

Final Report

**PERFORMANCE-RELATED SPECIFICATIONS OF CONCRETE
BRIDGE SUPERSTRUCTURES**

FHWA/IN/JTRP-2001/8

Volume 4

Bond of Epoxy-Coated Bars with Thicker Coatings

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16. Abstract In Volume 4 of the final report, the results of an evaluation of the bond performance of epoxy-coated bars with a coating thickness up to 18 mils are presented. The experimental work on the bond performance of epoxy-coated bars with thickness up to 18 mils indicates that the current AASHTO requirements for development length of epoxy-coated bars up to #8 could be safely extended to coating thickness of up to 18 mils. Thus, no change to the bond specifications is recommended in order to implement the use of bars with diameters up to a #8 with epoxy-coating thickness up to 18 mils.					
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1. INTRODUCTION

The thickness of the epoxy on the reinforcing bars was specified to be between 6 to 12 mils in INDOT's 1999 Standard Specifications, and currently, the epoxy thickness is to be between 8 and 13 mils (INDOT, September 2002). By increasing the upper limit of thickness to 18 mils, it has been found that the number of defects during construction decreases by approximately 50% (Samples, 2000). It has been suggested that increasing the epoxy thickness could decrease the bond strength between the reinforcing steel and the concrete (Samples, 2000). The focus of this task is to investigate the possibility of decreased bond performance due to thicker epoxy coatings. Deflections and cracking will be investigated since these are also related to the performance of the structure.

2. TEST PROGRAM

Three series of beams, A, B, and C, were tested. Series A was tested statically and Series B and C were tested under repeated loading. The detailed results of Series are available in Appelkans (2002). Table 2.1 summarizes the characteristics of each Series. The beams in Series A were purposely designed using a splice length well under AASHTO specifications to ensure that the beams would fail in bond. The goal in Series A is to establish differences in bond strength between bars with different coating thicknesses.

The loading schedule for the beams in Series B and C is intended to simulate traffic effects prior to one final cycle to failure. The beams in Series B and C are designed with splice lengths meeting AASHTO specifications. In Series B, the beams were under repeated loading to simulate traffic effects. Each beam was loaded to 1,000,000 cycles. At 100,000 cycle intervals, the testing was stopped to measure crack widths, count the number of cracks, and take photographs. After 300,000 cycles the beams were loaded until 1,000,000 cycles. Upon completion of the repeated loading port statically loaded to failure. The purpose of Series B and C is to find any differences in ultimate capacity, deflection behavior, and number of cracks between the 12 and 18 mil epoxy coated bars. The beam cross-sections and loading patterns were chosen to simulate a typical concrete bridge deck as found in Indiana.

Table 2.1: Specimen Characteristics

Series	Depth (in)	Bar Size	Concrete Strength (psi)	Splice Length (in)	Number of beams (uncoated)	Number of beams (12 mil)	Number of beams (18 mil)
A	8	#5	4000	12-14	2	2	2
B	8	#5	5000	30	-----	2	2
C	16	#8	5000	76	-----	2	2

3. MATERIAL PROPERTIES

Figure 3.1 shows the concrete development strength for Batches 1 and 2 in Series A. Figure 3.2 contains the 28-day development strength for Series B. Note that the actual 28-day strength (5160 psi) is very close to the design value (5000 psi). Figure 3.3 shows the strength gain for the mix used in Series C. Figure 3.4 contains the data for the steel reinforcement.

