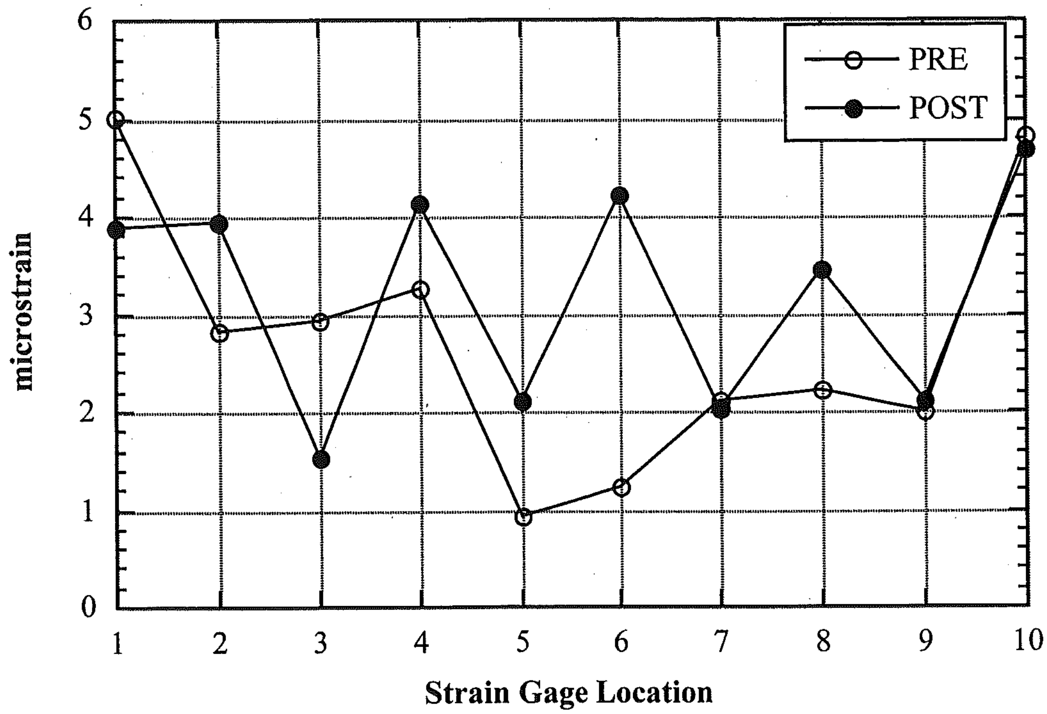

Figure 33. Strain, Run 5

7. CONCLUSIONS AND RECOMMENDATIONS

The test results indicate that there is a significant effect of strengthening using CFRP laminates on the behavior of concrete deck slab. Strains measured on the bottom surface of the slab on the CFRP strips are lower than those measured directly on the concrete surface under the same load (the second test). Also, strains measured in the same location on the concrete slab before (the first test) and after strengthening (the second test) on CFRP strips differ; the strains measured on CFRP strips are lower.

The test results show, that CFRP sheets glued to the concrete surface perform as a composite section and they do share the load as expected from design. Smaller deflection measured in location where CFRP strips were glued compared with that measured in locations where concrete was not strengthened confirms the beneficial effect of the CFRP strengthening method. The average decrease in deflection for all data points (longitudinal and transversal deflection) was about 30-40%.

The load test was performed on a structure with a considerable stiffness. Therefore, the measured strains and deflections were very low. This makes it difficult to compare the results of prior and post tests. It is recommended in the future to select another bridge, with a lower stiffness compared to the applied load effect or to use heavier truck/tank, so that the effect of strengthening with fibers can be more visible.

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Enroll Total: 16 Class Nbr: 1836
Enroll Cap: 20
Class Meeting Nbr: 1
Instructor: Nowak,Andrzej S Location: 2355 GGBL
Meeting Time: 02:30 PM - 04:00 PM Meeting Days: Monday Wednesday

ID	Name	Units	Level	Career	Prim Prog	Enrl Stat	Uniqname	ULWR			Enrl Date		
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