CIVIL & ENVIRONMENTAL ENGINEERING

REPORT APPENDIX

IDENTIFICATION OF CAUSES AND SOLUTION STRATEGIES FOR DECK CRACKING IN JOINTLESS BRIDGES

by

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Appendix A

MDOT Bridge Information for Field Investigation

Bridge ID No.	*Location*	*County*	*Date constructed*	*Date of inspection*	*Repair Actions taken*	*Skew (deg.)*	*Superstructure Type*	*Deck Forms*	*Crack Type*	*Transverse widespread?*	*Deck Rating (9-pt. scale)*	*Visit?*	*Reason*
19022-SO3-3	I-96 eb over Grange Rd.	Clinton	2007	2008	None	21	Concrete I-beam	Metal SIP	Transverse and diagonal cracking throughout, transverse cracks in headers at the joints	Yes?	7	Yes?	Transverse cracking appears to be widespread, possibly visit based on close proximity
19022-S03-4	1-96 wb over Grange Rd.	Clinton	2007	2008	Epoxy sealer in cracks	21	Concrete I-beam	Metal SIP	Transverse and diagonal and longitudinal cracks in all spans, transverse cracks in headers	Yes?	7	Yes?	Transverse cracking appears to be widespread, possibly visit based on close proximity
23152-S06	Millett Rd. over I-96	Eaton	2001	2008	Epoxy sealer in cracks	6	Side by side box beam	None (side-by-side)	Longitudinal cracks along box beams, some transverse cracks	No	6	No	Cracking appears to be dominated by longitudinal cracks, it is not crack type we are interested in
23152-S07	I-96 wb over Canal Rd.	Eaton	2001	2009	Epoxy sealer in cracks	42	Side by side box beam	None (side-by-side)	Longitudianl cracks along box beams, transverse cracks at construction joints,	No	6	No	Skew angle is too large, mostly longitudinal cracking
23152-S08	I-96 eb over Canal Rd.	Eaton	2001	2009	Healer sealer in 2007	49	Side by side box beam	None (side-by-side)	Transverse cracking throughout entire bridge, longitudinal cracks over box beams	Yes	6	No	Contains cracking pattern of interest, skew angle is too large
23152-S09	I-96 wb over Lansing Rd.	Eaton	2001	2009	Epoxy sealer in cracks	5	Side by side box beam	None (side-by-side)	Transverse cracking throughout, some transverse cracking in barriers	Yes	6	Yes	Appears to have cracking pattern of interest, skew is not large, close proximity

Bridge ID No.	*Location*	*County*	*Date constructed*	*Date of inspection*	*Repair Actions taken*	*Skew (deg.)*	*Superstructure Type*	*Deck Forms*	*Crack Type*	*Transverse widespread?*	*Deck Rating (9-pt. scale)*	*Visit?*	*Reason*
23152-S10	I-96 eb over Lansing Rd.	Eaton	2001	2009	Epoxy sealer in cracks	5	Side by side box beam	None (side-by-side)	Transverse cracking and map cracking throughout, transverse cracking in barriers	Yes	6	Yes	Appears to have cracking pattern of interest, skew is not large, close proximity
33045-S02-3	I-496 eb over Pennsylvania Ave.	Ingham	2000	2009	None	15	Side by side box beam	None (side-by-side)	Transverse cracking over the piers, as well as longitudinal and diagonal cracking throughout	Yes	7	Yes	Appears to have cracking pattern of interest, skew is not large, close proximity
33045-S02-4	I-496 wb over Pennsylvania Ave.	Ingham	2000	2009	None	15	Side by side box beam	None (side-by-side)	Transverse cracks, spaced less than 5 feet, open transverse cracks on both piers	Yes	6	Yes	Appears to have cracking pattern of interest, skew is not large, close proximity
38101-B01	I-94 over Sandstone Creek	Jackson	1953, rehab in 2008	2009	None	20	Steel beams	None (removable forms used)	Some diagonal and transverse cracking, spalling at concrete patches, heavy map cracking	Yes	5	No	Appears to have cracking pattern of interest, but new overlay and widening may have dominated cracking
38101-S11	Hawkins Rd. over I-94	Jackson	1958, rehab in 2009	2009	None	0	Spread box beams	Metal SIP	New concrete deck replacement; no cracking yet observed, previously had longitudinal cracking	Yes?	8	Yes	While no official cracking inspection has been created, photos indicate possible cracking, and the new deck replacement would be of interest from the early-age standpoint
47064-S08	Kensington Rd. over I-96	Livingston	2009	2009	None	21	Steel girder	Metal SIP	New concrete deck replacement; some transverse cracking by construction joints, no extensive cracking for new deck	Yes?	9	Yes?	Photos indicate possible cracking, new deck of interest for early-age; however, extensive cracking not yet observed
58151-S01	Sterns Rd. over I-75	Monroe	2009	2009	None	0	Spread box beams	Metal SIP	New concrete deck replacement; no cracking yet observed, previously had many transverse cracks	Yes?	8	Yes?	Photos indicate possible cracking, new deck of interest for early-age; however, extensive cracking not yet observed

Bridge ID No.	*Location*	*County*	*Date constructed*	*Date of inspection*	*Repair Actions taken*	*Skew (deg.)*	*Superstructure Type*	*Deck Forms*	*Crack Type*	*Transverse widespread?*	*Deck Rating (9-pt. scale)*	*Visit?*	*Reason*
58152-B04-1	I-75 nb over The Huron River	Monroe	2009	2009	None	12	Steel beams	Metal SIP	Diagonal cracking, random cracking, numerous patches and spalling	No	7	No	Cracking appears to be random, photos do not indicate transverse cracking due to restrained shrinkage
58152-B04-2	I-75 sb over The Huron River	Monroe	2009	2009	None	12	Steel beams	Metal SIP	Transverse cracking adjacent to expansion joints, new deck in 2009, no extensive cracking noted	No	9	No	No extensive cracking was noted after construction
76011-B01	M-52 over The Looking Glass River	Shiawassee	2000	2009	Epoxy overlay	0	Spread box beams	Metal SIP	Epoxy overlay with diagonal, transverse, and longitudinal cracks,	Yes	6	Yes	Appears to have extensive cracking
81104-S09	Baker Rd. over I-94	Washtenaw	2007	2009	None	2	Side by side box beam	None (side-by-side)	Several longitudinal cracks throughout the deck	No	7	No	Cracking appears to be dominated by longitudinal cracks, it is not crack type we are interested in
81104-S10	Zeeb Rd. over I-94	Washtenaw	2002	2008	None	28	Side by side box beam	None (side-by-	Longitudinal cracks between box beams, some	No	7	No	Cracking appears to be dominated by longitudinal

								side)	transverse cracking parallel to construction joints				cracks, it is not crack type we are interested in
41026-S02	Walker Rd. over I-96	Kent	2006	2006 (part-width constr.)	None	6	Concrete Spread Box	Metal SIP	Transverse and longitudinal cracking	Yes	unknown	No	Part-width construction affected bridge performance
41064-B04	M-6 eb over Buck Creek	Kent	2001	2001 (immediately)	Epoxy sealer in cracks	0	Concrete I-beam	Metal SIP	Transverse cracking at the piers, longitudinal cracking at approaches	No	unknown	?	Visitation will be determined after seeing photos documenting the damage
41131-S06	44th Street over US-131	Kent	2009	2009 (part-width constr.)	None	11	Steel	Metal SIP	Transverse cracking throughout, concentrated at the piers	Yes	unknown	No	Part-width construction affected bridge performance
41064-S05	Burlingame Rd. Over M-6	Kent	2001	2009 (immediately)	None	11	Concrete I-beam	Metal SIP	Transverse cracking near middle pier, longitudinal at the ends of the bridge, map cracking throughout	No	unknown	?	Visitation will be determined after seeing photos documenting the damage
2nd submission													
Bridge ID No.	Location	County	Date constructed	Date of inspection	Repair Actions taken	Skew (deg.)	Superstructure Type	Deck Forms	Crack Type	Transverse widespread?	Deck Rating (9-pt. scale)	Visit?	Reason
56044-B04-3	US 10 eb over Sanford Lake	Midland	2008	2010	Latex overlay	unknown	Concrete I-beam	None (removable forms used)	New concrete deck replacement; several transverse and longitudinal cracks, spaced at	Yes	7	Yes	Several transverse cracks are evident from photos and inspection report

									10'				
56044-B04-4	US 10 wb over Sanford Lake	Midland	2008	2010	Latex overlay	unknown	Concrete I-beam	None (removable forms used)	New concrete deck replacement; no problems noted	No	9	No	No cracking problems are evident for new concrete deck construction
3rd submission													
Bridge ID No.	Location	County	Date constructed	Date of inspection	Repair Actions taken	Skew (deg.)	Superstructure Type	Deck Forms	Crack Type	Transverse widespread?	Deck Rating (9-pt. scale)	Visit?	Reason
11015-B01-3	I-94 eb over Galien River	Berrien	2008	2008	None	0	Spread box beams	Metal SIP?	No inspection report obtained; Some small transverse cracks near piers and west abutment	No	unknown	No	Based on provided comments, it appears transverse cracking is not widespread, no photos were provided
11015-B01-4	I-94 wb over Galien River	Berrien	2008	2008	None	0	Spread box beams	Metal SIP?	No inspection report obtained; some edge scaling at construction joints, new deck construction	No	unknown	No	Cracking does not appear to be widespread
39013-S03	Milham Rd. over US-131	Kalamazoo	1999	2008	None	10	Spread box beams	Metal SIP?	No inspection report obtained; scattered transverse cracking and some longitudinal cracks, extensive partial	Yes	unknown	Yes?	Cracking appears to be possibly of interest

									deck replacement				
78062-B01	M-86 over Swan Creek	Kalamazoo	2008	2009	None	0	Spread box beams	Metal SIP?	No inspection report obtained; scattered longitudinal cracks and some areas of map cracking	No	unknown	No	Does not appear to have transverse cracking
4th submission													
Bridge ID No.	Location	County	Date constructed	Date of inspection	Repair Actions taken	Skew (deg.)	Superstructure Type	Deck Forms	Crack Type	Transverse widespread?	Deck Rating (9-pt. scale)	Visit?	Reason
73171-B02-2	I-75 sb over Cass River	Saginaw	1961, rehab in 2006	2010	None	unknown	Steel Girder	Metal SIP	Transverse and longitudianl cracking in the deck sturface	No	8	No	Cracking does not appear to be widespread, photos of the damage would be useful
73171-S08-2	I-75 sb over Genessee Ave.	Saginaw	1961, rehab in 2006	2010	None	unknown	Steel Girder	Metal SIP	Open cracking between construction joints, some longitudinal cracks	No	8	No	Transverse cracking does not appear to be widespread
5th submission													
50013-S03	25 Mile Rd. over M-53	Macomb	2009	2010	None	unknown	Spread box beams	Metal SIP	Transverse and horizontal cracks at pier area	No	8	Yes?	Some transverse cracking is evident from the photos, but it may not be

													widespread enough, deck is in good condition
63172-S05	Walton Blvd. over I-75	Oakland	1962, rehab date unknown	2010	None	unknown	Spread box beams	Metal SIP	Transverse and longitudinal cracks over pier, shrinkage cracking scattered throughout	Yes	8	Yes?	Some transverse cracking is evident, but it may not be widespread enough, deck is in good condition
Bridge ID No.	Location	County	Date constructed	Date of inspection	Repair Actions taken	Skew (deg.)	Superstructure Type	Deck Forms	Crack Type	Transverse widespread?	Deck Rating (9-pt. scale)	Visit?	Reason
6th submission													
unknown	I-196 over Mid-Michigan RR	Kent	2006	unknown	None	45	unknown	unknown	No inspection report obtained; extensive transverse cracking, spaced evenly across bridge	Yes	unknown	No	While the cracking is exactly the type we are looking for, the bridge has a large skew and experienced part-width construction
Other Bridges													
unknown	Halsted Rd. over I-696	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	*No information has been sent on these bridges except for the plans, these are

													bridges we are modeling
unknown	Chocolay River in U.P.	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	*No information has been sent on these bridges except for the plans, these are bridges we are modeling
29011-S14	M-57 over US-27	Gratiot	1999?	Unknown	Unknown	0	Spread box beams	Metal SIP?	No inspection report obtained; photos and plans sent; based on photos, widspread transverse cracking throughout entire bridge	Yes	unknown	Yes	Based on the photos, it appears the bridge has widespread transverse cracking, somewhat close proximity to MSU, need bridge inspection report

Appendix B

Field Inspection Detailed Results

1: I-96 at Lansing Road

- Side-by-side concrete box beams
- 3-span, continuous deck for live-loading, simply supported beams
- *Mostly longitudinal cracking evident, spaced at the same spacing as the width of the beams (3-4 feet). Transverse cracking only evident at the construction joints, by the piers, and also at the approach slabs. Cracking is not likely due to restrained concrete shrinkage.*

Figure 1. Overall Bridge View

Figure 2. Cracking in deck fascia

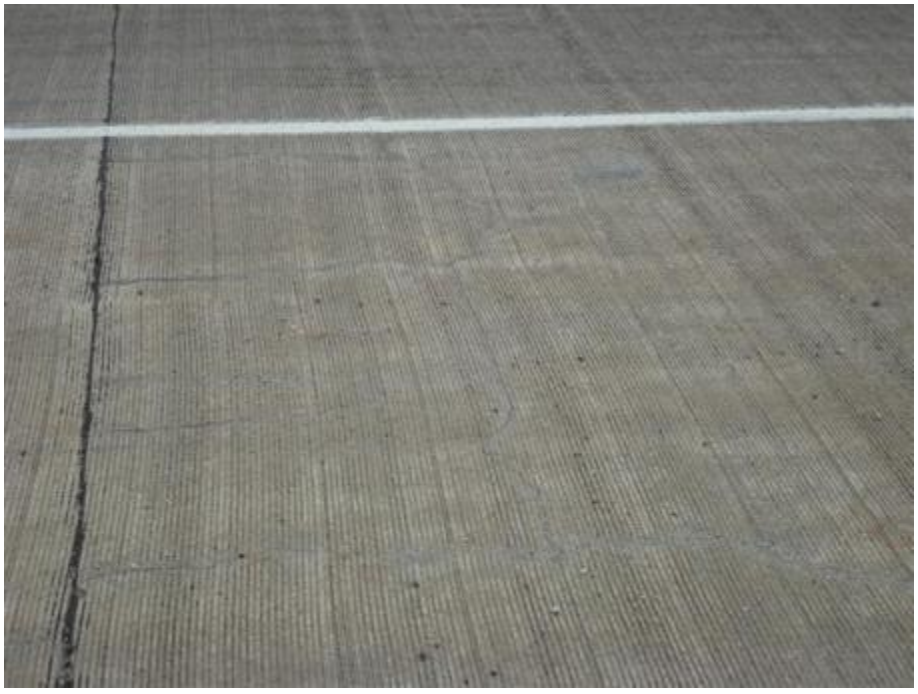


Figure 3. Longitudinal cracks in the deck surface, near the approach slab

Figure 4. Overall deck view

2: I-496 at Pennsylvania Ave.

- Side-by-side concrete box beams
- 3-span, continuous deck for live-loading, simply supported beams
- *Cracking pattern was difficult to observe due to traffic on the freeway. Bridge was not crossed to obtain a detailed observation of the deck. Some vertical cracking was evident in the barrier walls, spaced evenly. Some transverse cracking was evident on the underside fascia of the deck, close to the piers. According to MDOT photos, it appears that longitudinal cracking is dominant in this bridge.*

Figure 5. Overall Bridge View

Figure 6. Transverse cracking in deck fascia

Figure 7. Overall bridge deck view

Figure 8. Cracking in approach pavement

Figure 9. Extensive cracking in barrier wall

3: M-52 over the Looking Glass River

- Spread concrete box beams
- 1-span, continuous deck and fully integral beams at the abutment.
- *There was some transverse cracking in the deck fascia, at the underside of the deck. The barrier walls experienced widespread vertical/transverse cracks. Both transverse and longitudinal cracking was evident in the deck.*

Figure 10. Bridge overall view

Figure 11. Bridge underside

Figure 12. Cracking in deck fascia

Figure 13. Vertical cracking in barrier wall, transverse cracking in the deck

Figure 14. Longitudinal crack in the deck

Figure 15. Transverse cracking in the deck

Figure 16. Longitudinal cracks

Figure 17. Large crack in barrier wall

Figure 18. Deck overall vie

*5: M-57 over US-127**

- Spread concrete box beams
- 4-span, continuous deck for live loading, simply supported beams (semi-integral abutment).
- *Some diagonal shear cracking was evident in the beams, near the piers.*
  Transverse cracking was evident throughout the entire deck surface, spaced at every 3' to 4'. The cracking continued over the pier areas. The crack density was much greater in the area over the piers, or in the "middle" deck pour.
  According to the inspection reports, the cracks were previously sealed. As evident in the inspection, the cracking has continued through the seals.

**This bridge shows the most evidence of evenly-spaced transverse cracking, and is likely the best prototype candidate for cracking due to restrained concrete shrinkage.*

Figure 19. Bridge overall view

Figure 20. Cracking in beams by the pier

Figure 21. Connection at the abutment

Figure 22. Overall bridge deck view

Figure 23. Bridge expansion joint and sleeper slab

Figure 24. Cracking in barrier wall

Figure 25. Transverse crack near construction joint

Figure 26. Transverse cracks in deck surface

Figure 27. Transverse cracking in deck

Figure 28. Transverse cracks in deck

7: I-96 over Grange Road

- Concrete I-beams
- 3-span, continuous deck for live-loading, simply supported beams
- *Some fairly widespread transverse/vertical cracking is evident in the concrete barrier walls. Some transverse cracking is evident in the bottom of the deck/deck fascia. The top deck surface did not have many evident signs of cracking. The bridge appears to be new/recently renovated.*

Figure 29. Overall bridge view

Figure 30. Cracking on underside of deck, by the pier area

Figure 31. Bridge deck underside

Figure 32. Overall bridge view

Figure 33. Bridge deck surface

Figure 34. Bridge deck surface (other side)

16: Hawkins Road over I-94

- Spread concrete box beams
- 2-span, continuous deck for live-loading, simply supported beams
- *Some fairly widespread transverse/vertical cracking is evident in the concrete barrier walls. The bottom of the deck/deck fascia does not have any signs of cracking. There is a large extent of transverse cracking in the area of the pier, near the middle of the bridge deck. Longitudinal cracking is evident throughout the bridge, spaced evenly at the same spacing of the beams.*

**This deck was replaced in 2009, and at the time of the inspection report there were no defects reported for the deck.*

Figure 35. Bridge overall view

Figure 36. Bridge underside

Figure 37. Longitudinal cracking in bridge surface

Figure 38. Close-up of longitudinal crack

Figure 39. Transverse cracking in pier area

Figure 40. Bridge surface overall view (note longitudinal cracks)

Figure 41. Transverse cracking in pier area

Figure 42. Transverse cracking in pier area

Figure 43. Bridge expansion joint (relatively clean of debris)

17: I-94 over Sandstone Creek

- Steel beams
- 3-span (small spans), continuous deck for live load, non-integral beams (beams are not cast into the abutment), rocker bearings at the ends, fixed bearings at the piers.
- Removable plywood forms used underneath.
- *Some cracking is evident on the underside of the deck, although it is not widespread. Some cracking is also evident in the concrete barrier walls. Not much cracking (longitudinal nor transverse) is evident in the bridge deck. The deck was difficult to observe due to traffic on the freeway.*

Figure 44. Bridge overall view

Figure 45. Semi-integral abutment detail

Figure 46. Bridge underside (note no SIP metal forms were used)

Figure 47. Cracking in barrier wall and deck fascia

Figure 48. Bridge expansion joint and approach slab (some cracking in approach)

Figure 49. Bridge deck surface (no notable cracks)

Figure 50. Bridge deck overall view

4: US-10 eb over Sanford Lake

- Spread Concrete I-girders (MI-1800 I-beam)
- 3-span, continuous deck for live-loading, continuous beams
- Removable plywood forms underneath
- *The eastbound side had significant longitudinal cracking throughout, and transverse cracking in the areas of the piers and approach slabs. The westbound side had no significant cracking in the bridge surface, some longitudinal cracking at the east approach.*

Figure 51. Overall Bridge View (Eastbound side)

Figure 52. Girder connection at the abutment

Figure 53. Bridge underside (note no SIP forms are used)

Figure 54. Deck approach slab and expansion joint (some longitudinal cracking)

Figure 55. Overall Bridge Deck View (Eastbound)

Figure 56. Longitudinal cracking in bridge deck

Figure 57. Transverse cracking near the first pier

Figure 58. Transverse cracking close-up

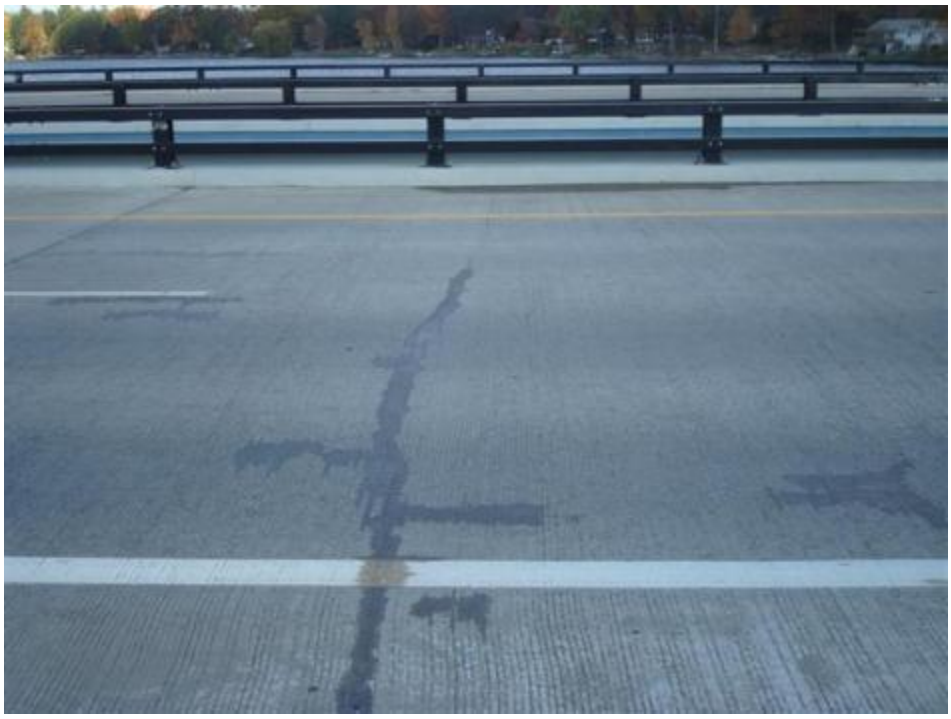


Figure 59. Additional transverse cracking at pier 2, as well as some longitudinal cracking

Figure 60. Identical designs for EB and WB sides

8: Kensington Rd. over I-96

- Steel girders
- 2-span, continuous deck for live loading, fully integral abutments, SIP metal forms underneath
- Sidewalk on west side of the bridge
- *Extensive transverse cracking is evident by construction joints, and close to the pier area. Longitudinal cracking is evident throughout the bridge deck. The barriers and sidewalk have extensive vertical/transverse cracking as well, some of which continued into the bridge deck as transverse cracks. Interestingly, this bridge was recently re-constructed (2009), yet it is experiencing a relatively high amount of cracking*

Figure 61. Bridge overall view

Figure 62. Bridge connection at the abutment (note that the steel girders sit on elastomeric bearings, and are cast into the abutment, similar to box-beam bridges we have seen)

Figure 63. Bridge underside overall view

Figure 64. Bridge deck overall view

Figure 65. Large transverse crack at the abutment

Figure 66. Close-up of transverse crack (note how it cracked through the repair)

Figure 67. Longitudinal cracks in the deck

Figure 68. Transverse/vertical cracking in sidewalk and barrier wall

Figure 69. Transverse cracking by construction joint

Figure 70. Transverse cracking in barrier continuing to deck surface

14: 26-Mile Rd. over M-53

- Spread concrete box beams
- 2-span, non-integral abutment (beams are not cast into abutment), continuous deck for live load, SIP forms used
- *There is a heavy amount of transverse cracking in the area of the pier, and scattered longitudinal cracking throughout the bridge. The longitudinal cracking is spaced at the same spacing of the beams. There is also evenly-spaced transverse cracking in the sidewalk/barrier wall (spaced at 3-4')*