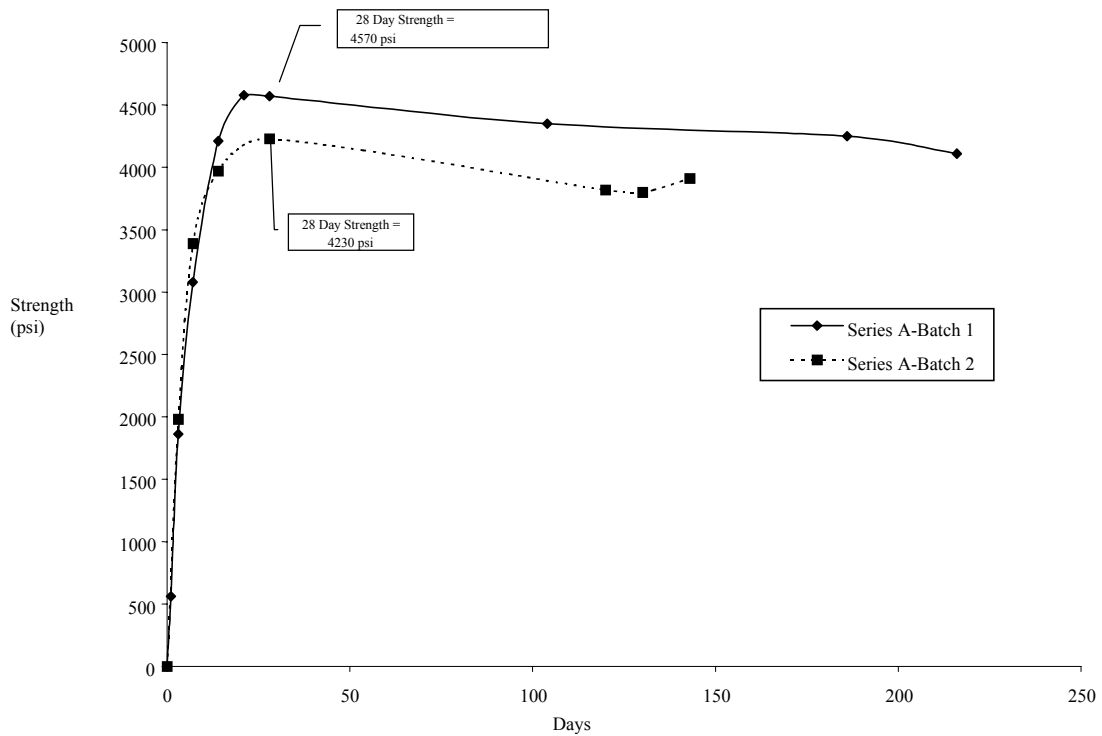


Figure 3.1 Concrete Strength Data for Batches 1 and 2 in Series A

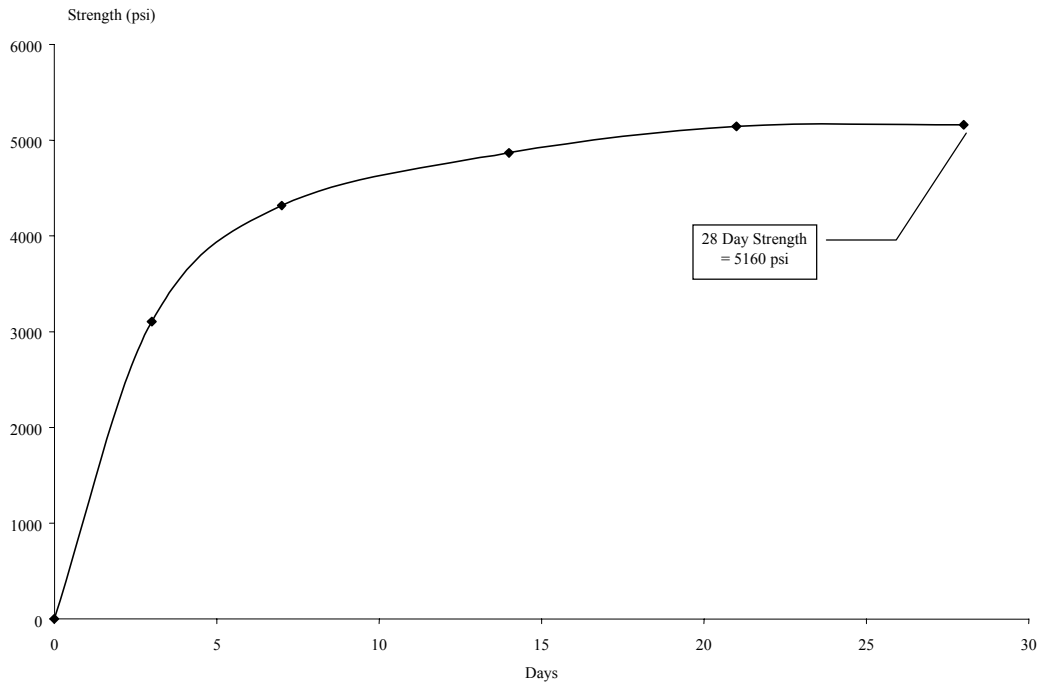


Figure 3.2 Concrete Strength Data for Series B

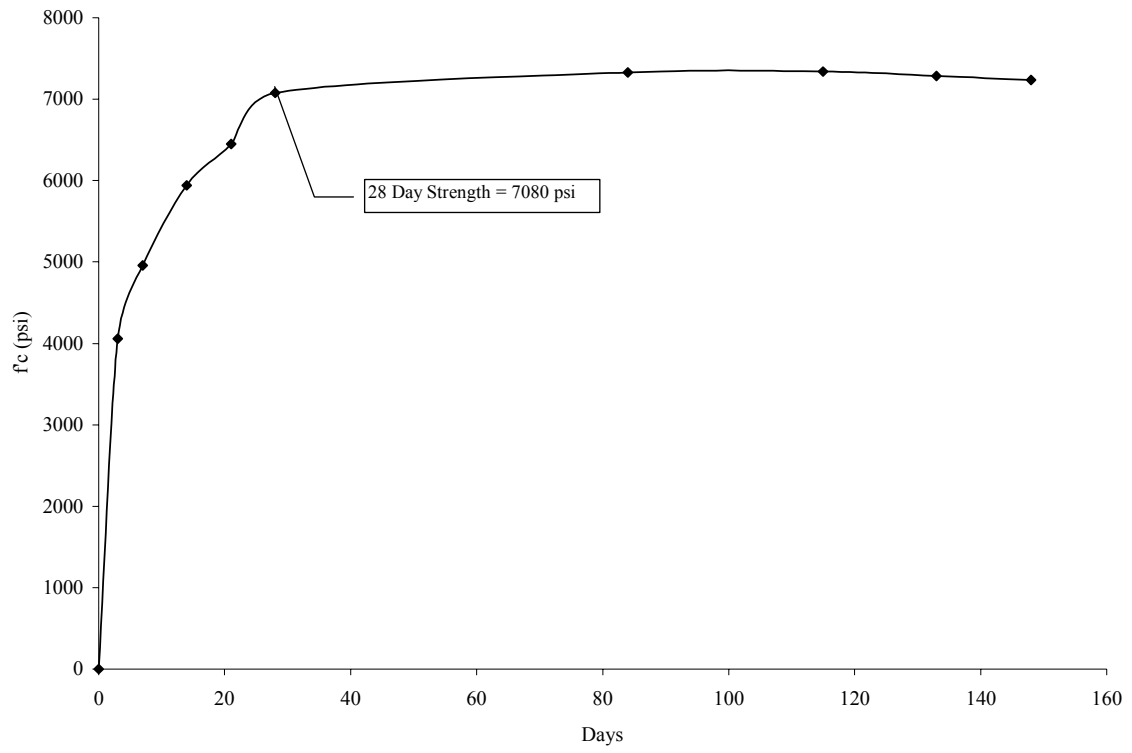


Figure 3.3 Concrete Strength Data for Series C

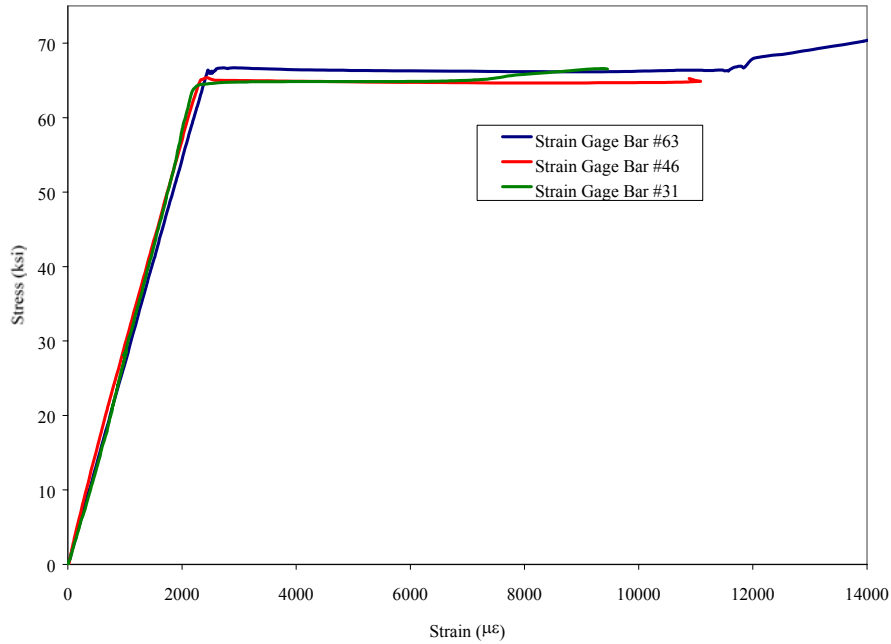


Figure 3.4 Steel Reinforcement: Series A, B, and C

4. SUMMARY OF WORK

The detailed results of Series A, B and C are shown in Table 4.1, and Figures 4.1, and 4.2 for Series A, Table 4.2, and Figures 4.3 and 4.4 for Series B, and Table 4.3 and Figures 4.5 and 4.6 for Series C. The tables contain a summary of the key experimental data.

Table 4.1 Summary of Test Results for Series A

Specimen Number	Epoxy Coating Thickness	Number of Cracks in the Splice Length	Splice Length (in.)	Failure Load (lbs)	Concrete Strength at Failure (psi)	Mode of Failure
A-U1	Uncoated	4	14	12600	4350	Bond
A-U2	Uncoated	3	12	12900	3820	Bond
A-E12-1	12 mil	4	14	12100	4250	Bond
A-E12-2	12 mil	3	12	12500	3800	Bond
A-E18-1	18 mil	4	14	12800	4110	Bond
A-E18-2	18 mil	3	12	11000	3911	Bond

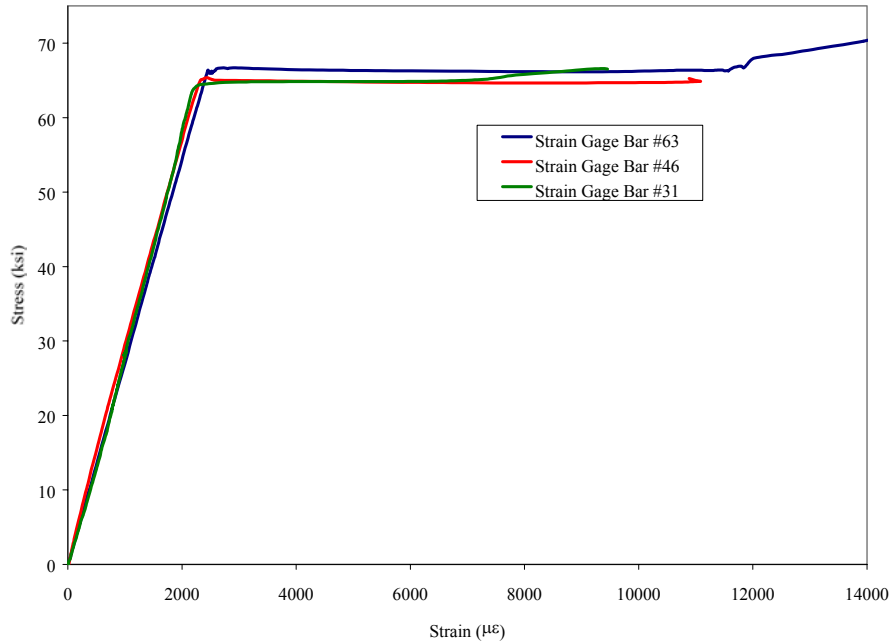


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A-E12-2	12 mil	3	12	12500	3800	Bond
A-E18-1	18 mil	4	14	12800	4110	Bond
A-E18-2	18 mil	3	12	11000	3911	Bond