Figure 71. Bridge overall view

Figure 72. Cracking in outside fascia of deck and barrier

Figure 73. Connection at the abutment (note that beam is not cast into abutment)

Figure 74. Bridge underside

Figure 75. Longitudinal cracking in approach slab

Figure 76. Cracking in barrier, at railing connection (typical)

Figure 77. Large longitudinal crack in deck surface

Figure 78. Heavy transverse cracking in pier area

Figure 79. Transverse cracking continuing into the sidewalk

Figure 80. Transverse and longitudinal cracking

Figure 81. Almost identical cracking in opposite approach slab

15: Walton Blvd. over I-75

- Spread concrete box beams
- 2-span, non-integral abutment (beams are not cast into abutment), continuous deck for live load, SIP forms used.
- *Heavy transverse cracking in pier area, scattered longitudinal cracking spaced at beam spacing. Evenly-spaced transverse/vertical cracks in barrier wall*

**This bridge design is very similar to 26-Mile Rd. over M-53, and the cracking pattern was also very similar*

Figure 82. Overall bridge view

Figure 83. Bridge underside

Figure 84. Connection at the abutment (same as 26-Mile Rd. over M-53)

Figure 85. Bridge surface overall view

Figure 86. Cracking in barrier wall (typical)

Figure 87. Longitudinal cracking in bridge surface

Figure 88. Longitudinal and transverse cracks in pier area

Figure 89. Transverse cracking in pier area

Figure 90. Transverse cracking in second span, near the abutment

6: Halsted Rd. over I-696

- Steel Girders
- 4-span, non-integral abutments, deck is continuous for live loading, SIP metal forms (this information was obtained from the bridge design plans)
- *Some cracking is evident in the barrier wall, spaced at 3-4'. Some transverse cracking in area of the piers, and a small amount of longitudinal cracking scattered throughout.*

**Overall, the deck appears to be in good shape, and is not in as bad of condition as noted by MDOT in previous meetings. The deck appears to have recently been re-constructed.*

Figure 91. Bridge overall view

Figure 92. Bridge surface view

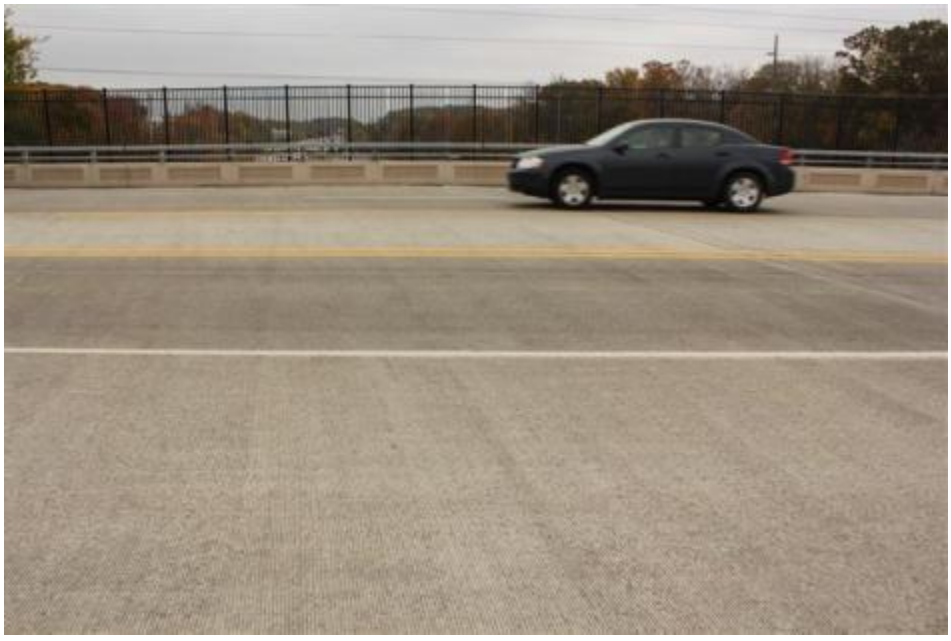


Figure 93. Possible longitudinal crack in the middle (it was not clear in the investigation whether it was a crack or roughed surface)

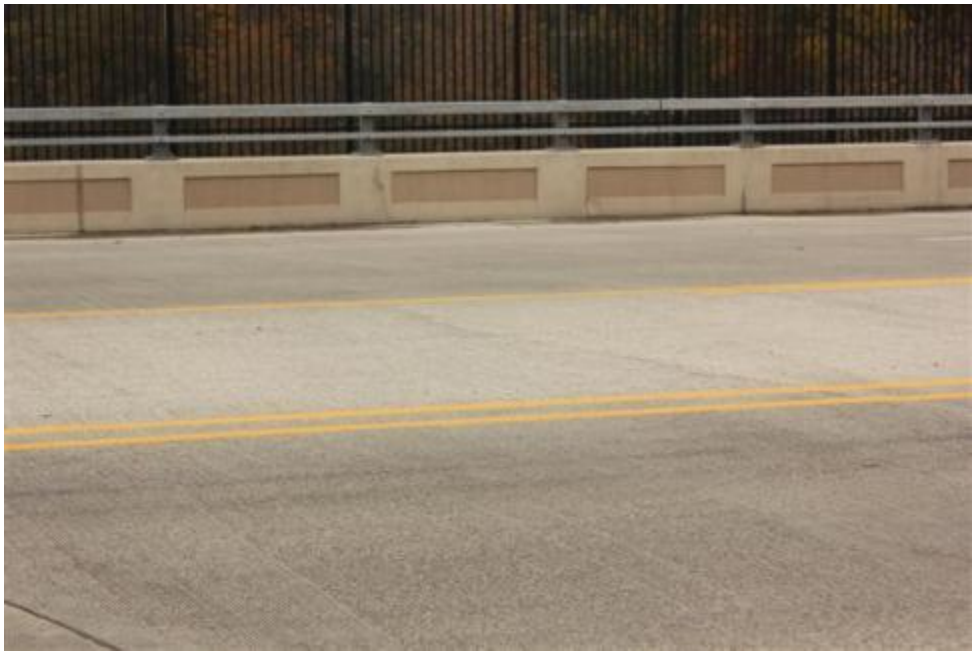


Figure 94. Cracking in barrier wall, potential transverse crack in the middle

Figure 95. Evenly-spaced vertical cracking in barrier wall

Figure 96. Bridge deck surface

10: M-6 over Buck Creek

- Concrete I-girders (MI-1800 Girders)
- 4-span, continuous deck for live loading, non-integral abutments, SIP forms used underneath
- Relatively long spans compared to other bridges investigated
- Girder spacing varied (larger spacing in the middle, smaller spacing at the sides)
- *Extensive transverse cracking was evident in the second span, between pier 1 and the middle pier. Transverse cracking was also evident at the piers, in the negative moment region. Not much evidence of longitudinal cracking. Identical cracking pattern was evident in the two approach slabs.*

Figure 97. Bridge overall view

Figure 98. View of side of bridge

Figure 99. Transverse cracking bridge deck, near the abutment

Figure 100. Close-up of transverse cracks

Figure 101. Non-integral abutment detail (note that beams are not cast into the abutment)

Figure 102. Bridge underside view (girder spacing is larger in the left side of the photo)

Figure 103. Bridge deck surface overall view

Figure 104. Transverse cracking in bridge deck

Figure 105. Extensive and evenly-spaced transverse cracks

Figure 106. More transverse cracks in bridge deck

Figure 107. Transverse cracking in bridge deck

Figure 108. Large transverse crack at opposite abutment

11: 44th Street over US-131

- Steel beams
- 2-span, continuous deck, non-integral abutment, SIP forms used underneath
- Bridge has a unique shape (see photos, it is a rectangular bridge, with trapezoidal approaches)
- *Extensive transverse cracking evident at the pier area, evenly spaced transverse cracking in the east span. Some vertical cracking evident in the barrier wall. Not much evidence of longitudinal cracking.*

Figure 109. Bridge approach overall view

Figure 110. Cracking in barrier wall

Figure 111. Transverse cracking in pier area

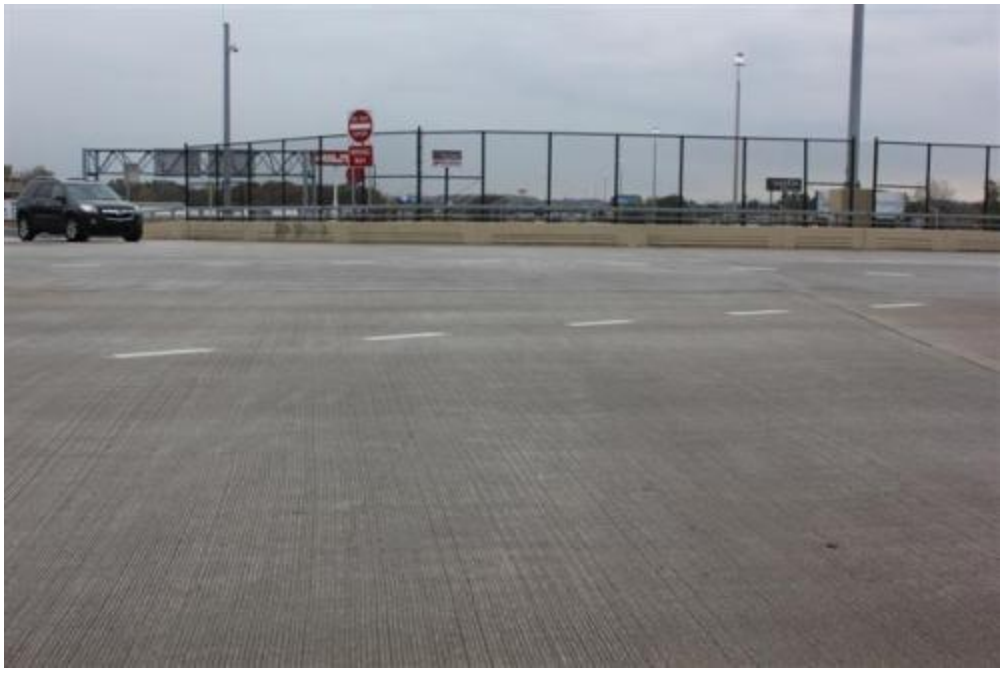


Figure 112. Transverse cracking in-between pier and abutment

Figure 113. Transverse cracking in bridge deck

Figure 114. Bridge deck overall view

Figure 115. Bridge overall view

Figure 116. Non-integral beams/continuous deck at the abutment

Figure 117. Bridge underside view

12: Burlingame Rd. over M-6

- Concrete I-girders (MI-1800)
- 2-span, continuous deck for live loading, integral abutment
- *Heavy amount of longitudinal cracking, spaced evenly at girder spacing through the entire bridge. Some transverse cracking evident at the approaches and in the middle by the pier. Random map cracking throughout.*

Figure 118. Cracking in barrier wall (typical)

Figure 119. Diagonal cracking near the abutment

Figure 120. Transverse cracking in pier area

Figure 121. Transverse cracking at the pier area

Figure 122. Bridge underside

Figure 123. Connection at the abutment

Figure 124. Diagonal cracking near the abutment

Figure 125. Longitudinal cracking

Figure 126. Random/map cracking on the shoulder

Figure 127. Evenly-spaced longitudinal cracks

Figure 128. Longitudinal cracks running through entire deck

13: Milham Ave. over US-131

- Spread box beams
- 4-span, semi-integral abutment, continuous deck for live loading, part-width construction, SIP forms used except for the area where the part-width construction took place
- *Numerous transverse cracks in the underside where the part-width construction meets, numerous transverse cracks in the deck fascia and barriers. Widespread transverse cracking throughout, especially in the area by the piers and also in positive moment regions. Some longitudinal cracking evident throughout, scattered randomly.*

  **Part-width construction may have had an effect on the cracking in this bridge*

Figure 129. Bridge overall view

Figure 130. Deteriorated outside/fascia of the bridge

Figure 131. Abutment connection detail

Figure 132. Bridge underside detail (note part-width construction area without SIP forms)

Figure 133. Transverse cracking in bridge underside

Figure 134. Transverse cracking

Figure 135. Cracking in barrier wall (typical)

Figure 136. Transverse cracking in bridge deck

Figure 137. Longitudinal/diagonal cracking near the abutment

Figure 138. Transverse cracking in the middle of the bridge

Figure 139. Transverse cracking in bridge deck and continuing into the sidewalk

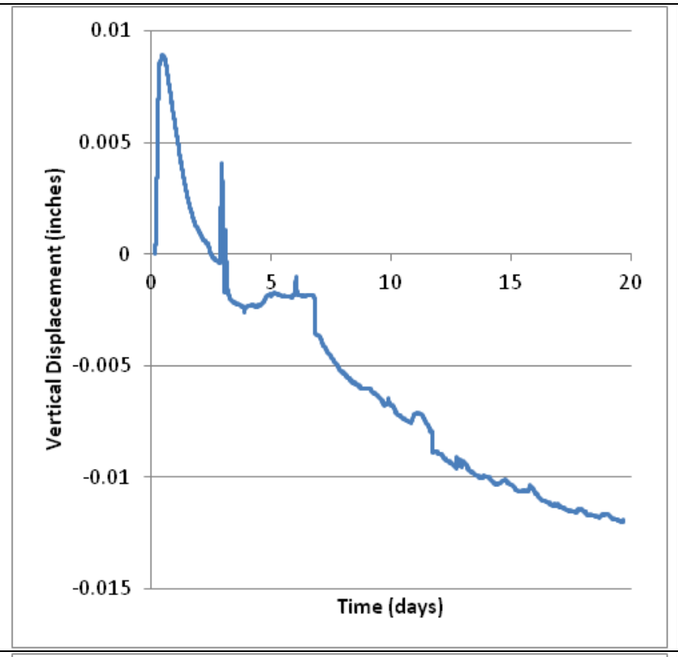
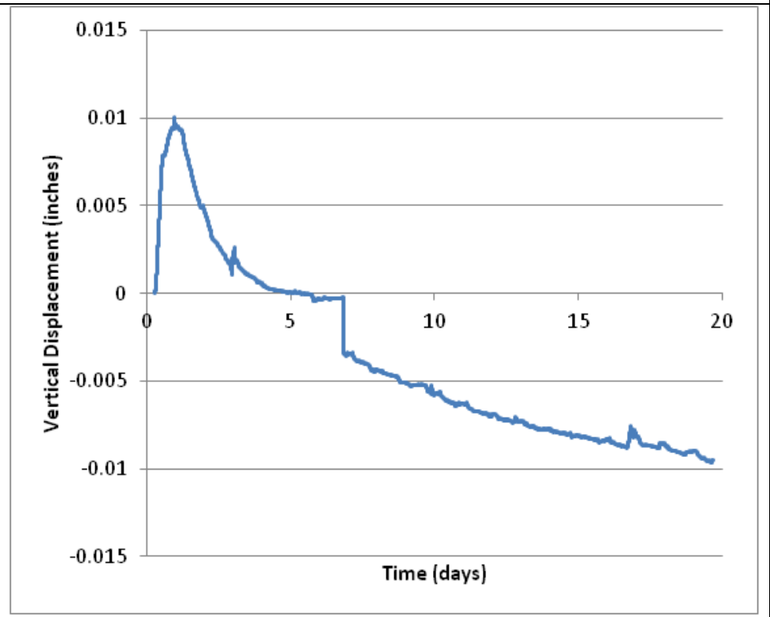
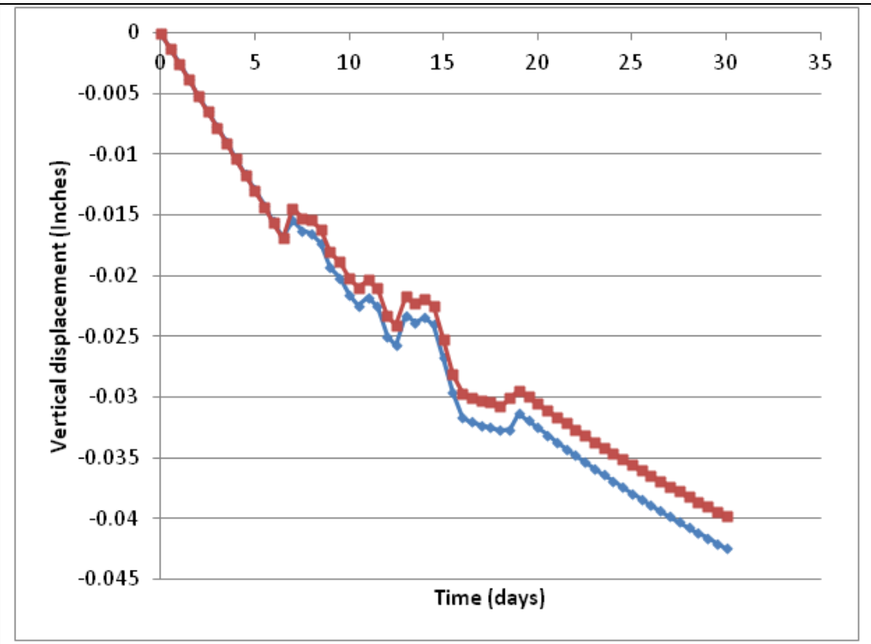
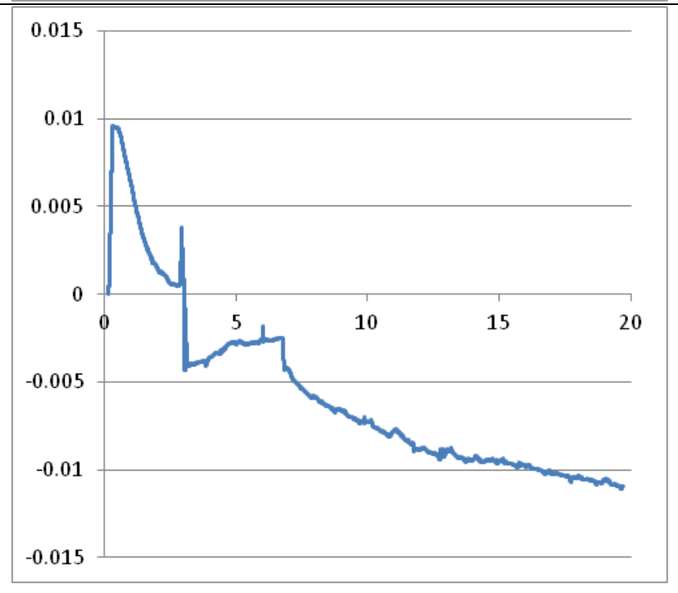
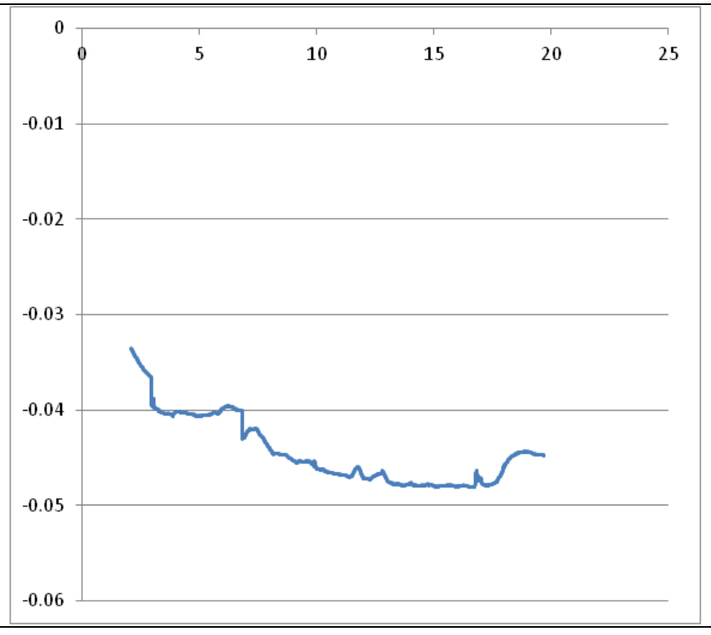
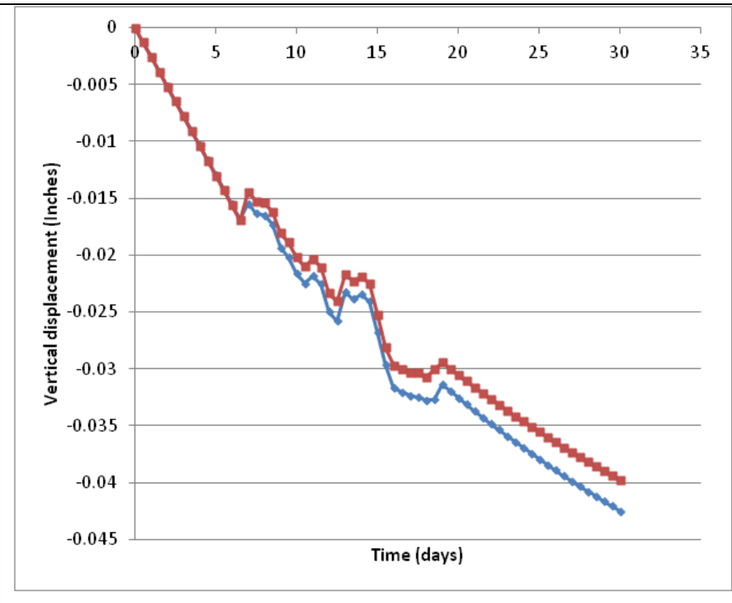
Figure 140. Evenly-spaced transverse cracks

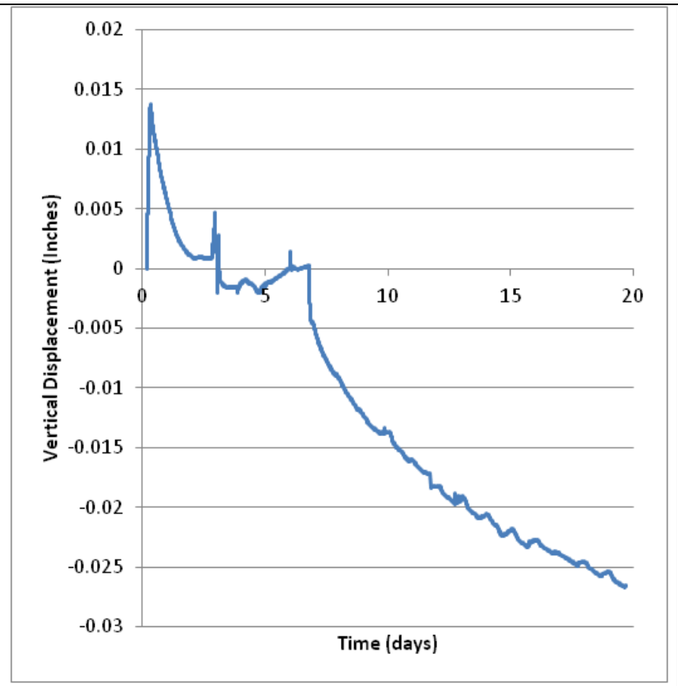
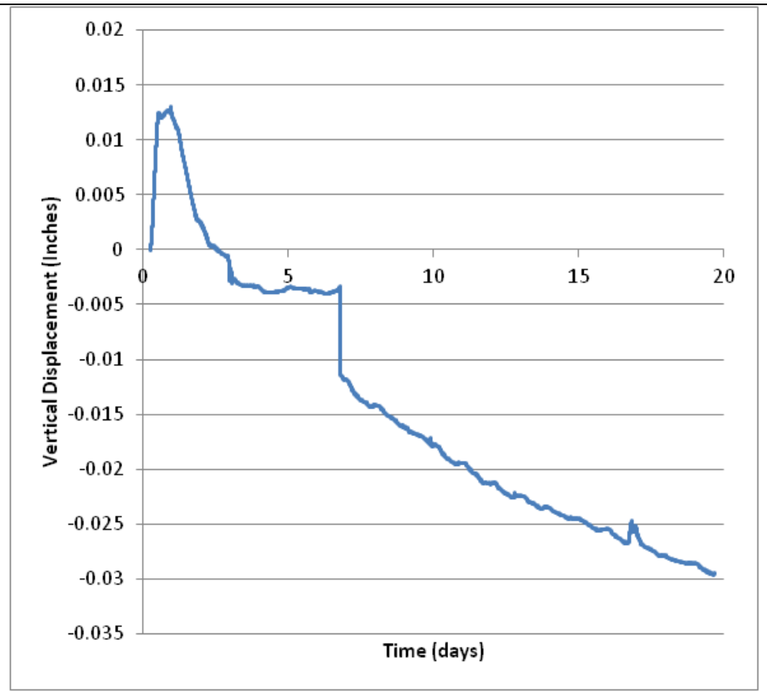
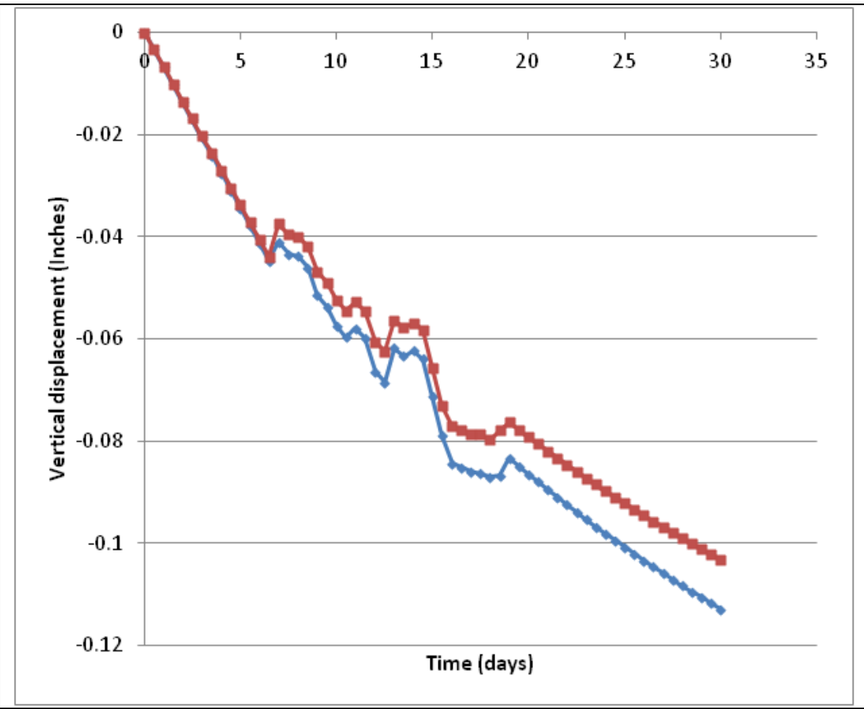
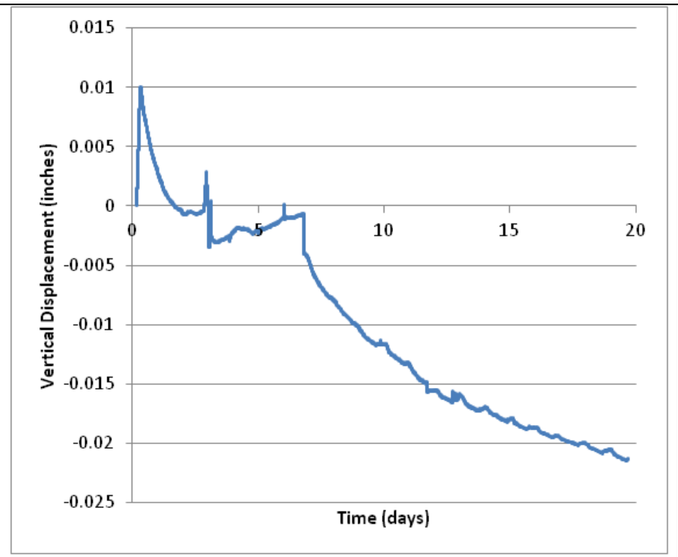
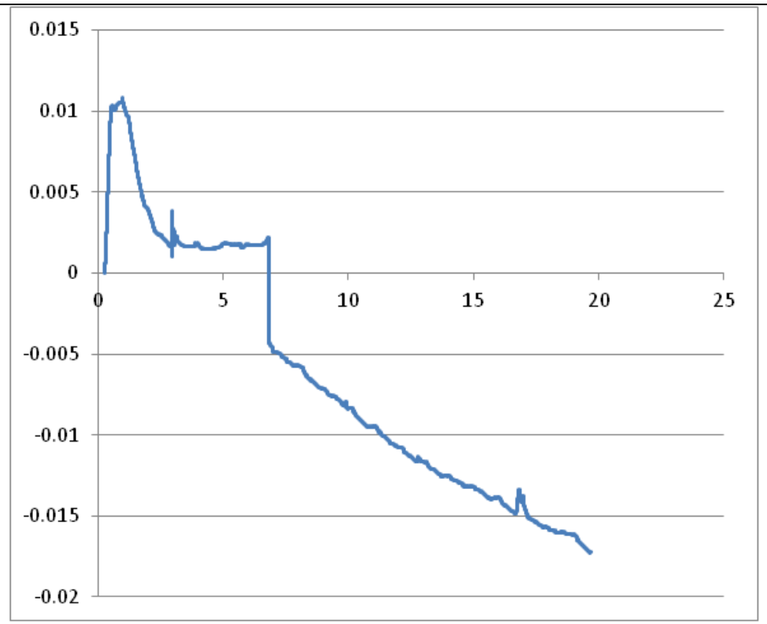
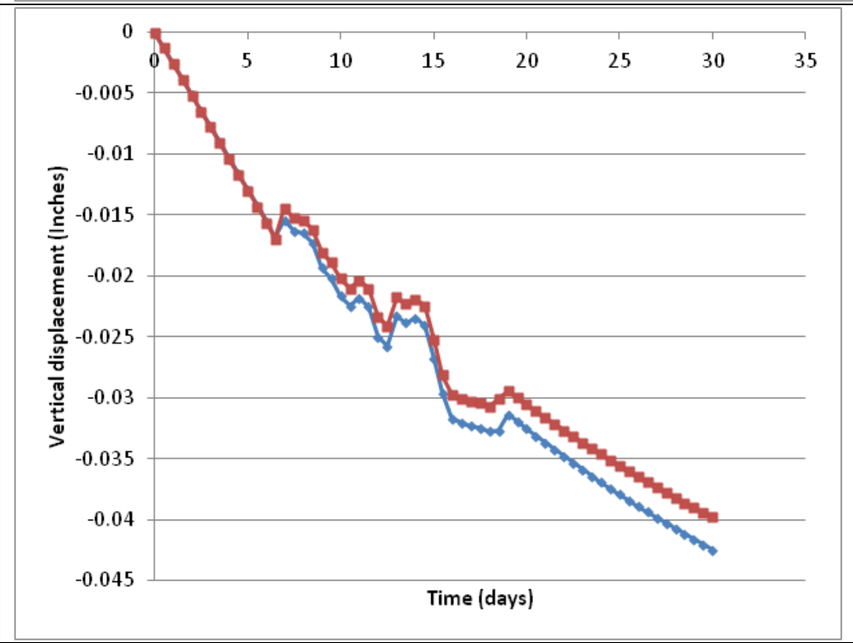
Figure 141. Random small longitudinal cracks

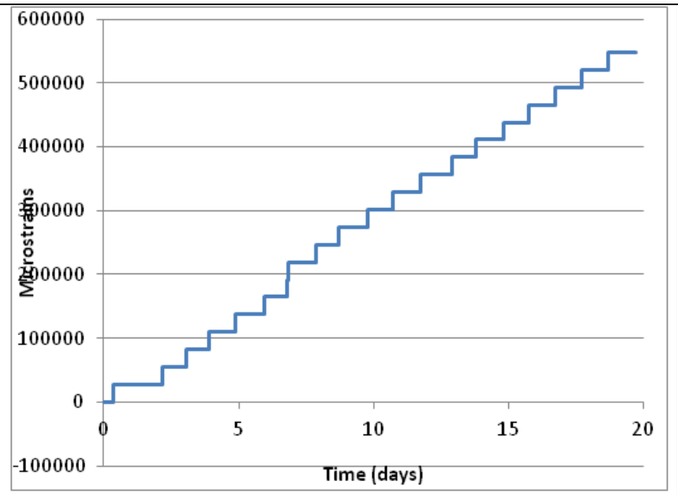
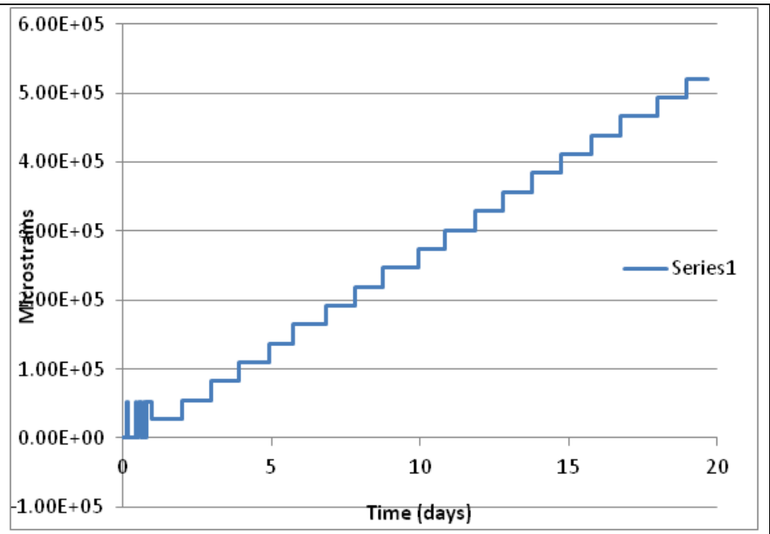
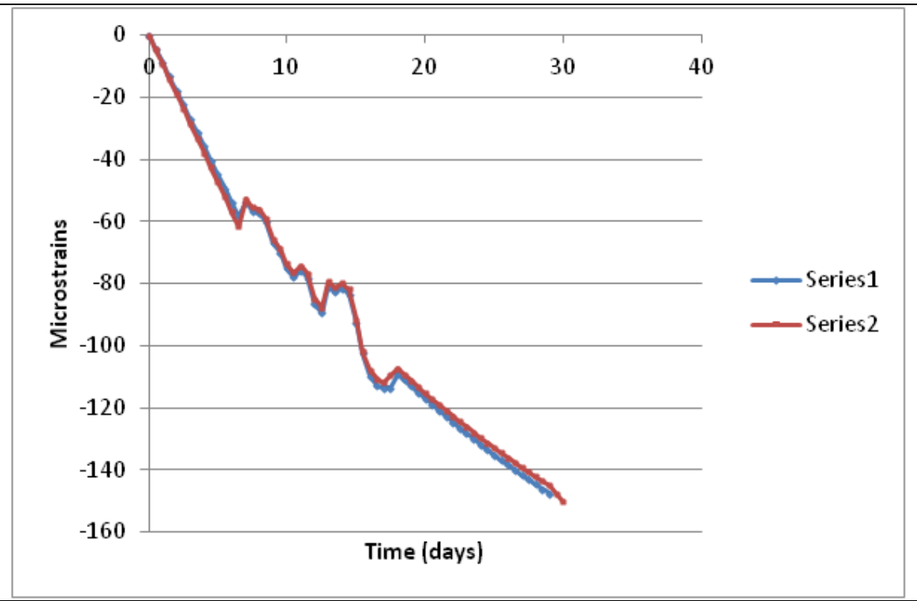
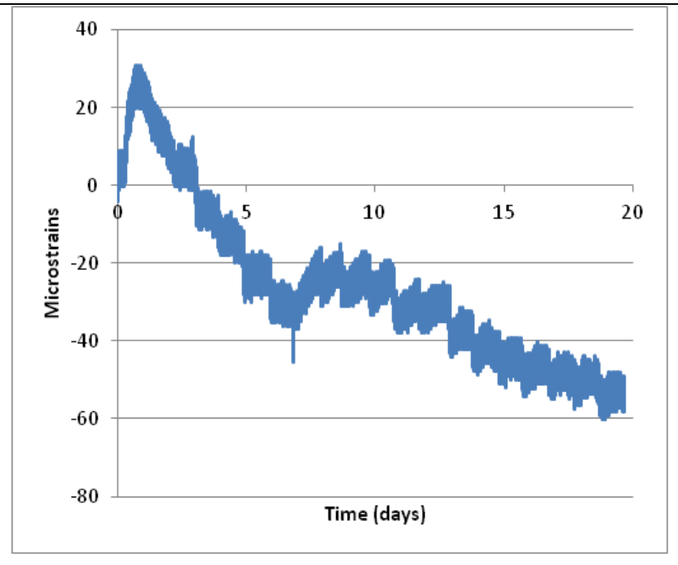
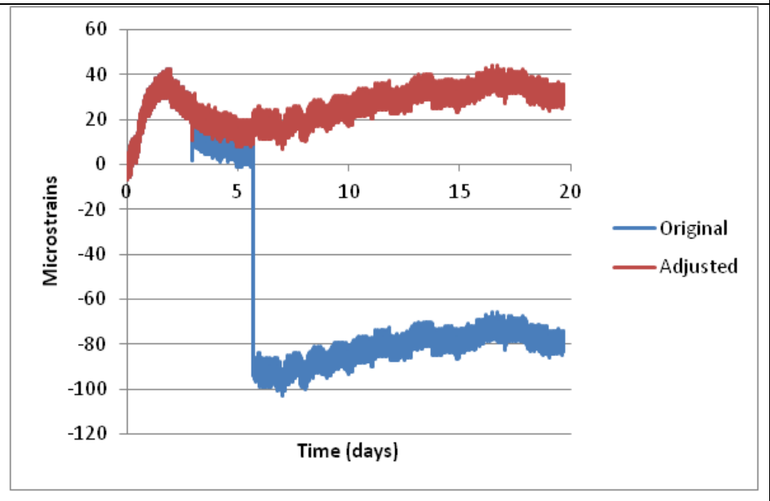
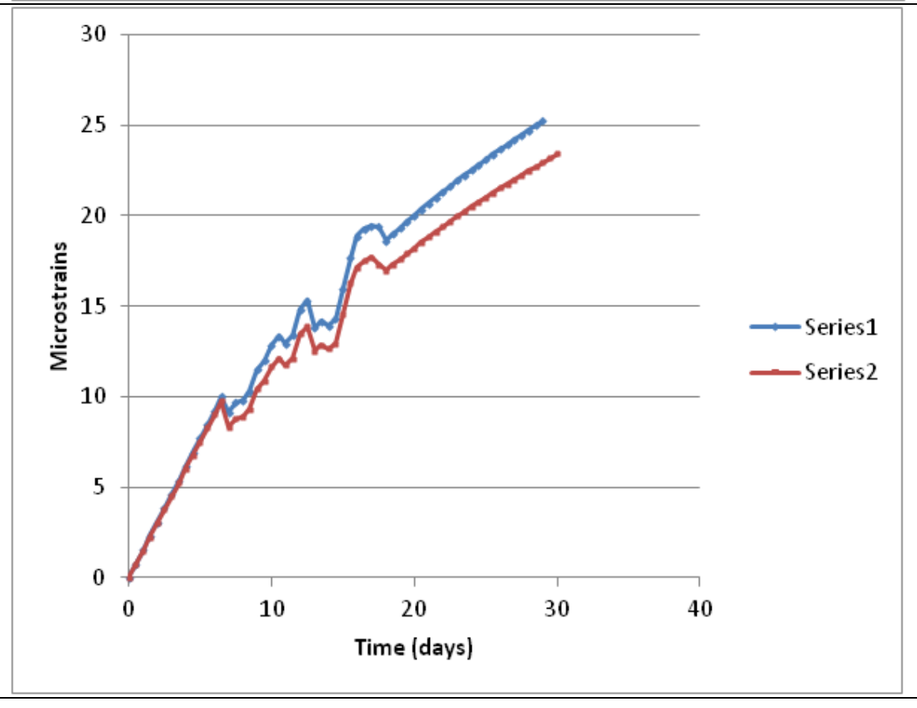
Figure 142. Bridge deck overall view

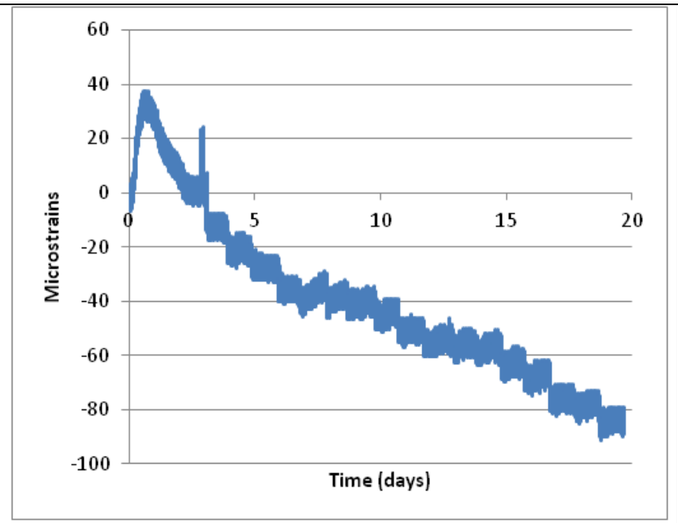
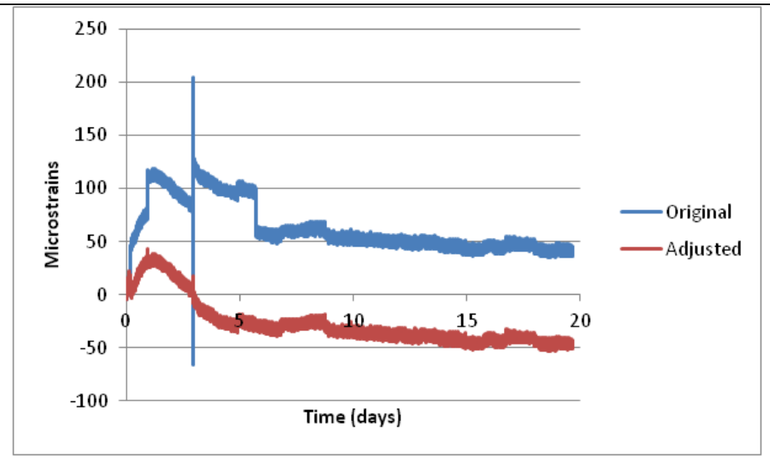
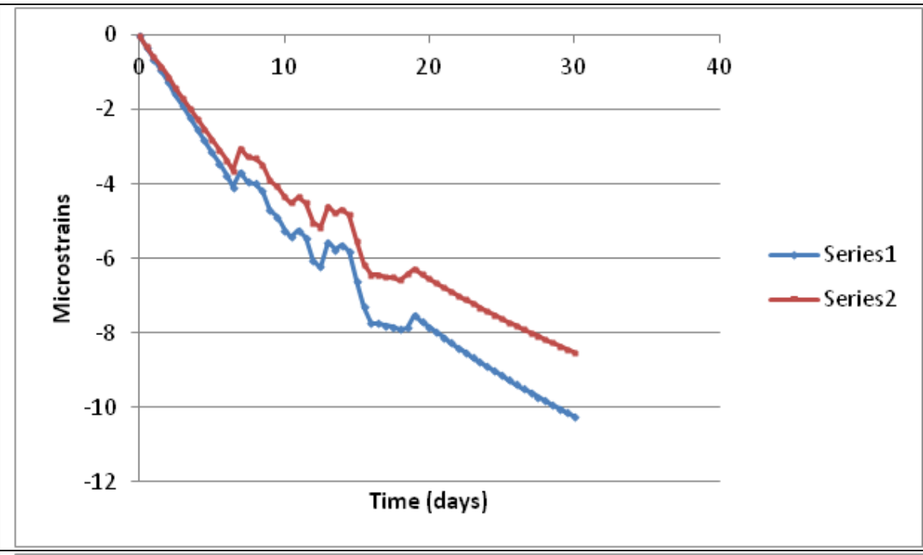
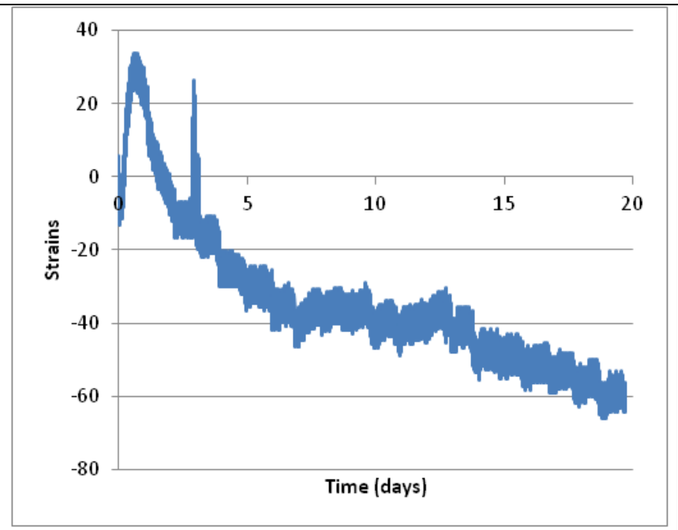
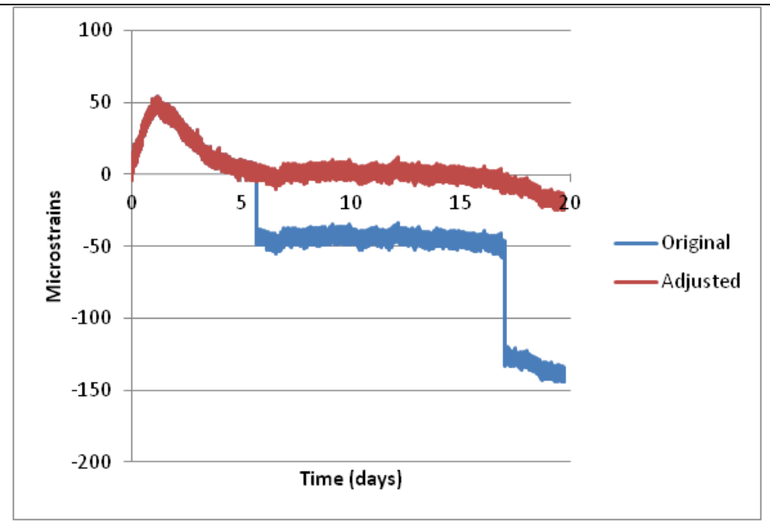
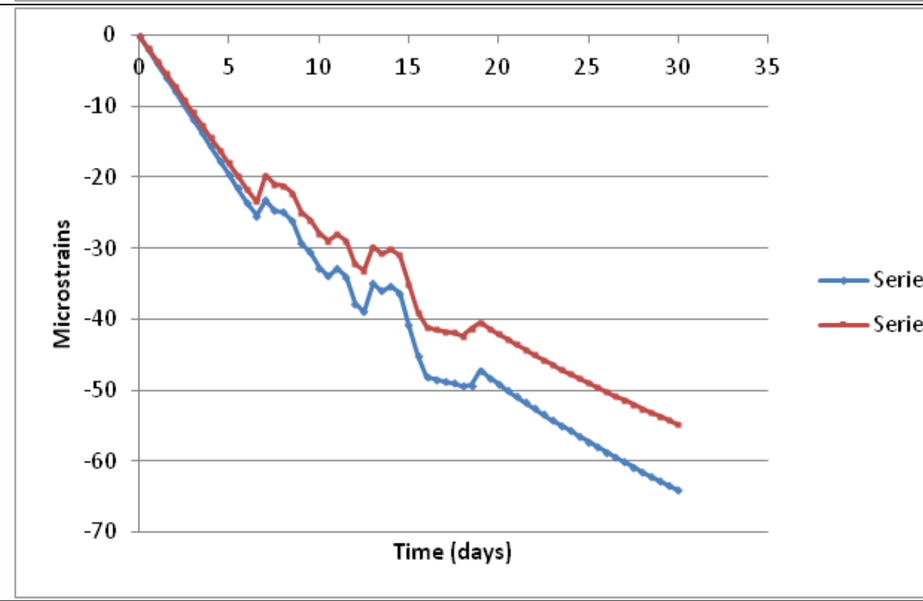
Appendix C