Table 4.2 Summary of Test Results for Series B

Specimen Number	Epoxy Coating Thickness	Number of Cracks in the Splice Length	Splice Length (in.)	Failure Load (lbs)	Concrete Strength at Failure (psi)	Mode of Failure
B-E12-1	12 mil	4	30	12900	5340	Shear-Compression
B-E18-1	18 mil	4	30	12500	5190	Flexure
B-E12-2	12 mil	4	30	12200	5200	Flexure
B-E18-2	18 mil	4	30	12700	5120	Flexure

Table 4.3 Summary of Test Results for Series C

Specimen Number	Epoxy Coating Thickness	Number of Cracks in the Splice Length	Splice Length (in.)	Failure Load (lbs)	Concrete Strength at Failure (psi)	Mode of Failure
C-E12-1	12 mil	8	76	92500	7280	Shear
C-E18-1	18 mil	8	76	99300	7240	Shear
C-E12-2	12 mil	9	76	96600	7340	Shear
C-E18-2	18 mil	9	76	91000	7330	Shear

The figures show load against tip-deflection behavior for all the specimens in Series A and B, and load against midspan-deflection in Series C. A comparison of the results for the 12-mil coated and 18-mil coated reinforced beams shows little difference in performance. The beams with the uncoated reinforcement were both stronger and more ductile at failure in Series A. This is expected and accounted for by both ACI and AASHTO codes. The beams in Series B with code splice lengths showed a satisfactory performance. The results of Series C confirmed the findings of Series B for specimens reinforced with #8 bars.