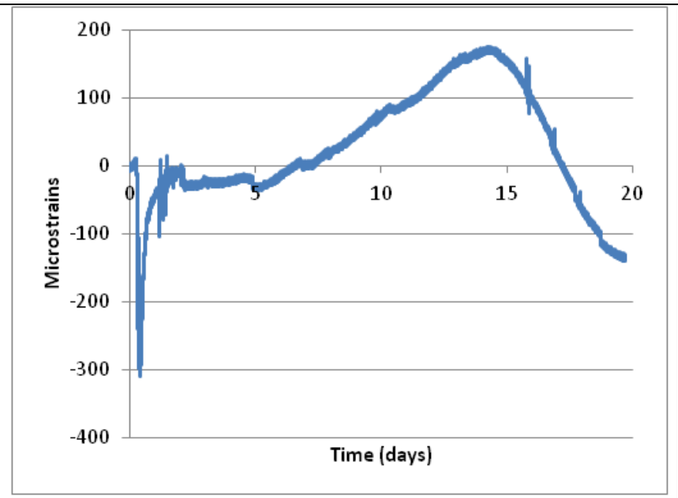
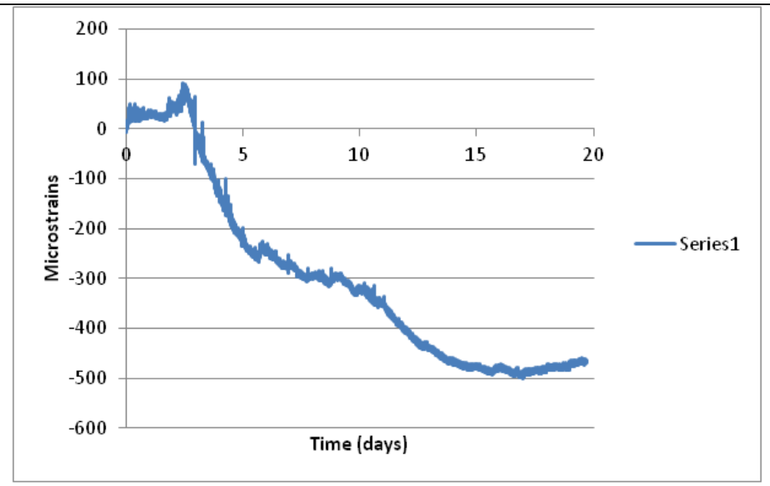
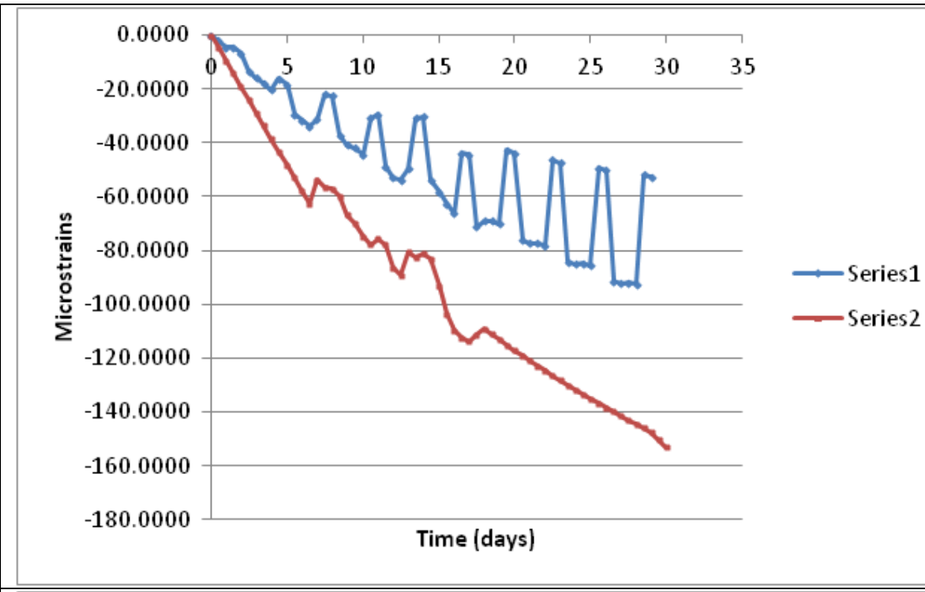
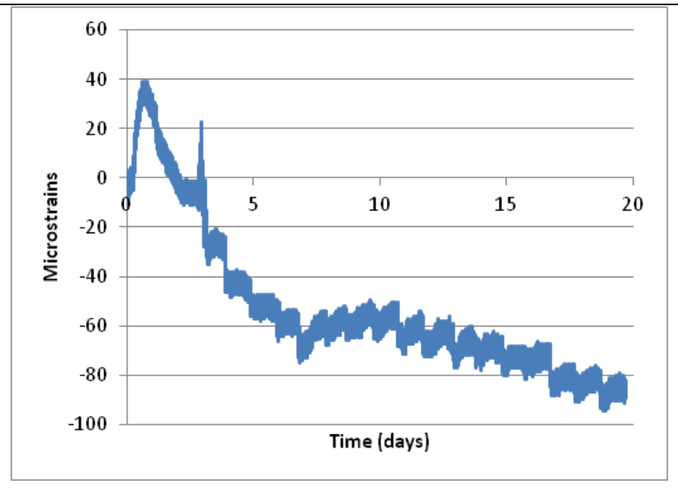
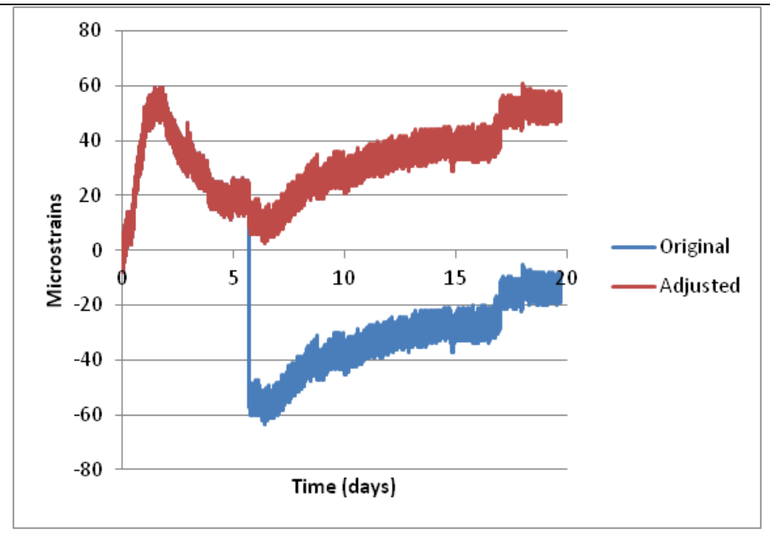
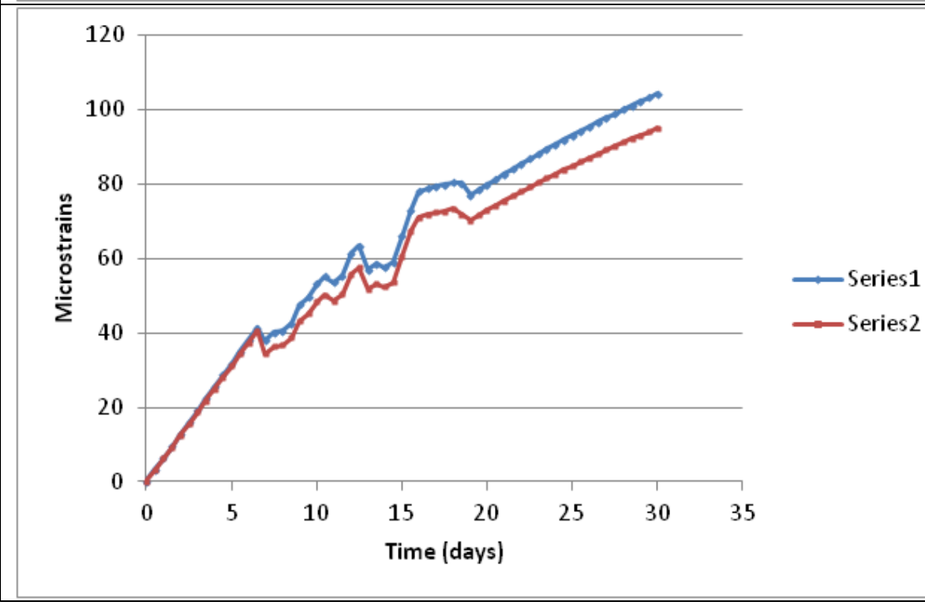
Laboratory Slab Models Full Data Set

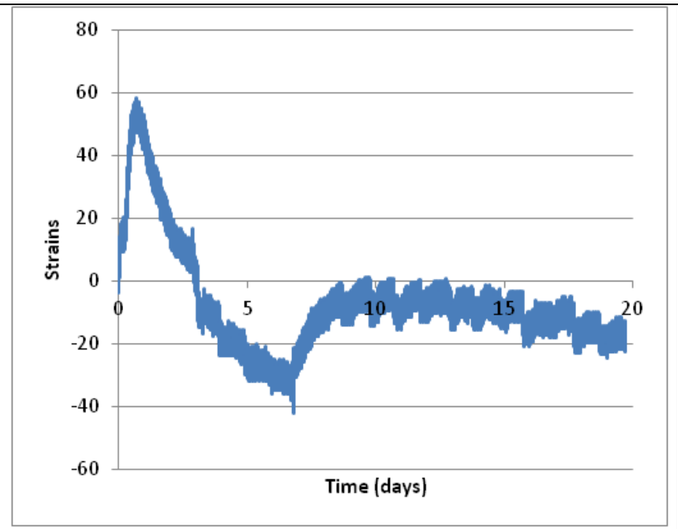
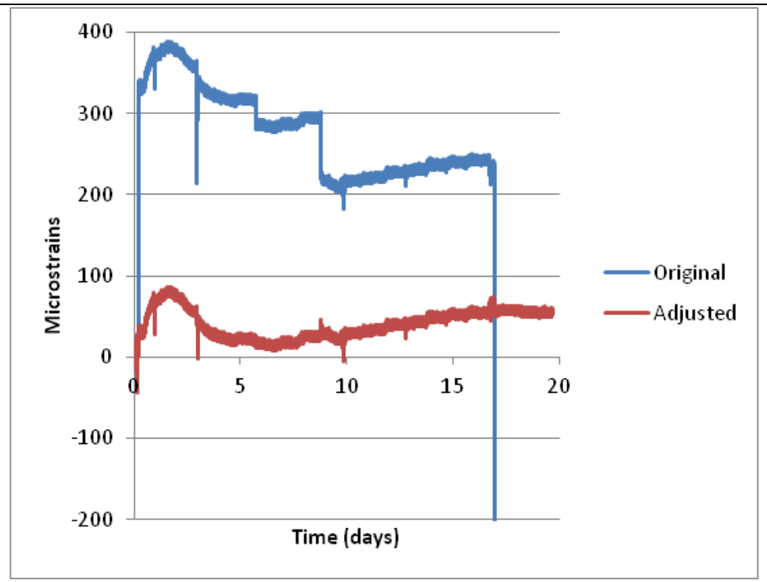
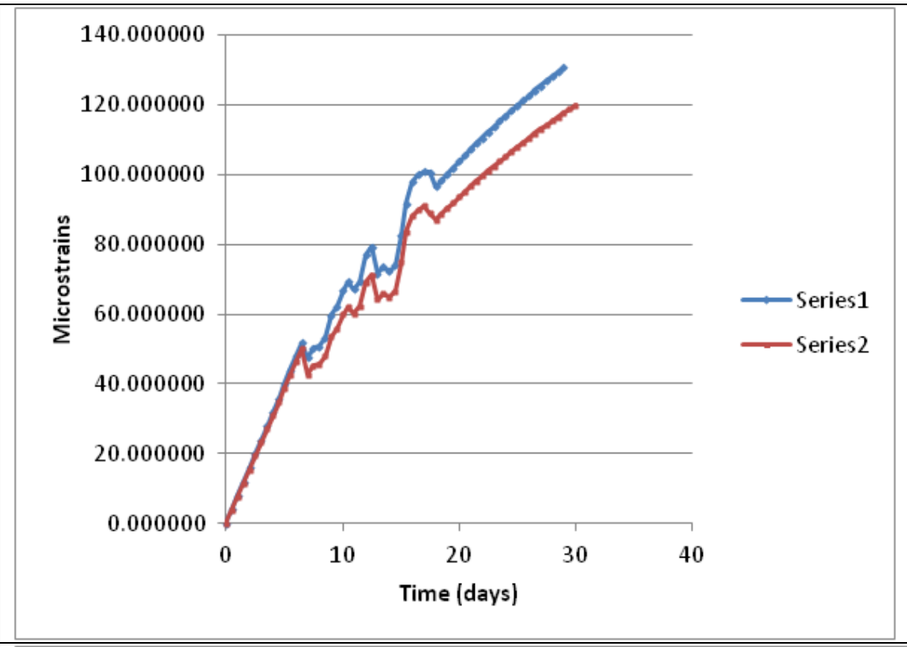
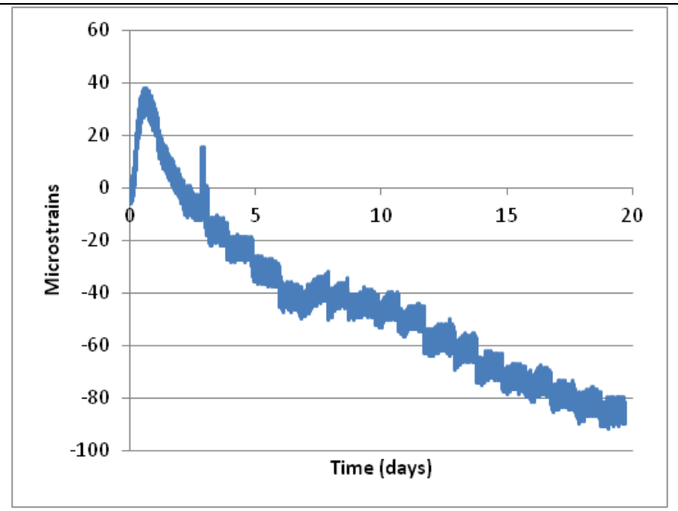
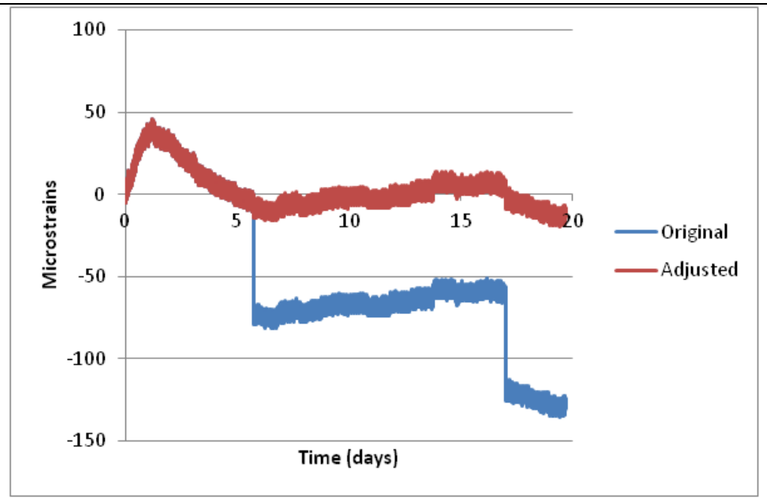
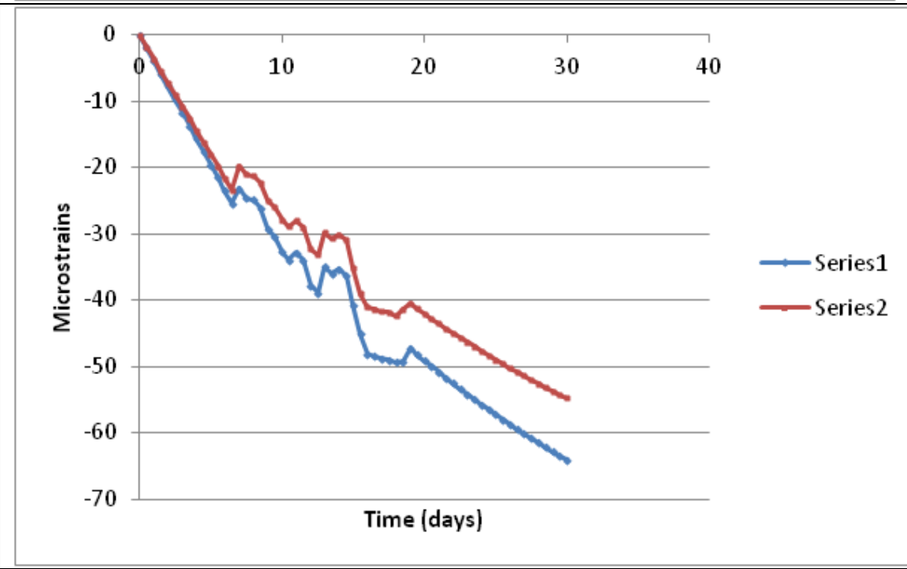
Instrumentation ID	Test Unit 3	Test Unit 4	Computer Model Output
L-G1-1/2			
L-G2-1/2			

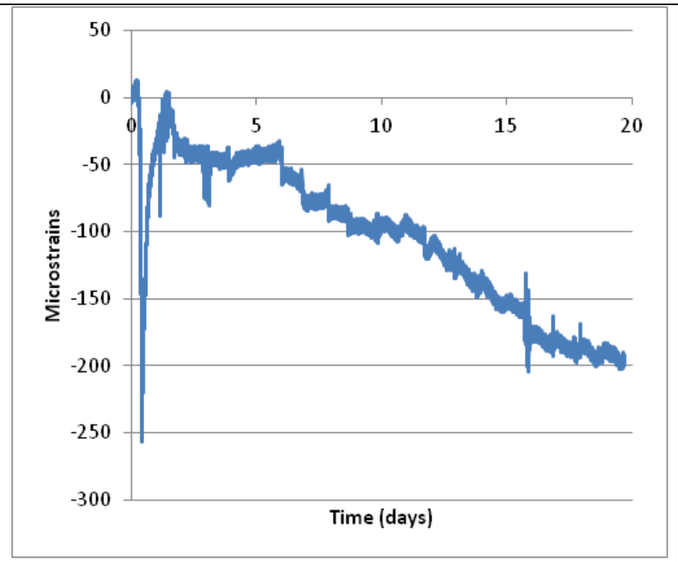
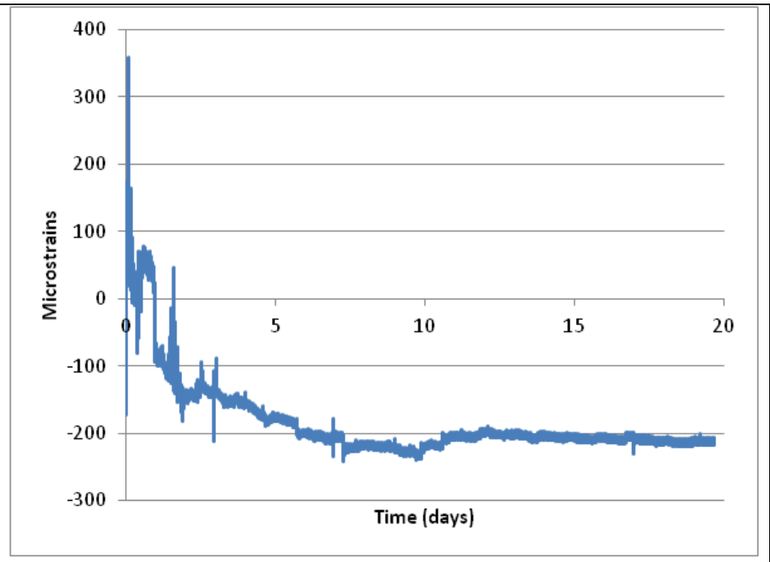
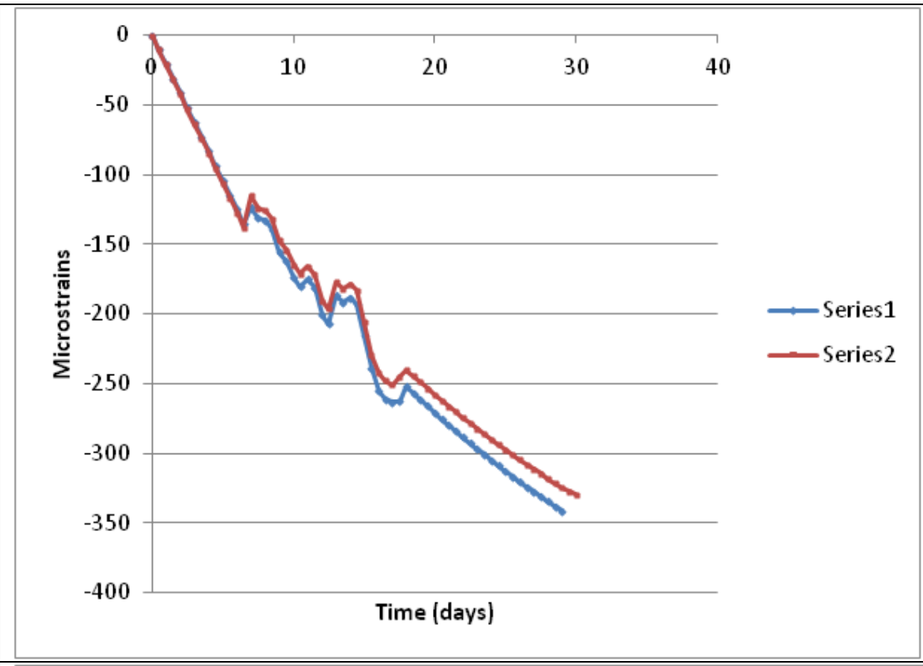
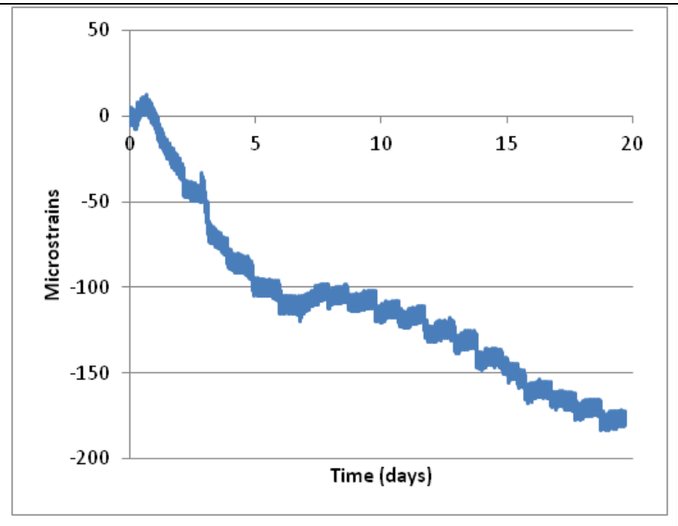
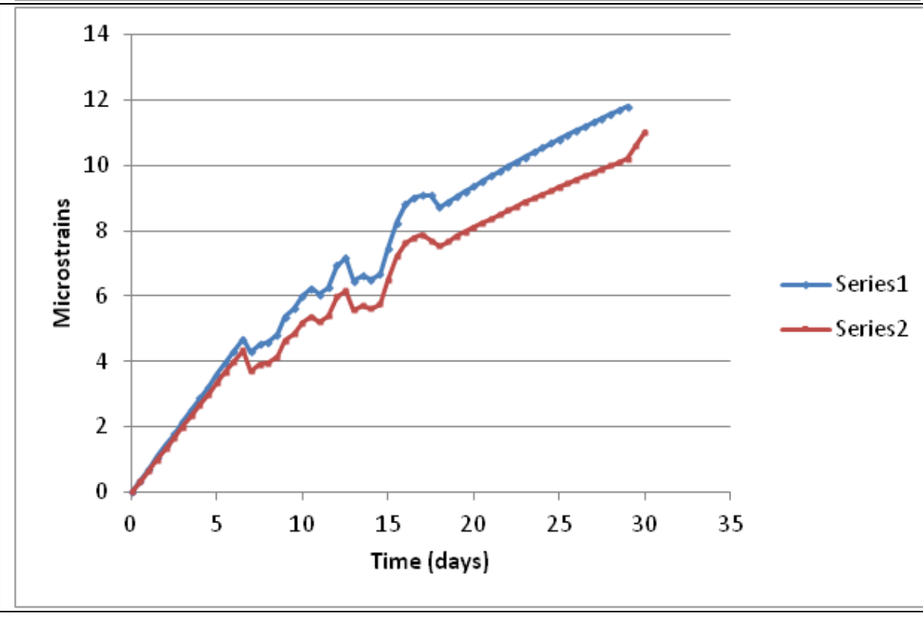
L-1/2-1/2	 Vertical Displacement (Inches) Time (days)	 Vertical Displacement (Inches) Time (days)	 Vertical displacement (Inches) Time (days)
L-1/2-3/4	 Vertical Displacement (inches) Time (days)		 Vertical displacement (Inches) Time (days)

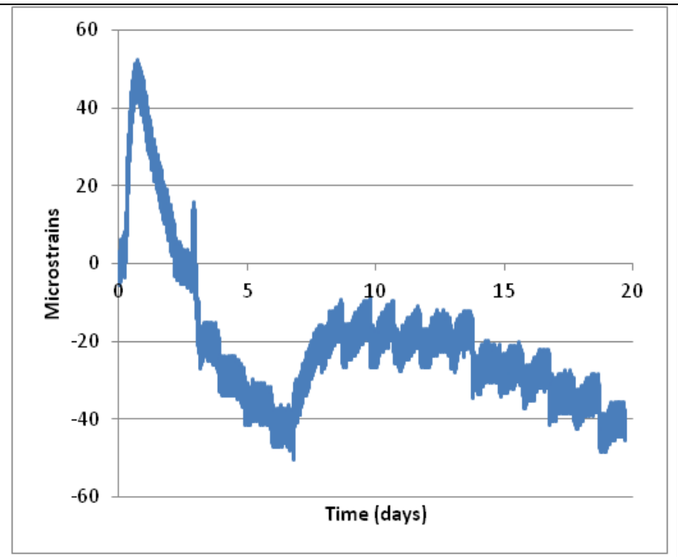
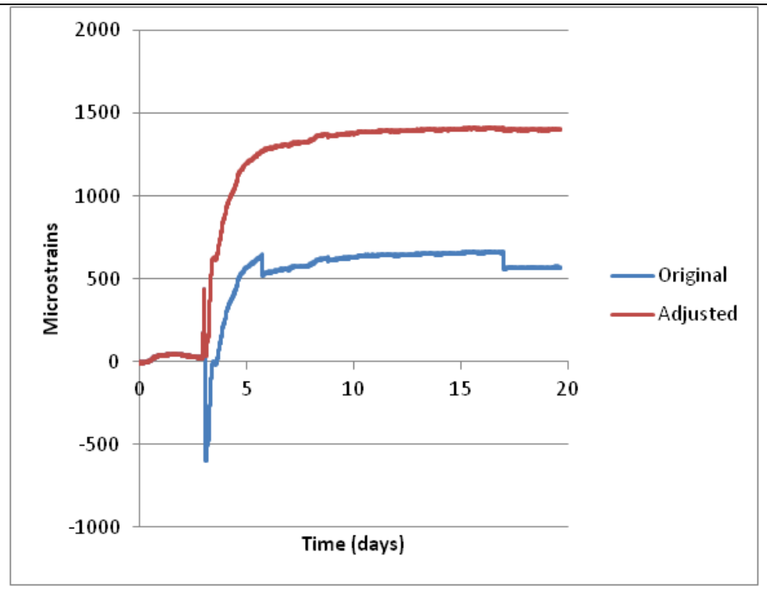
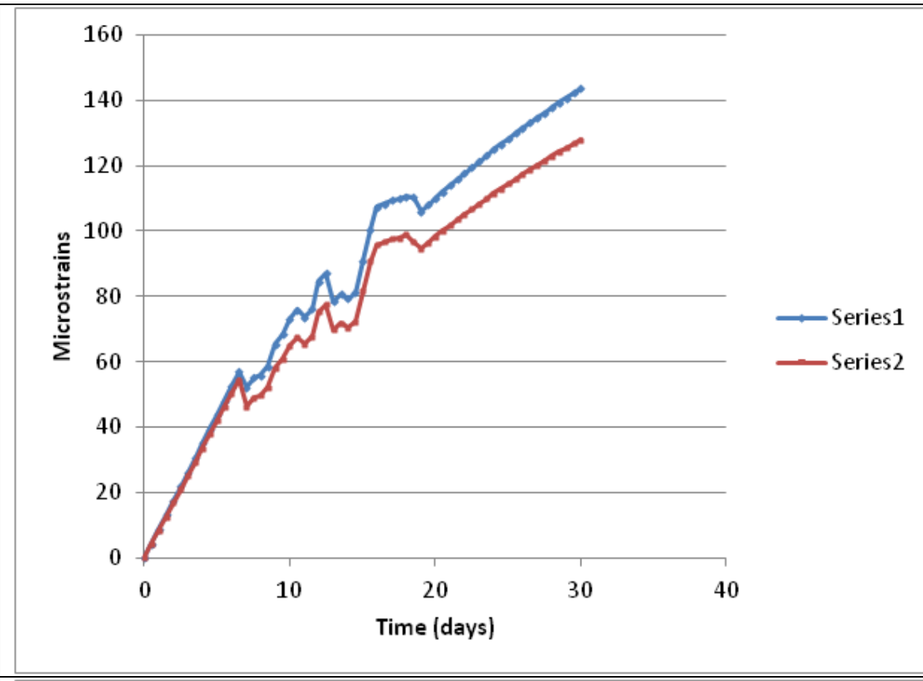
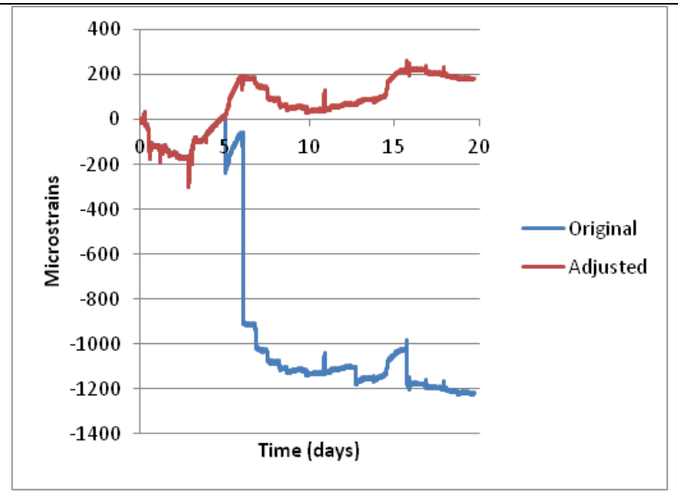
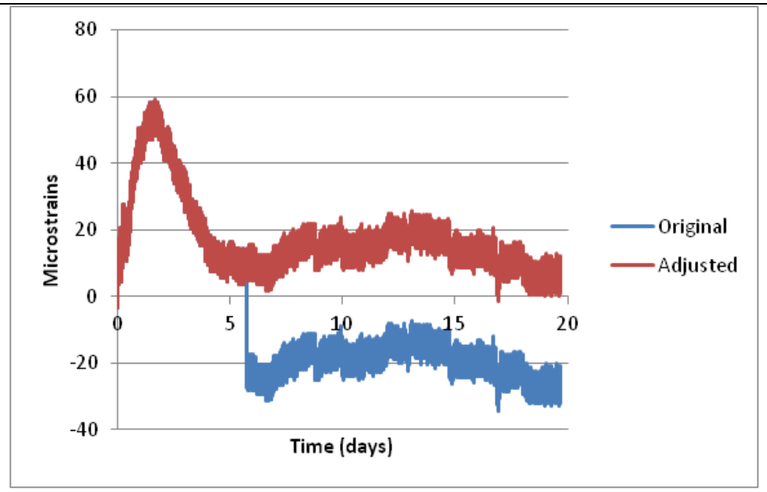
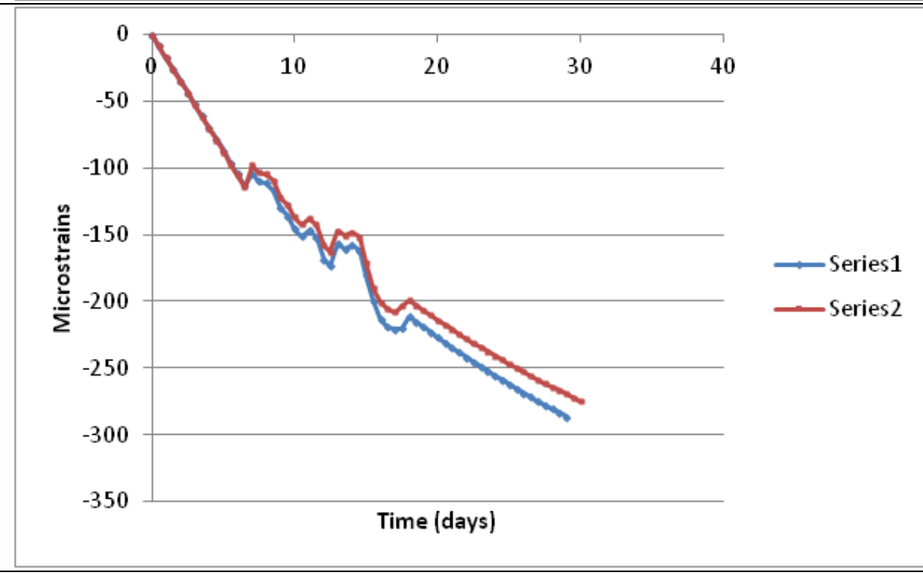
S-G1-Tf-M-3/4-L			
S-G1-Bf-M-3/4-L			

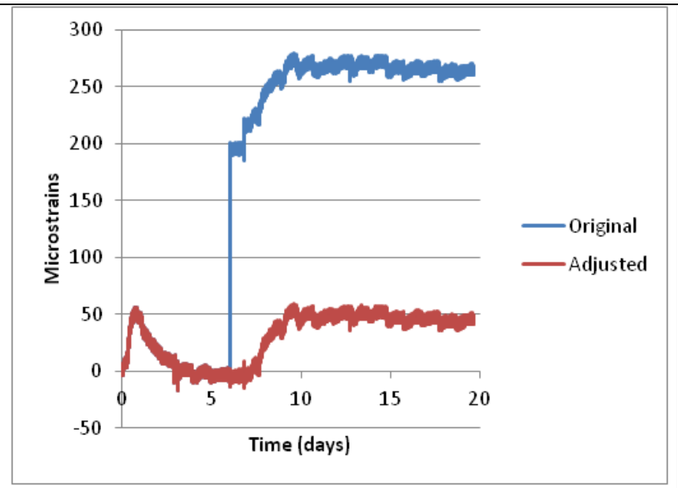
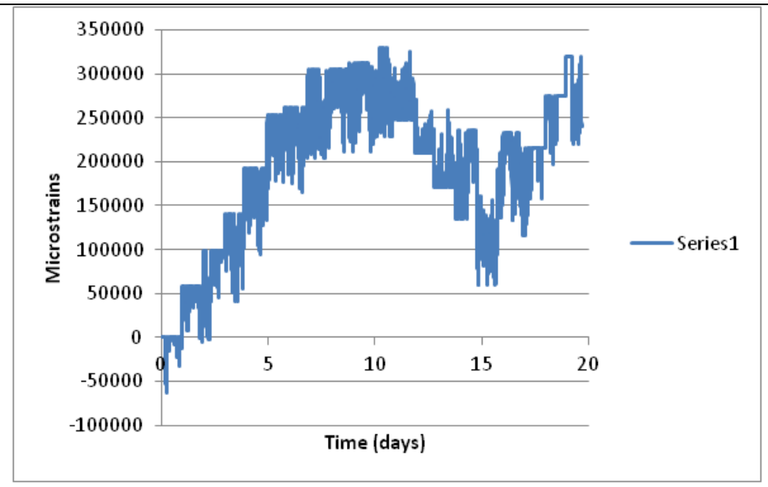
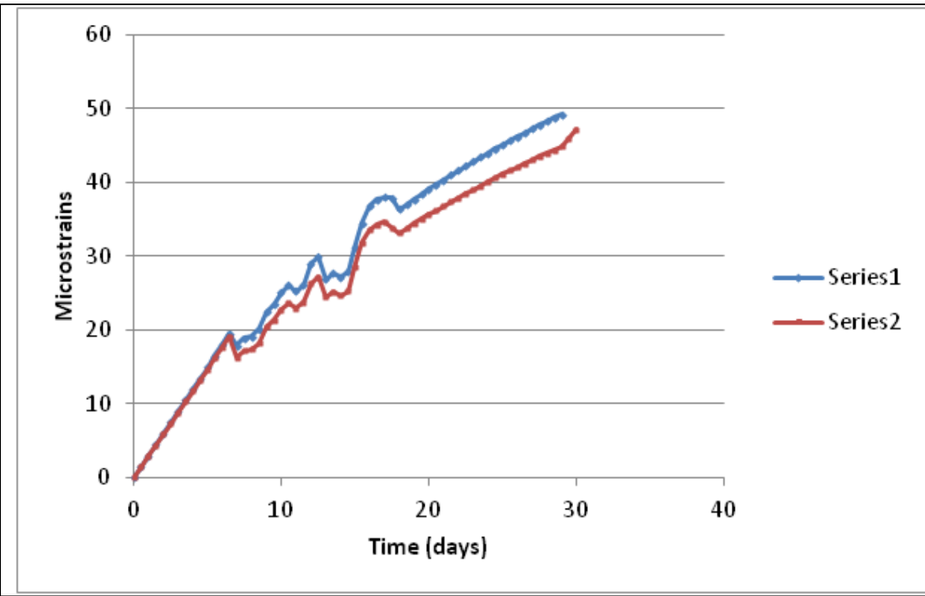
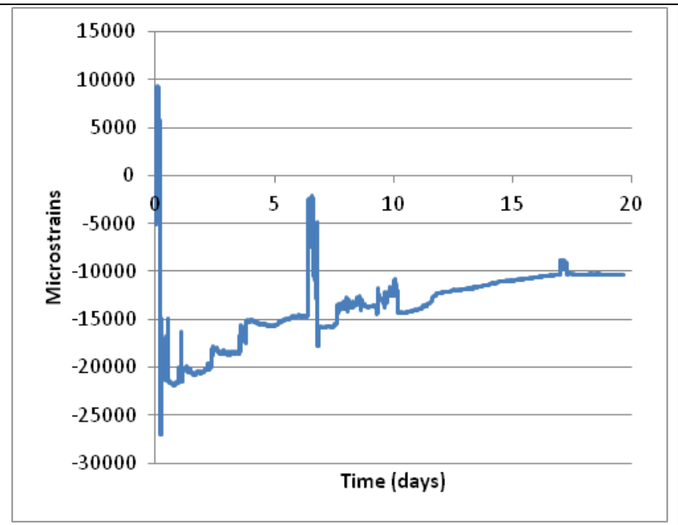
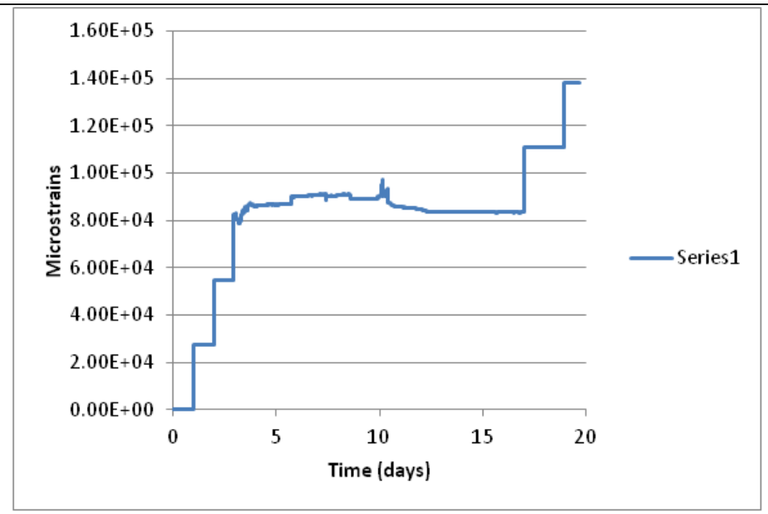
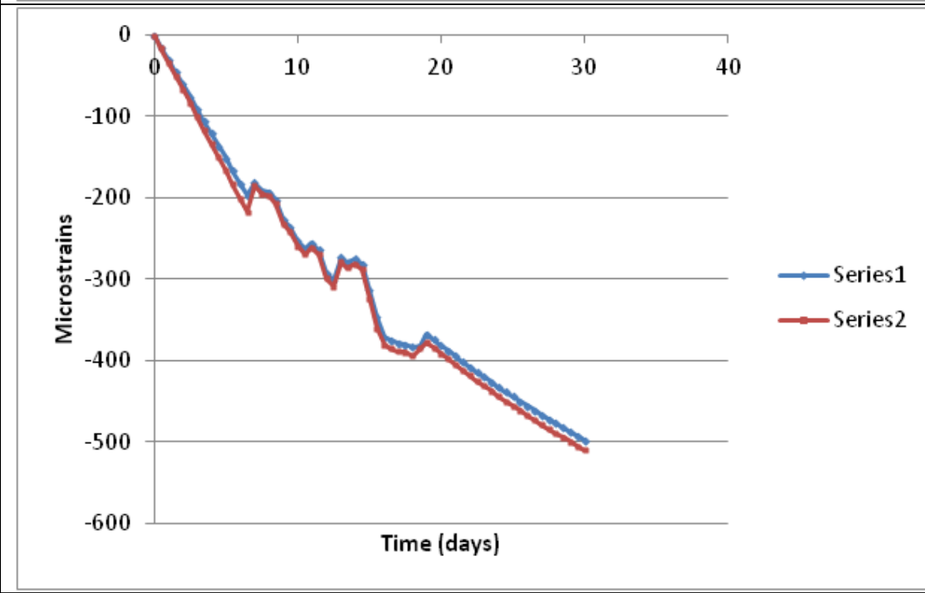
S-G1-W-O-3/4-L			
S-G1-W-O-1/2-L			

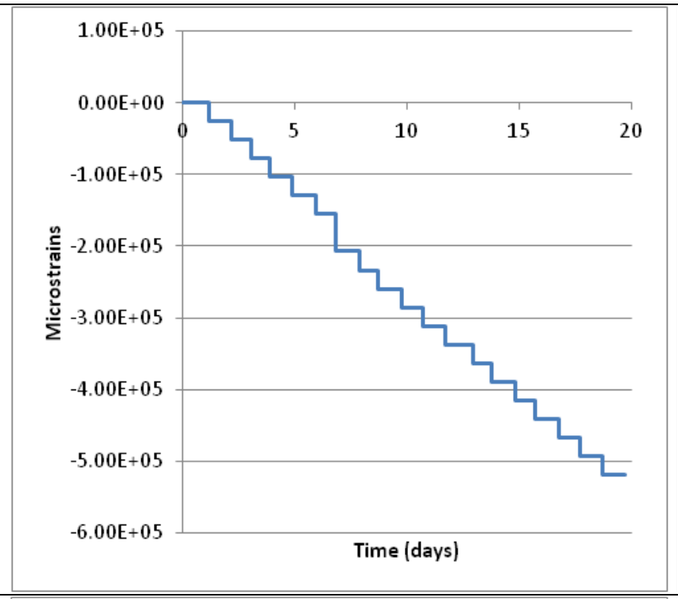
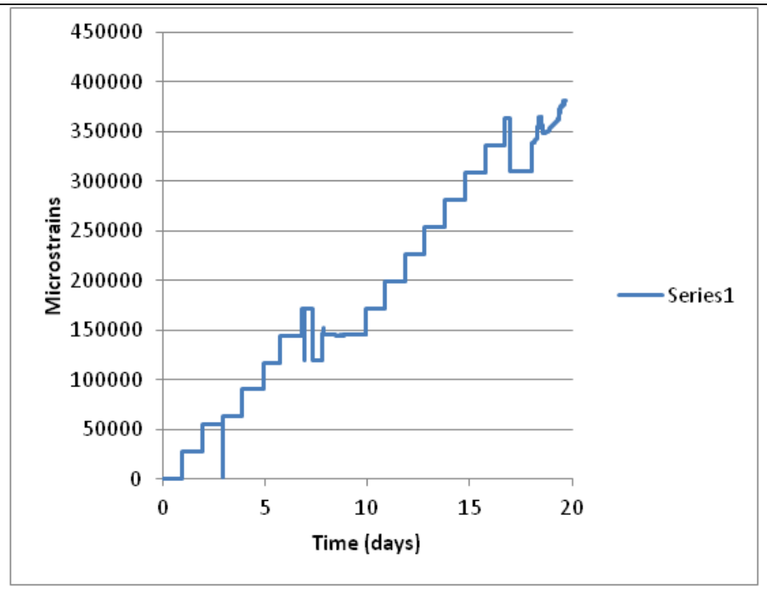
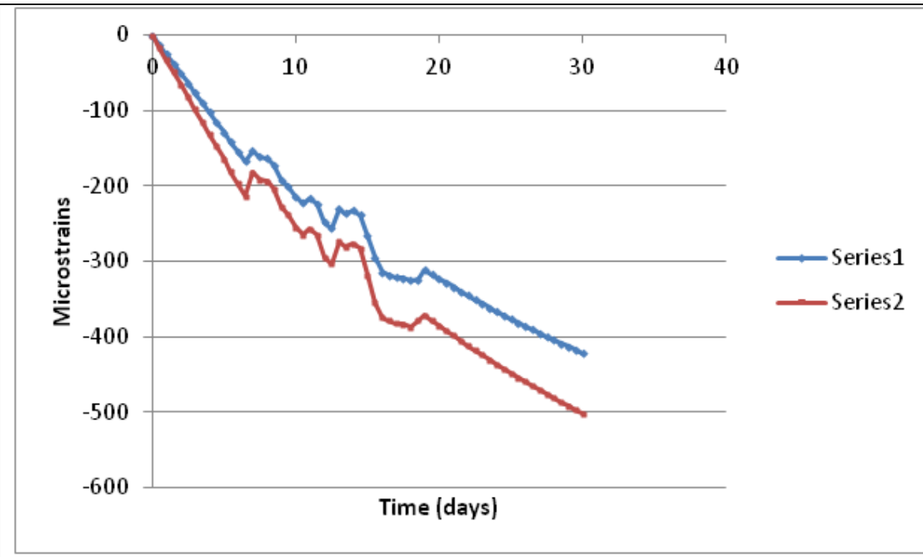
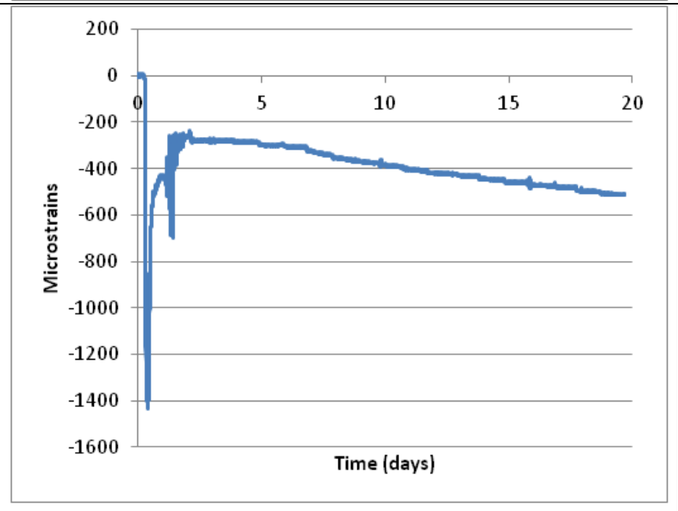
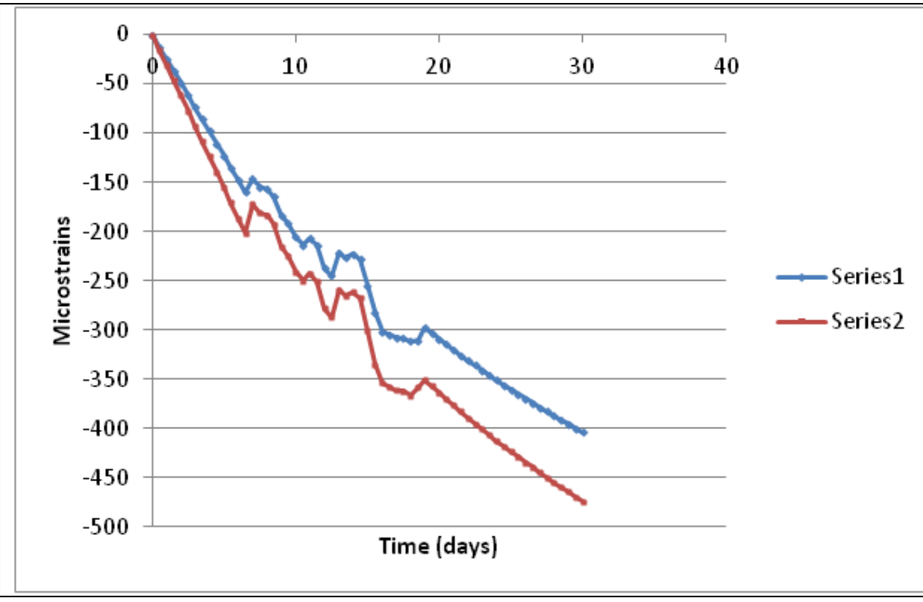
S-G1-Tf-M-1/4-L			
S-G1-Bf-I-1/2-L			