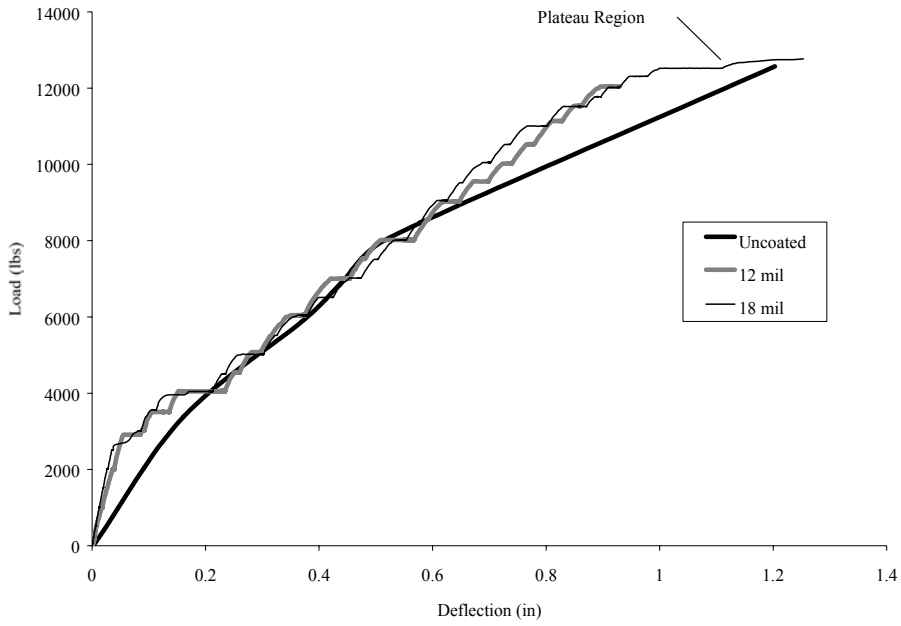


Figure 4.1 Load vs Tip-Deflection for Series A-Batch#1 Specimens

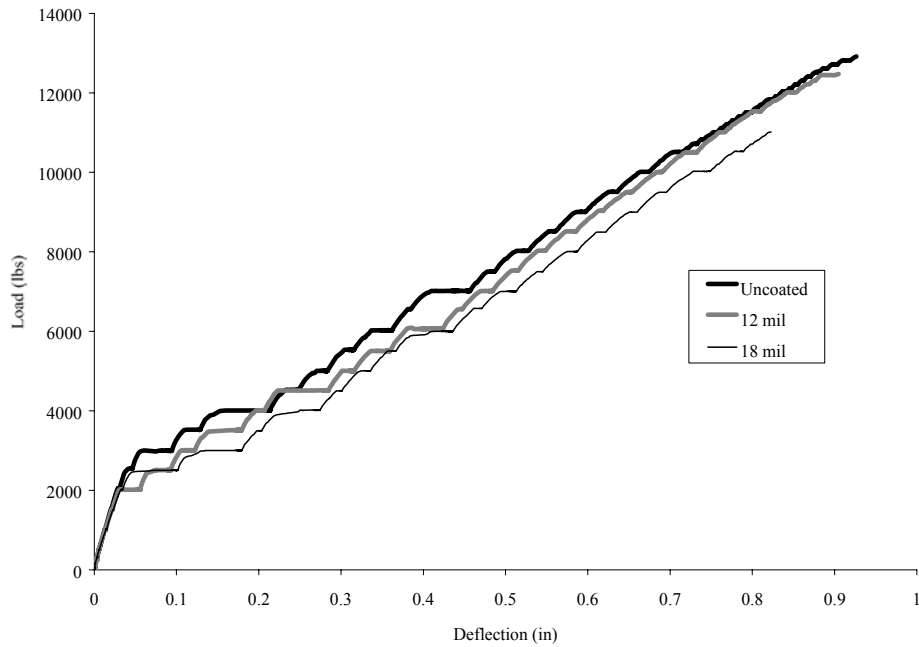


Figure 4.2 Load vs Tip-Deflection for Series A-Batch#2 Specimens

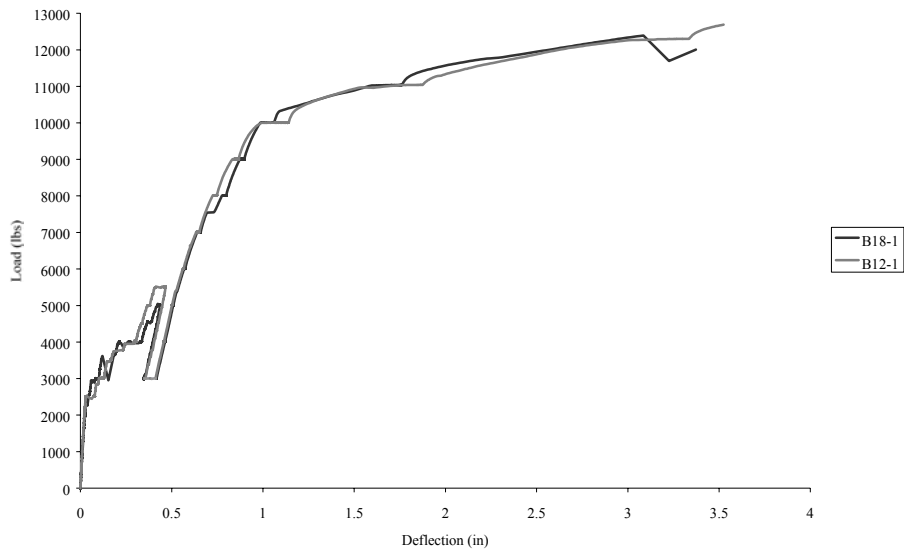


Figure 4.3 Load vs Tip-Deflection for Series B-Batch#1 Specimens

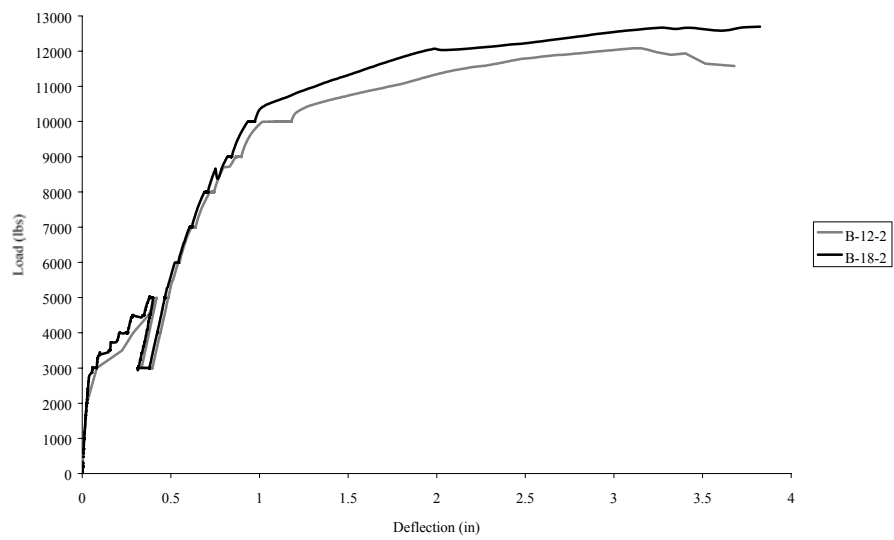


Figure 4.4 Load vs Tip-Deflection for Series B-Batch#2 Specimens

Load vs Midspan Deflection For Series C