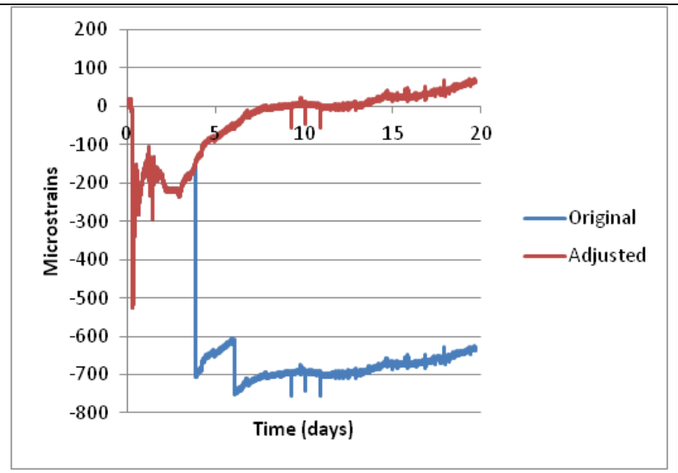
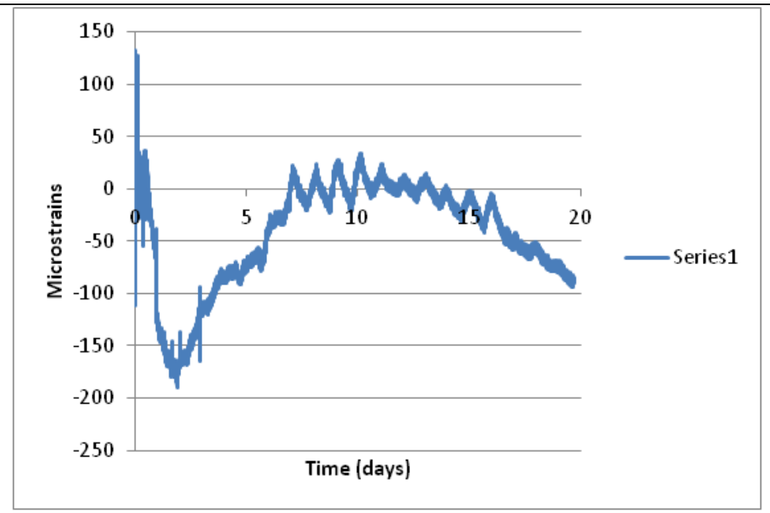
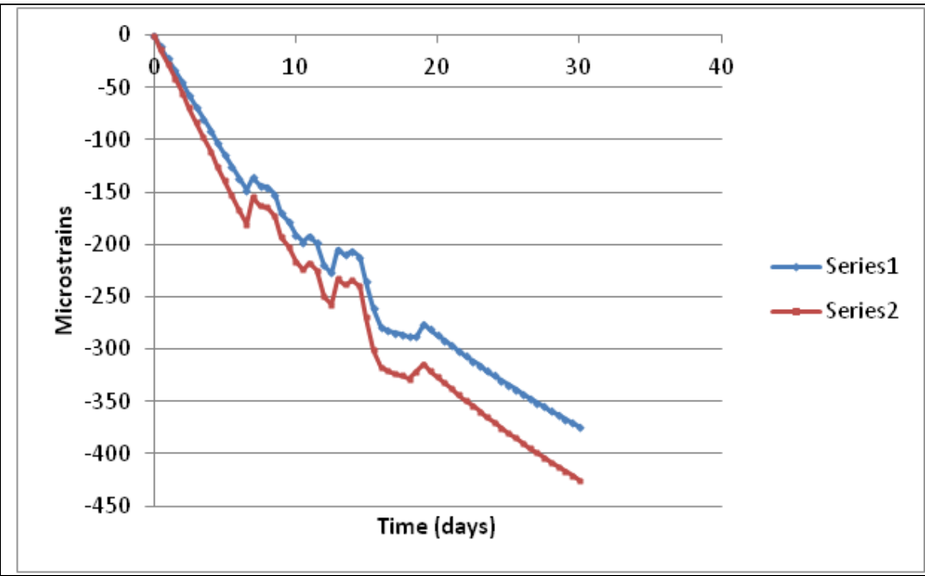
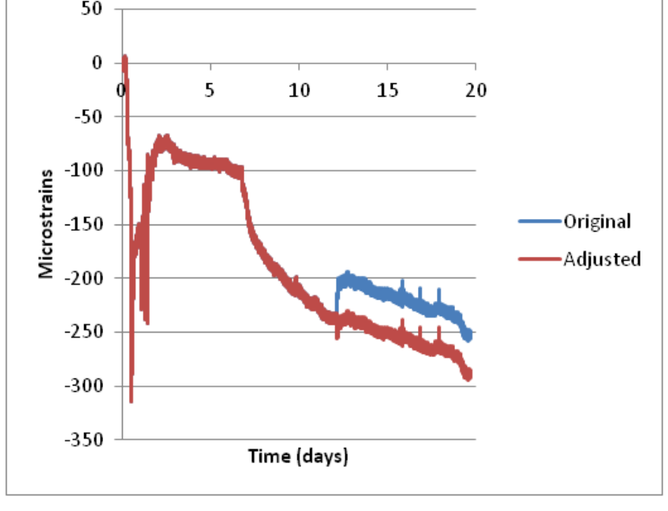
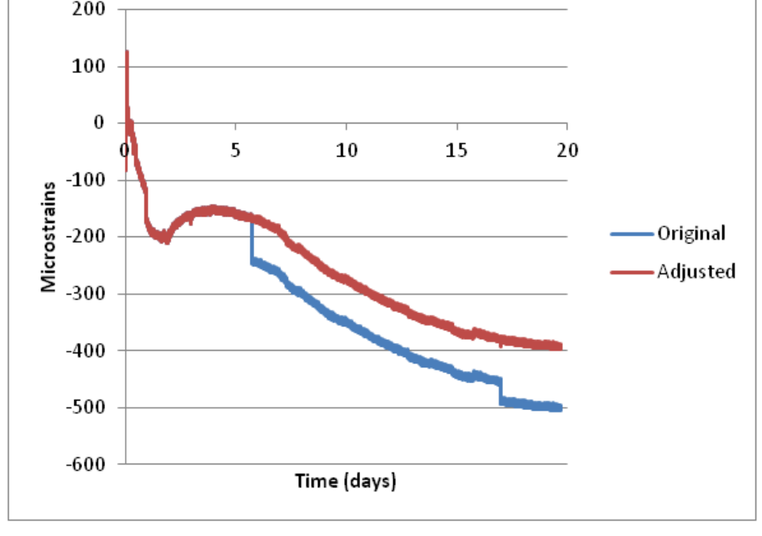
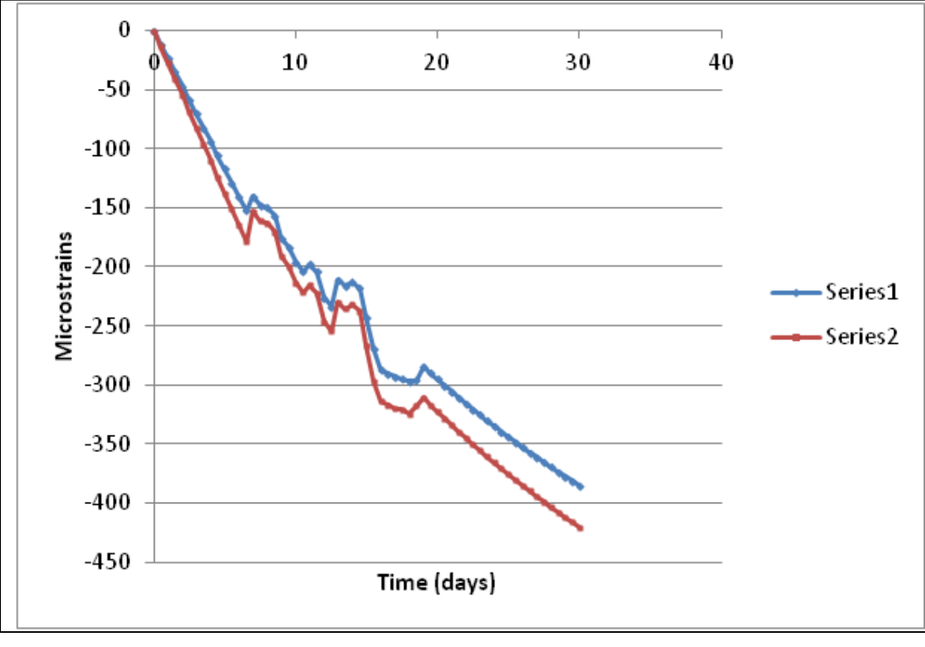
S-G1-Bf-M-1/2-L			
S-G1-W-I-1/2-L			

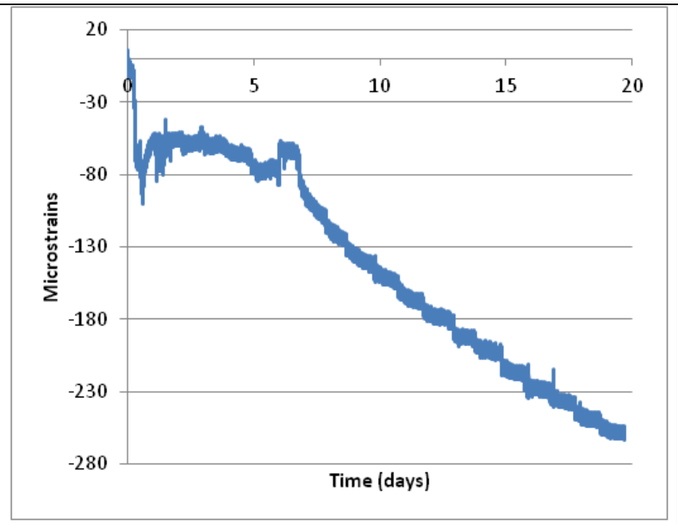
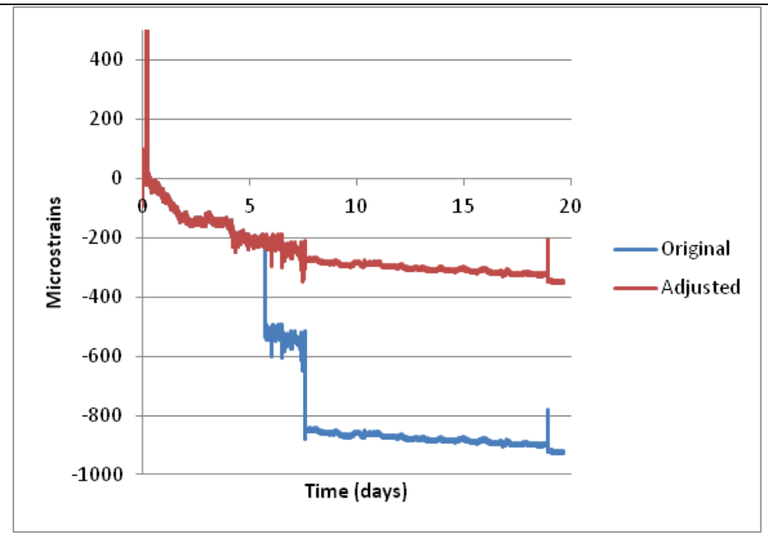
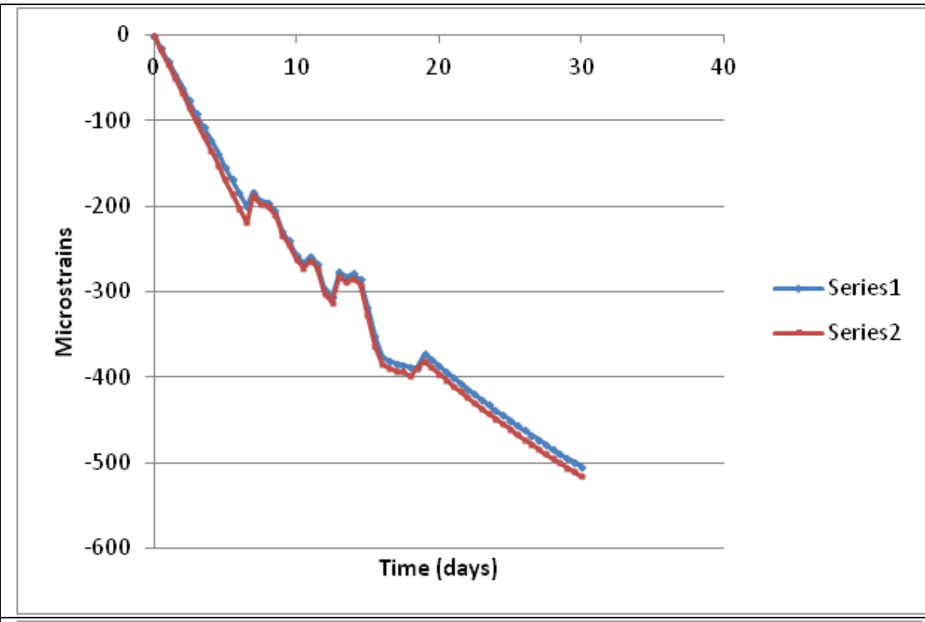
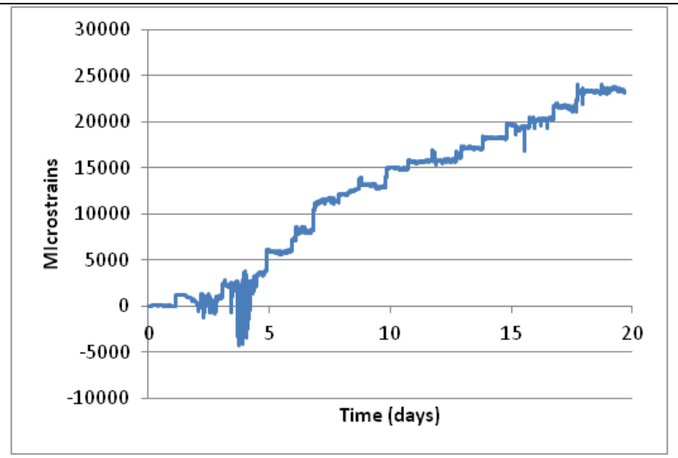
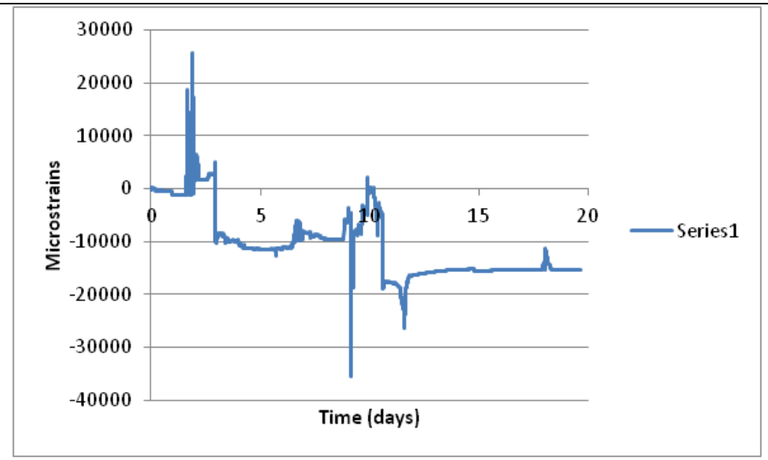
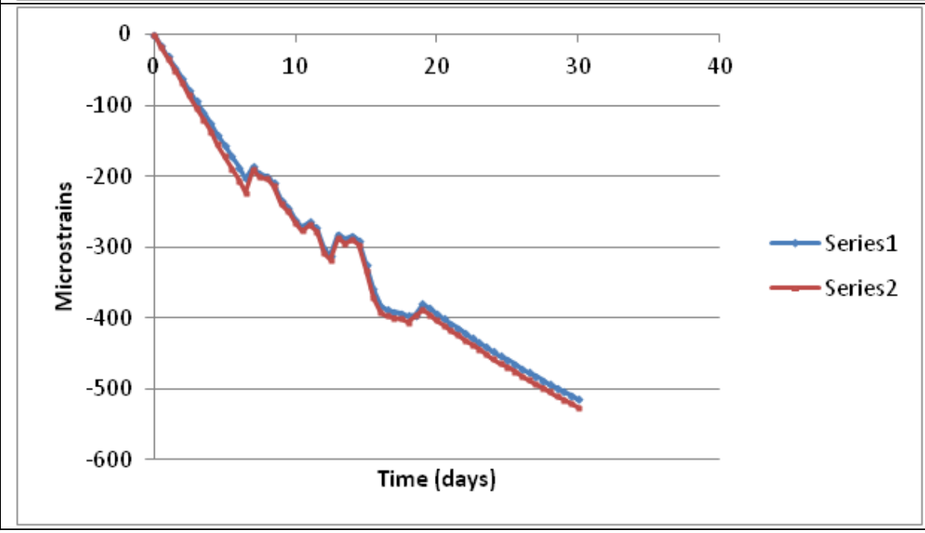
S-G1-Tf-M-1/2-L			
S-G1-Bf-M-1/4-L			

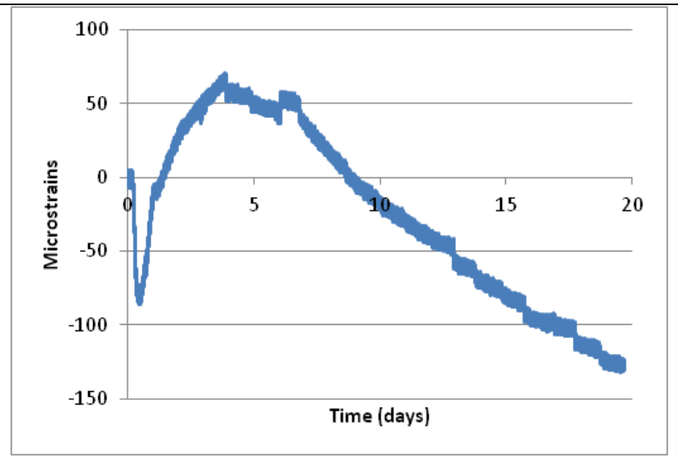
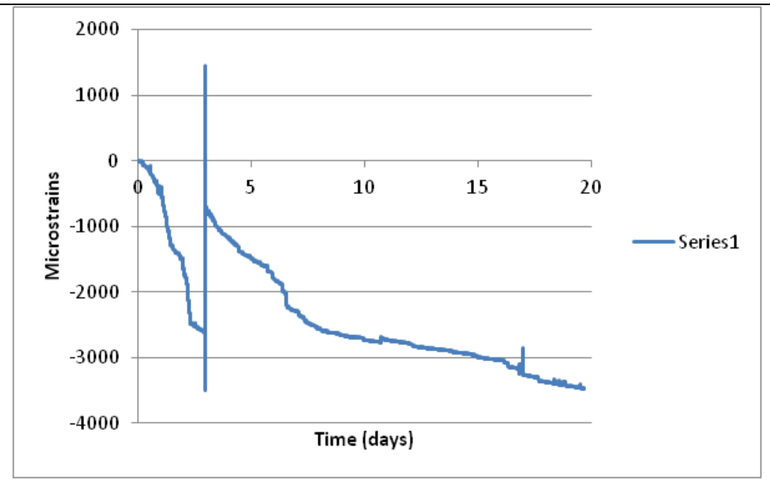
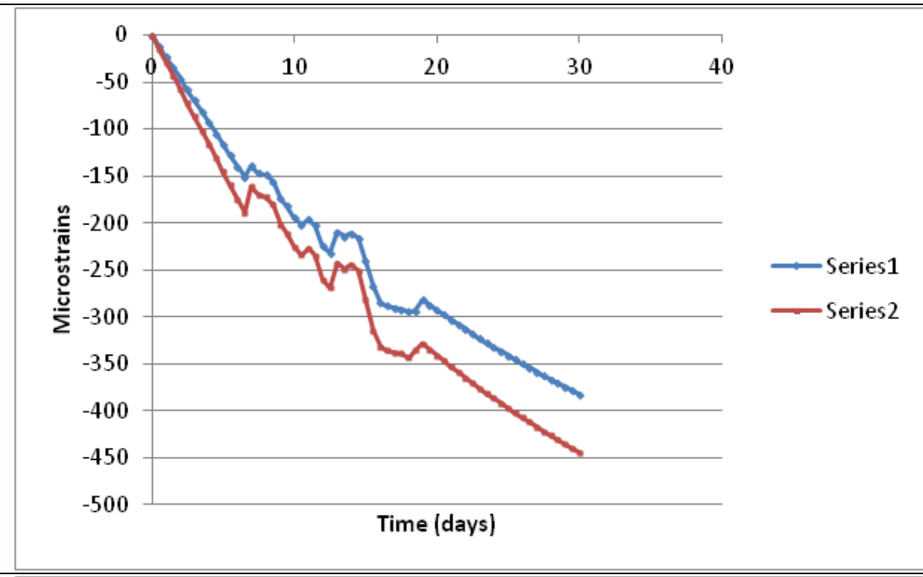
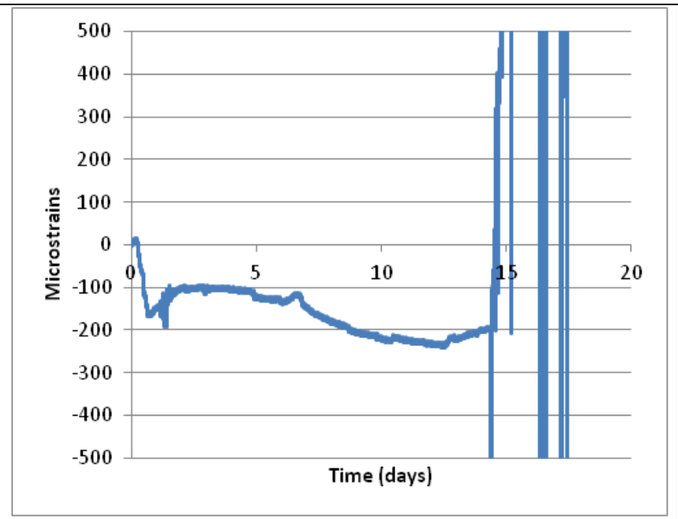
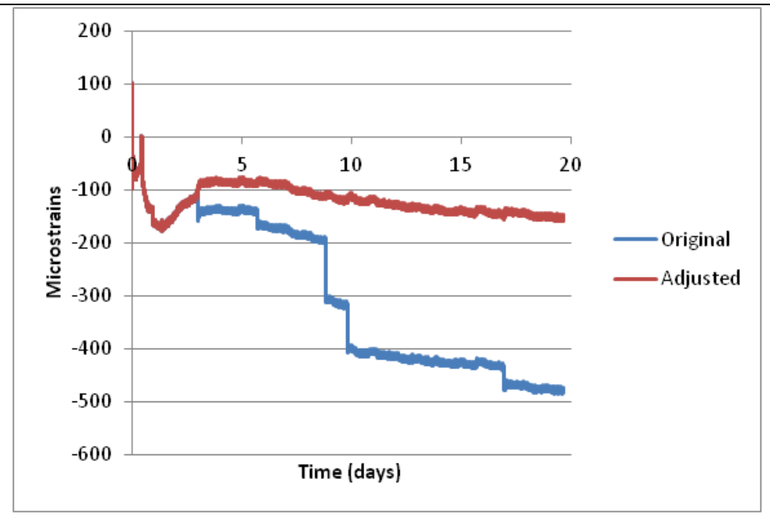
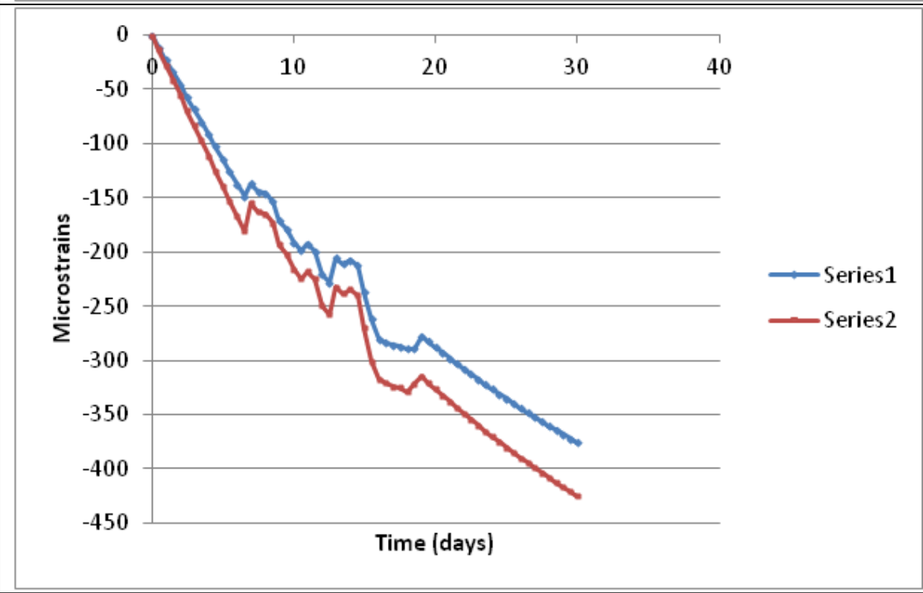
S-G1-Bf-O-1/2-L			
S-G2-Tf-M-1/2-L			

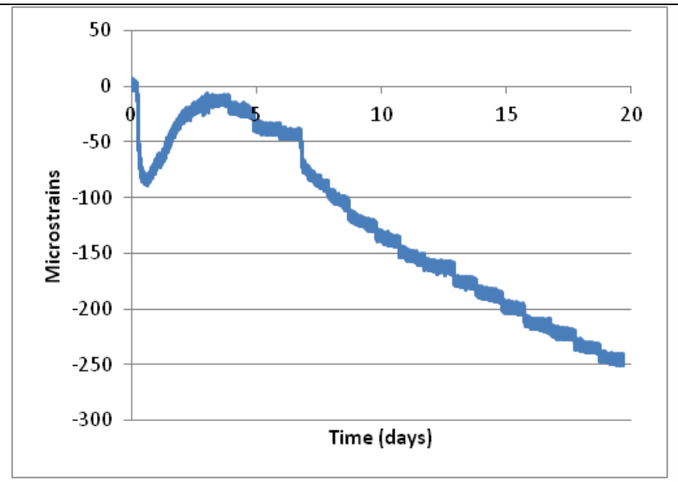
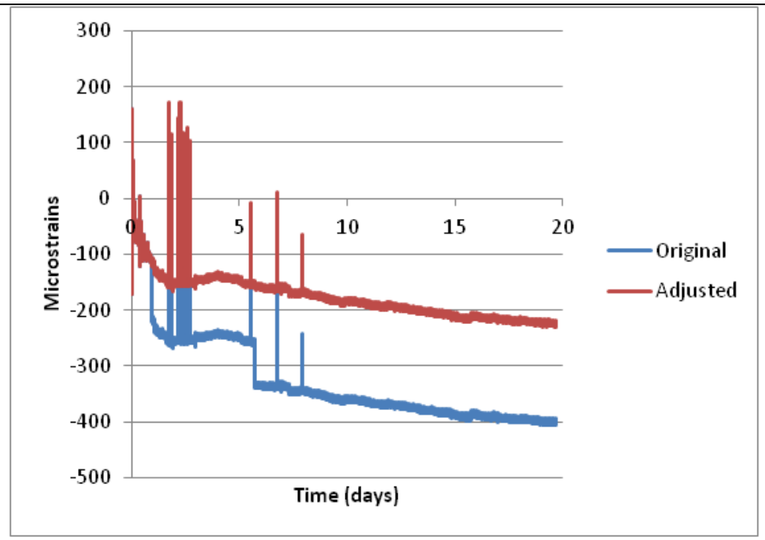
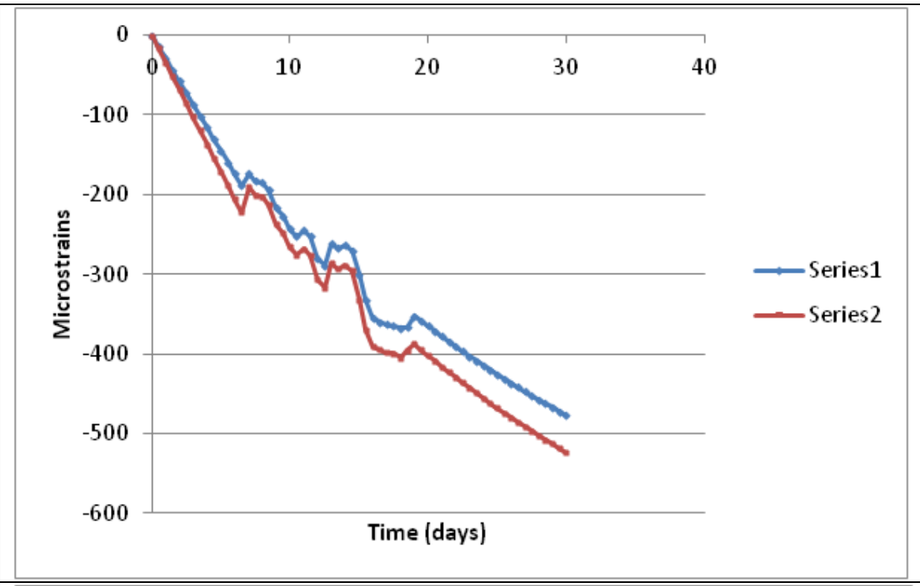
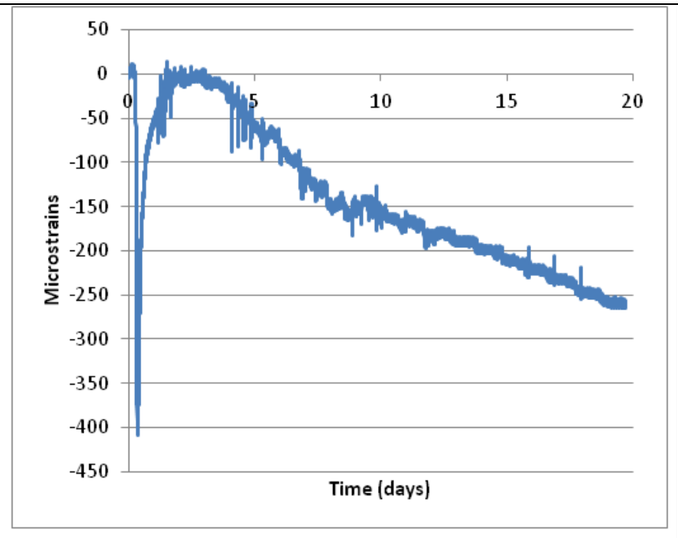
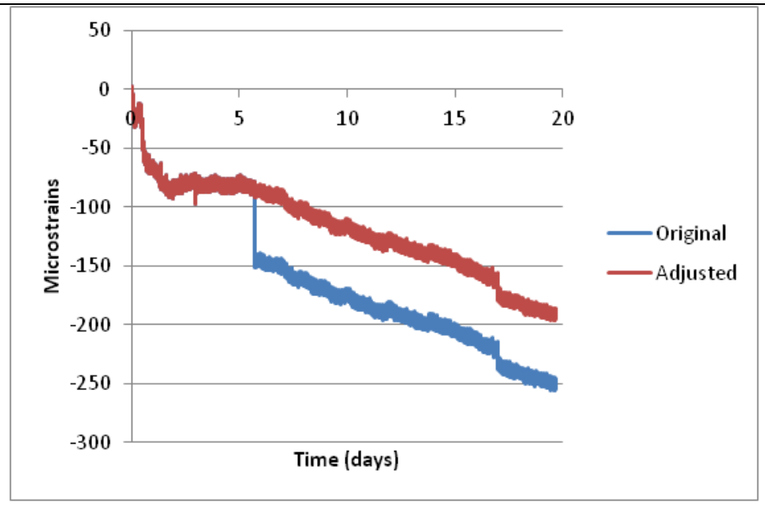
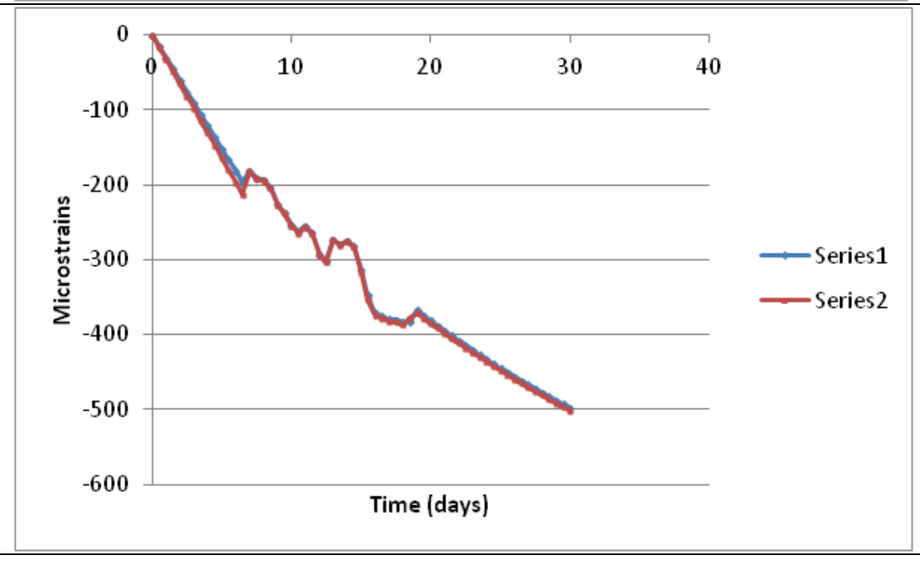
S-G2-Bf-M-1/2-L			
S-Tp-G1-1/2-L			

S-Tp-1/2-1/2-T			
S-Tp-1/2-1/4-T			

S-Tp-1/2-3/4-L			
S-Tp-1/2-1/2-L			

S-Tp-G2-1/2-L			
S-Tp-G1-3/4-L			

S-Tp-1/3-3/4-L			
S-Tp-1/2-1/4-L			

S-Tp-G1-1/4-T			
S-Tp-G1-1/2-T			

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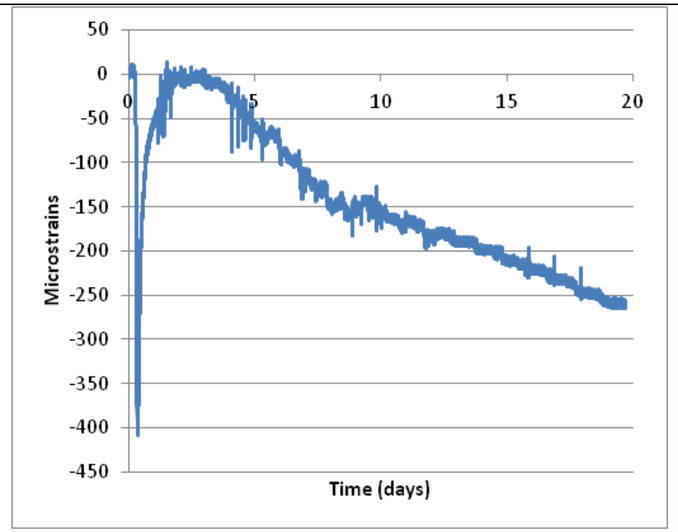

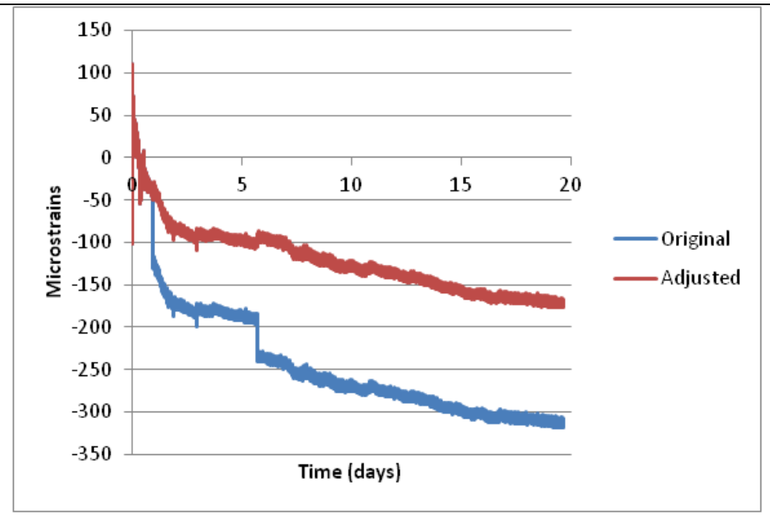

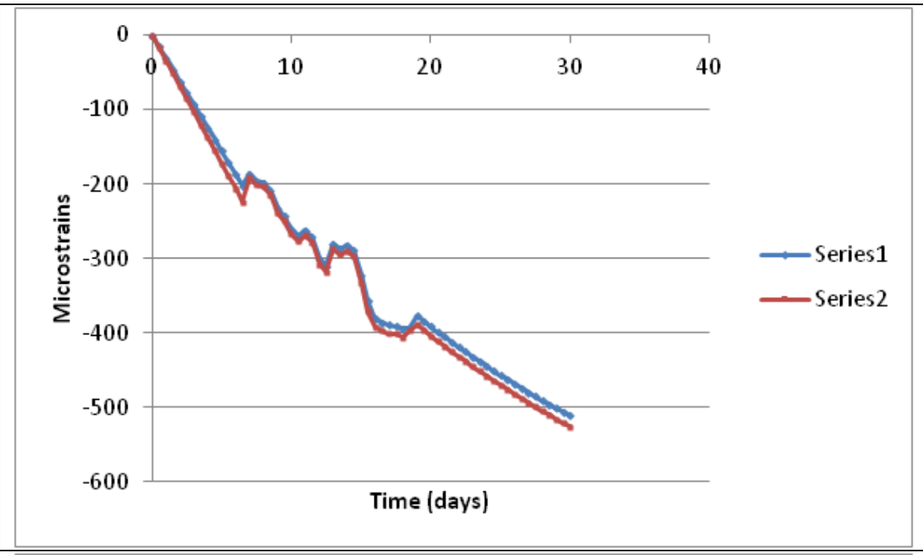

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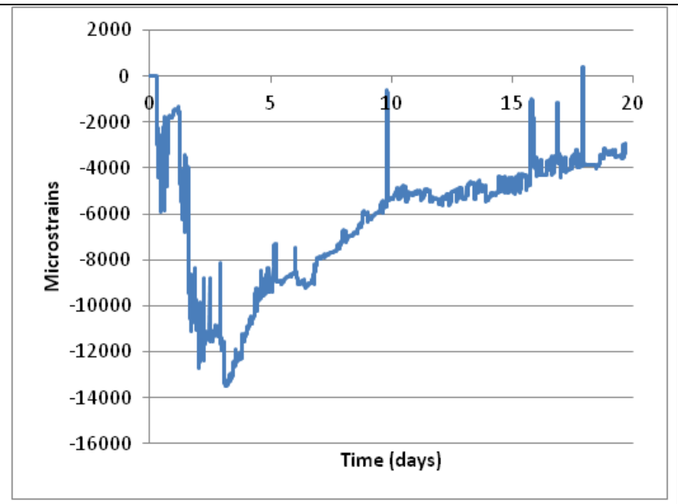
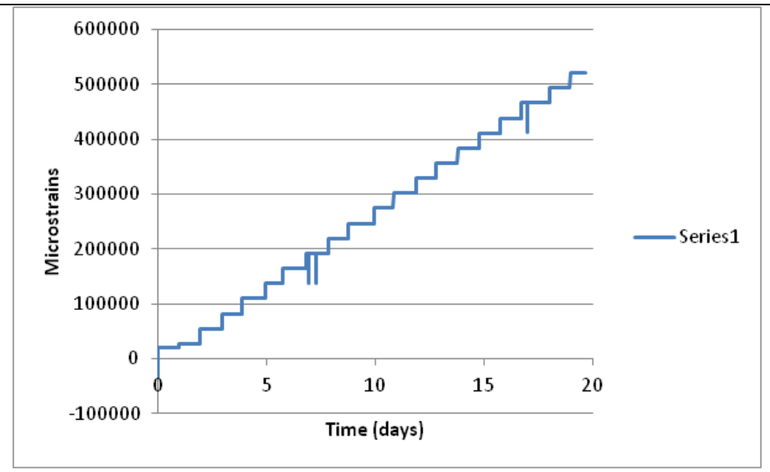
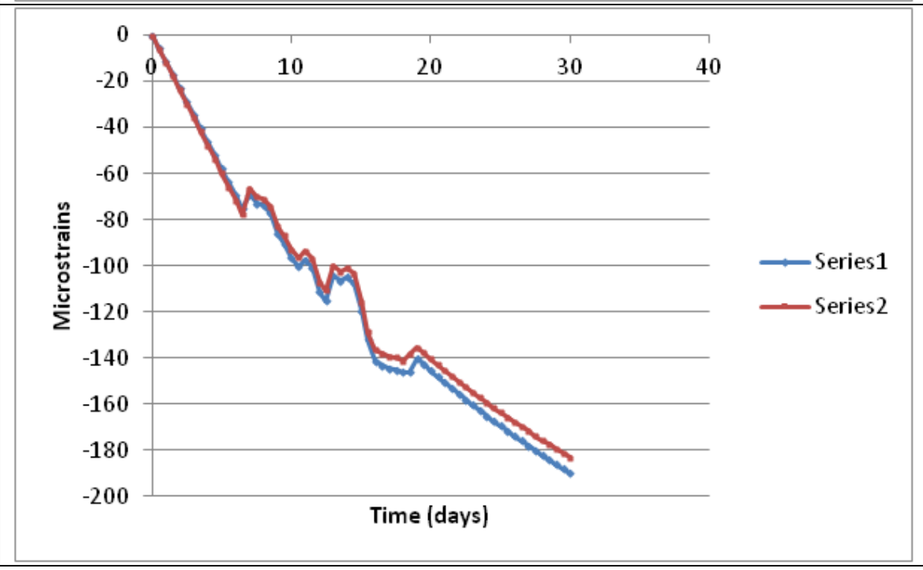
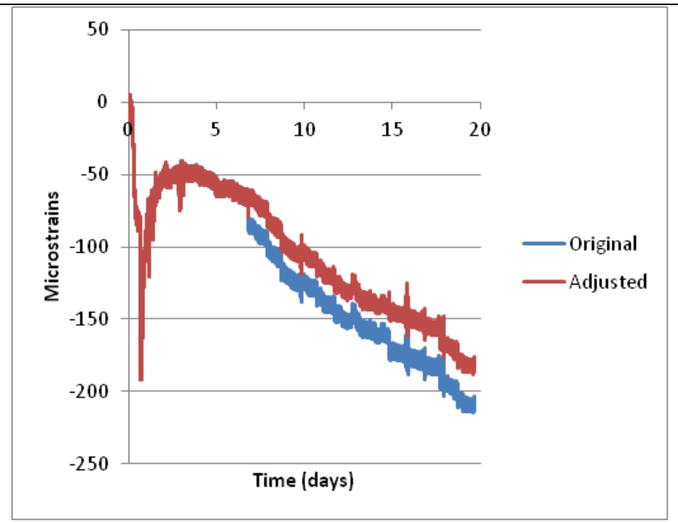
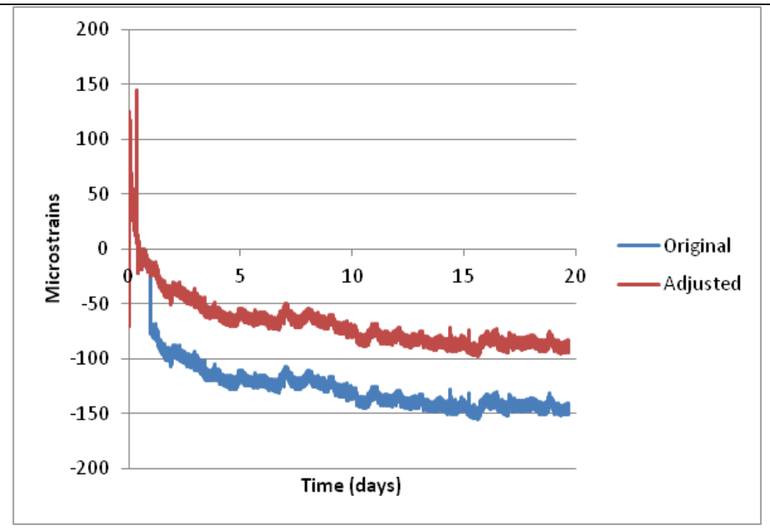
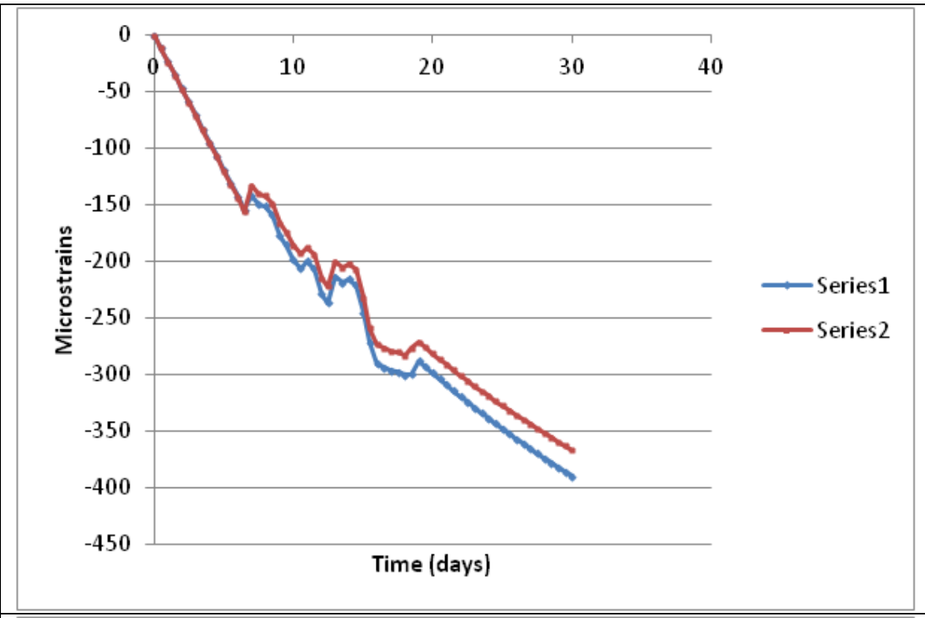
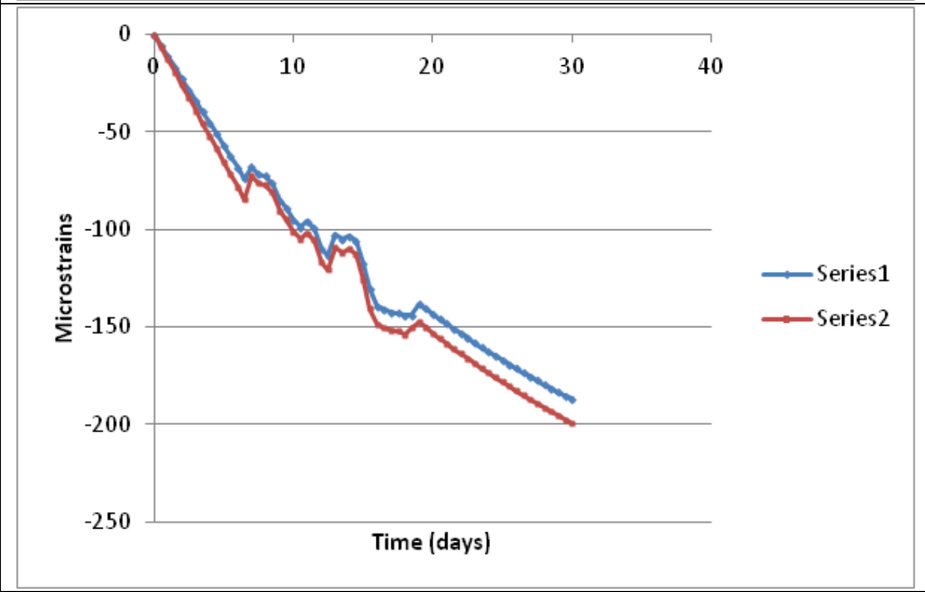
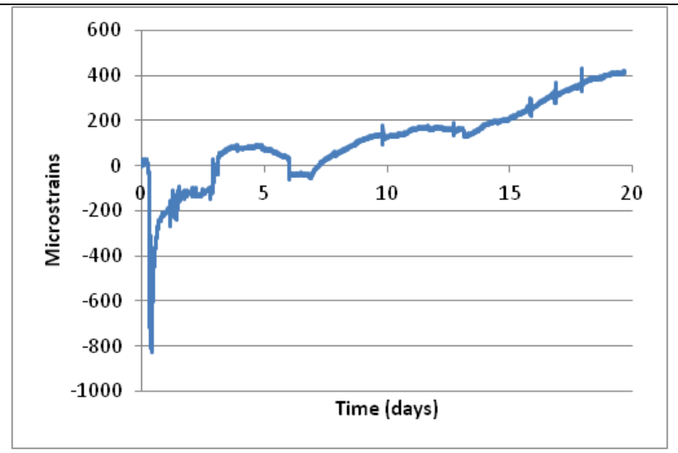
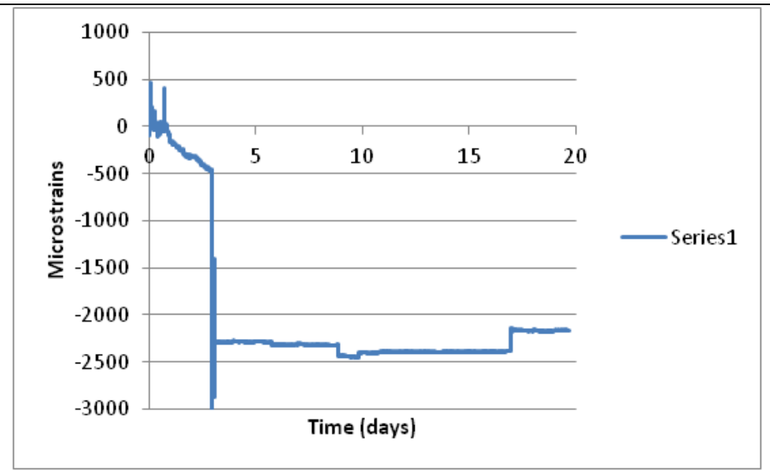
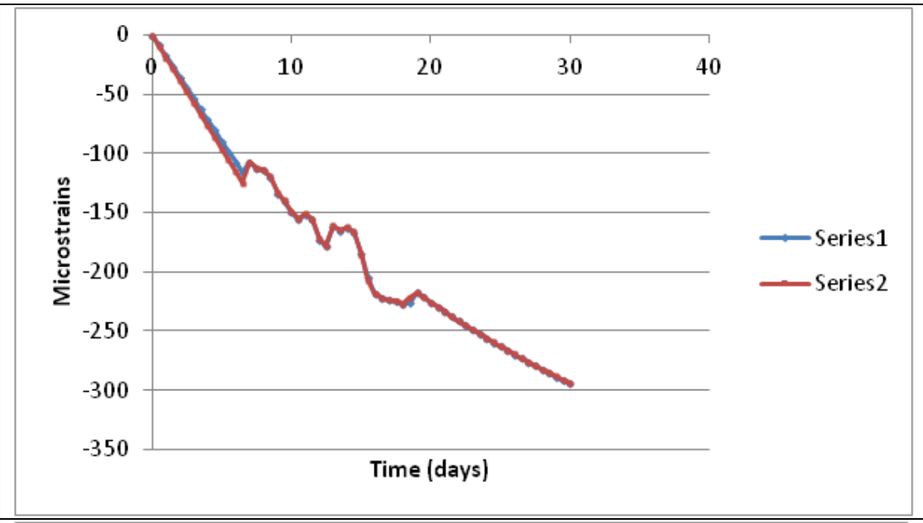
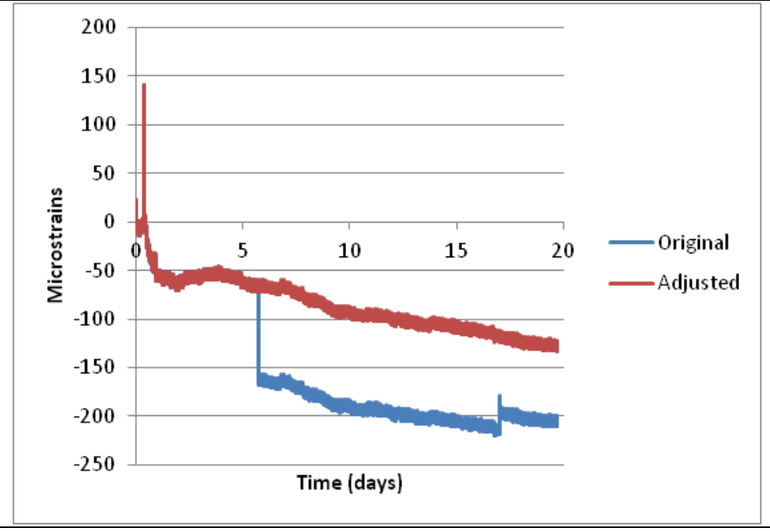
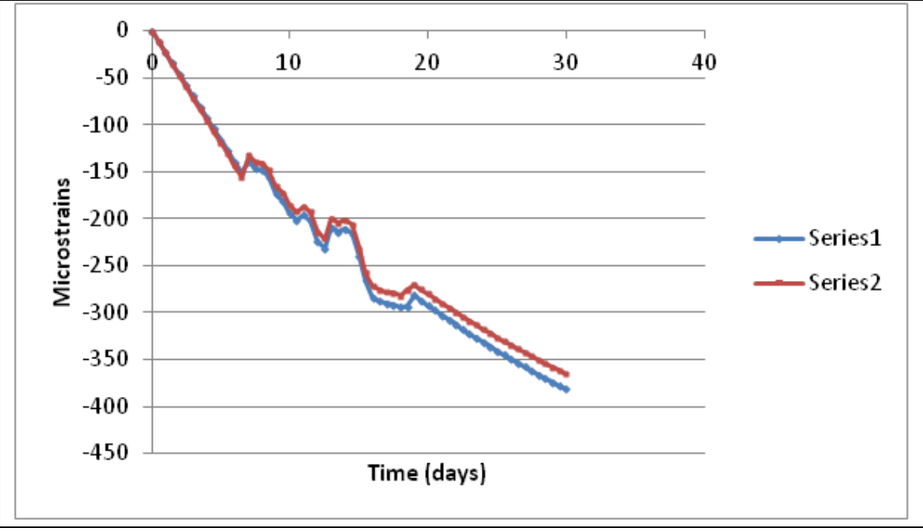