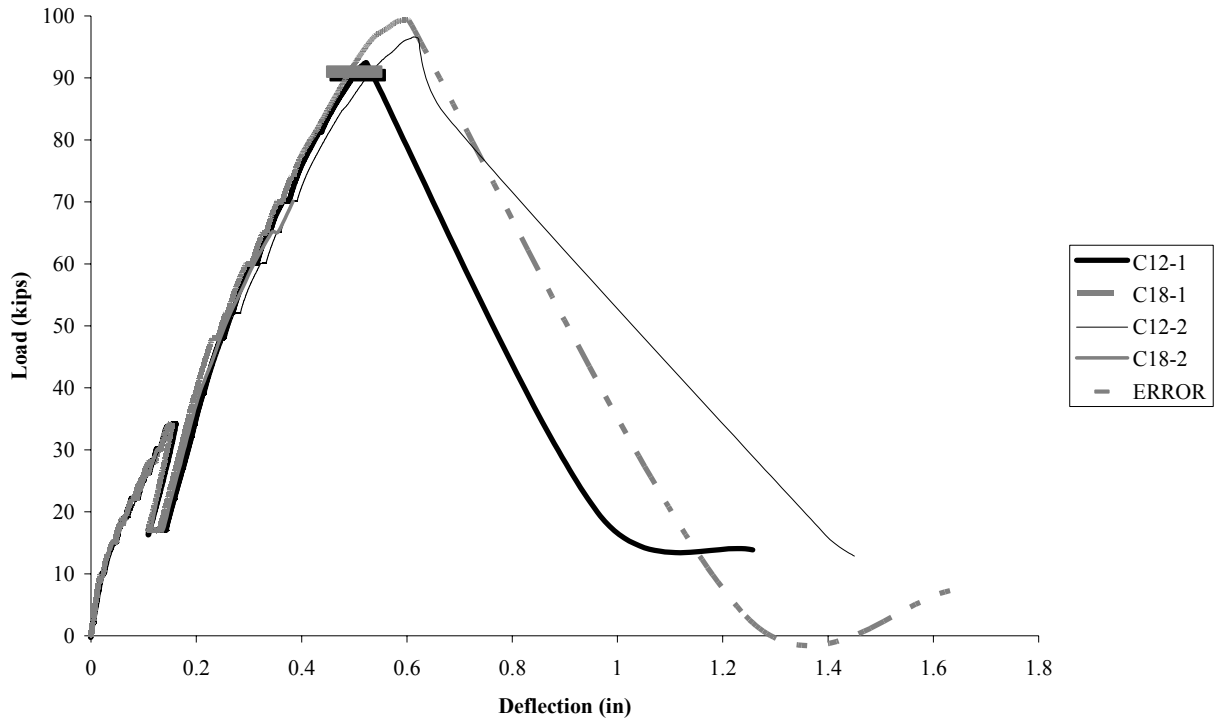


Figure 4.5. Load vs. mid-span deflection for Series C

5. FINDINGS

Based on the results from the experimental program conducted to date, it can be concluded that the current AASHTO requirements for development length of epoxy-coated bars can be extended to coating thickness of up to 18 mils.

6. REFERENCES

1. Samples, L. M., and Ramirez, J. A. (2000), "*Field Investigation of Concrete Bridge Decks in Indiana*," Concrete International, February, pp. 53-56.