S-Bt-G2-1/2-L			
S-Bt-1/2-3/4-L			

S-Bt-G1-1/4-T			
S-Bt-G1-1/4-L			

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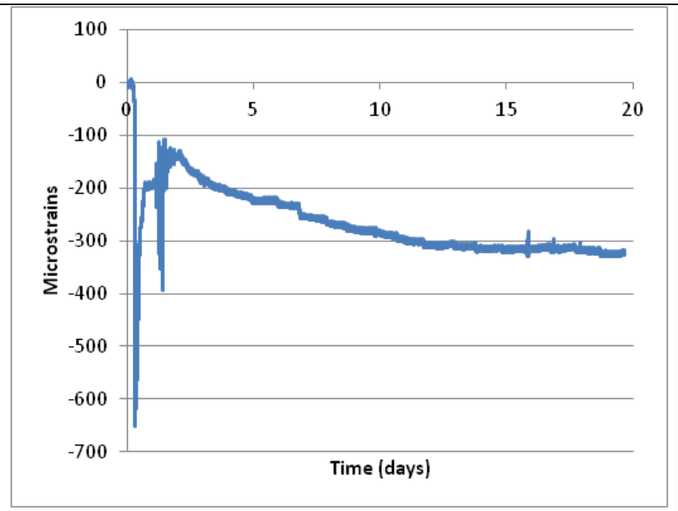

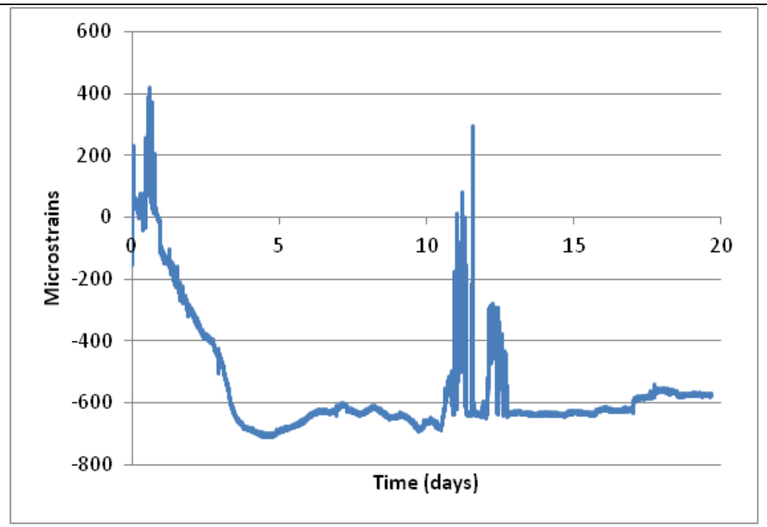

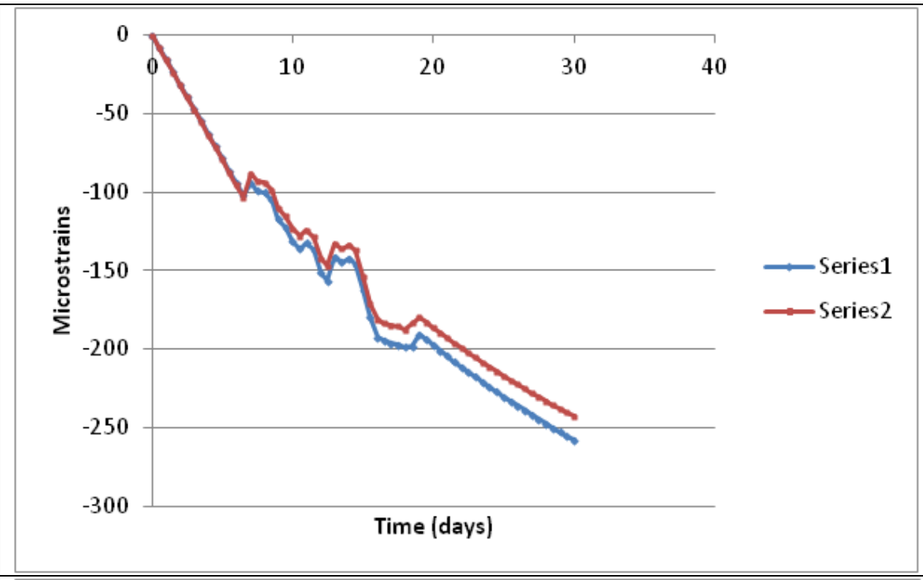

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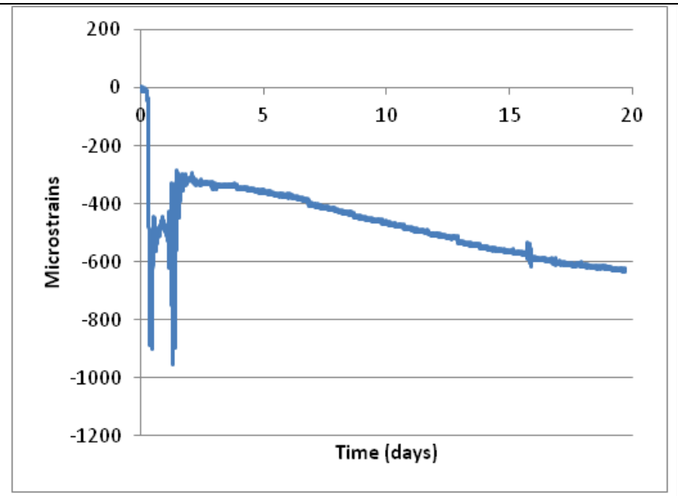
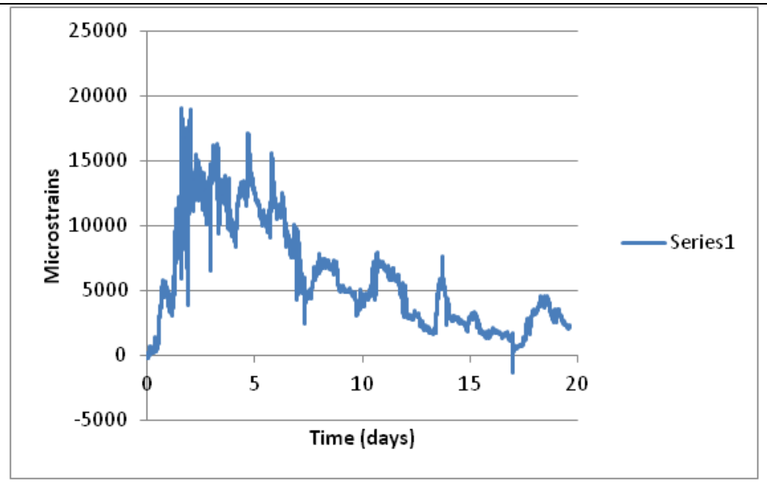
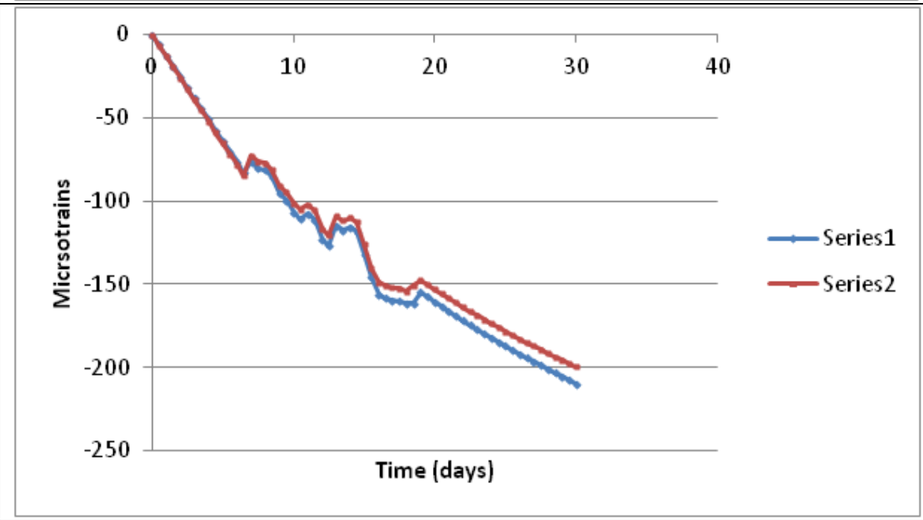
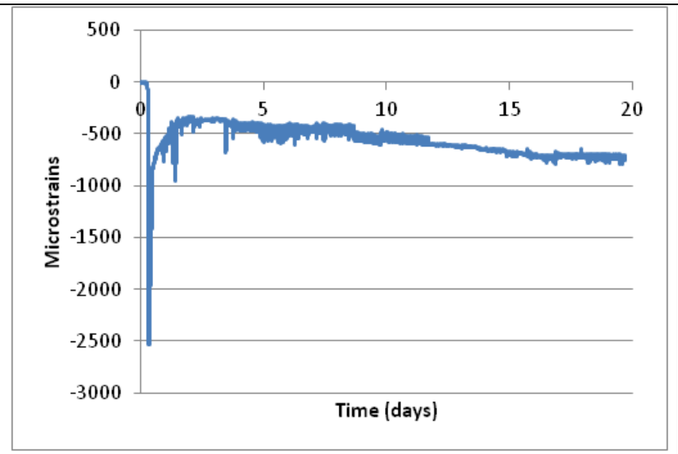
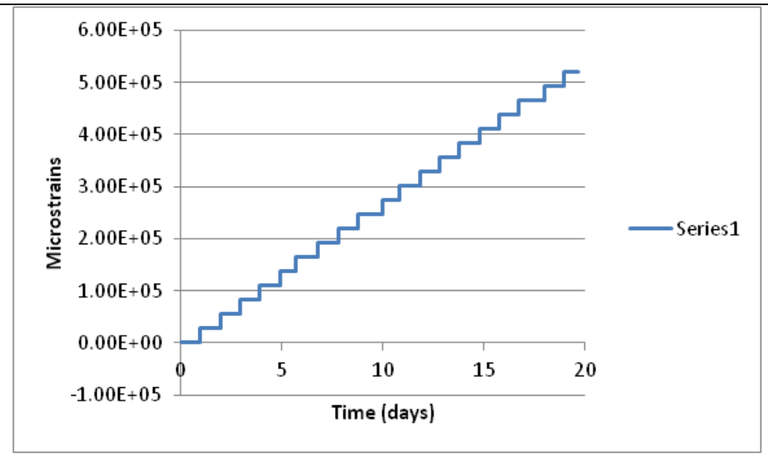
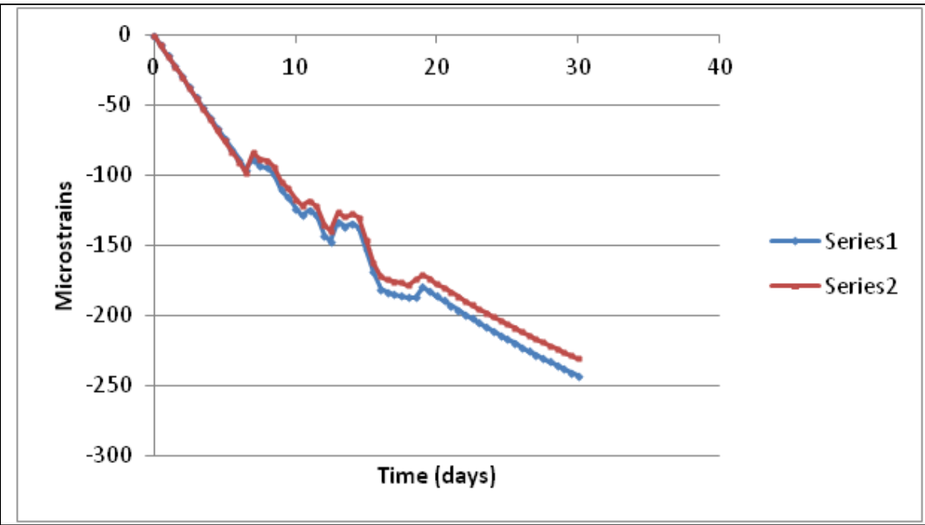
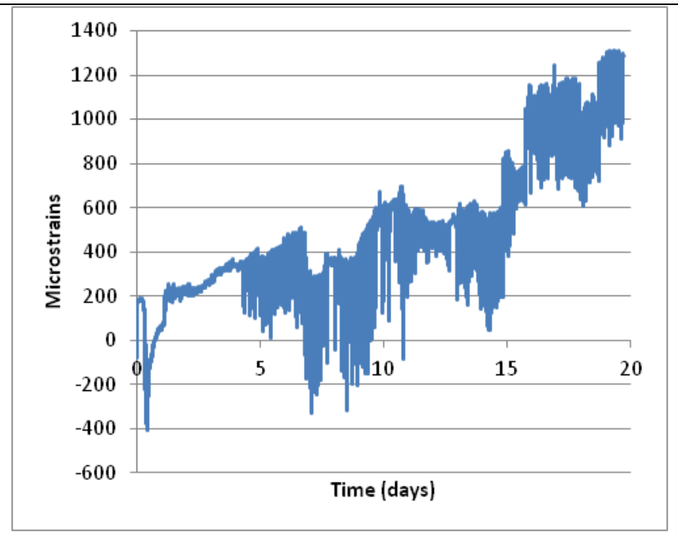
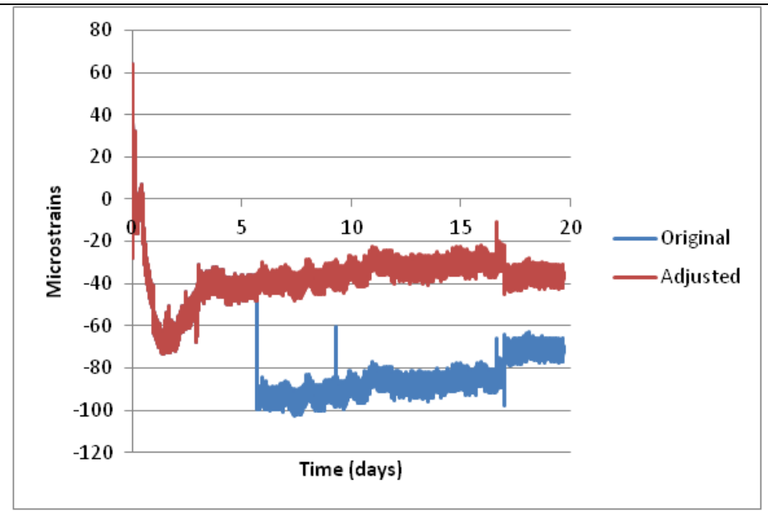
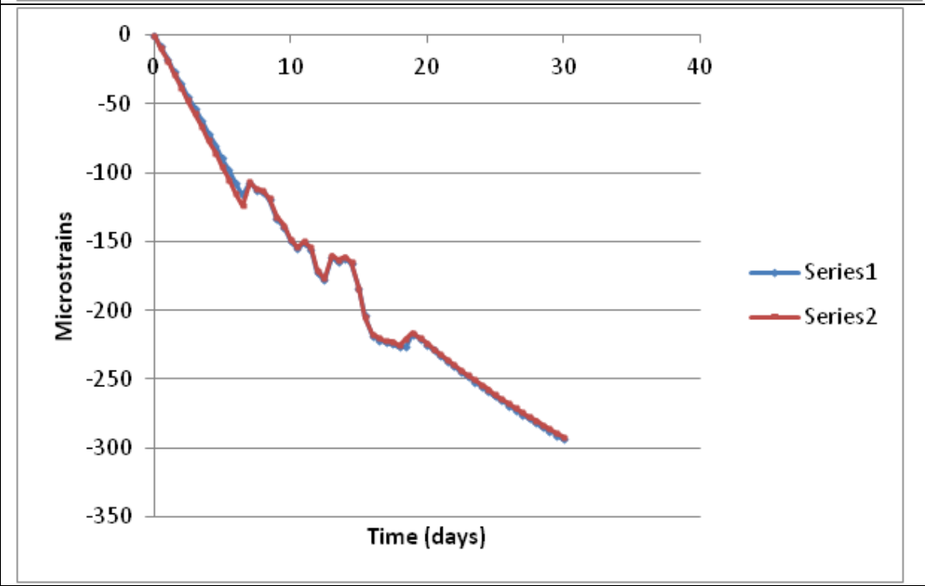
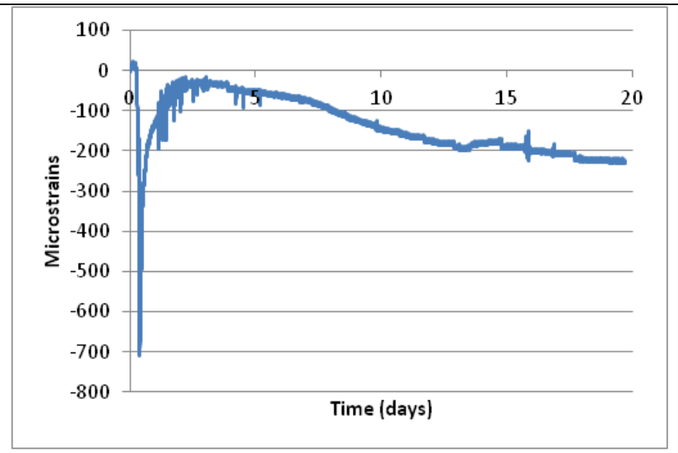
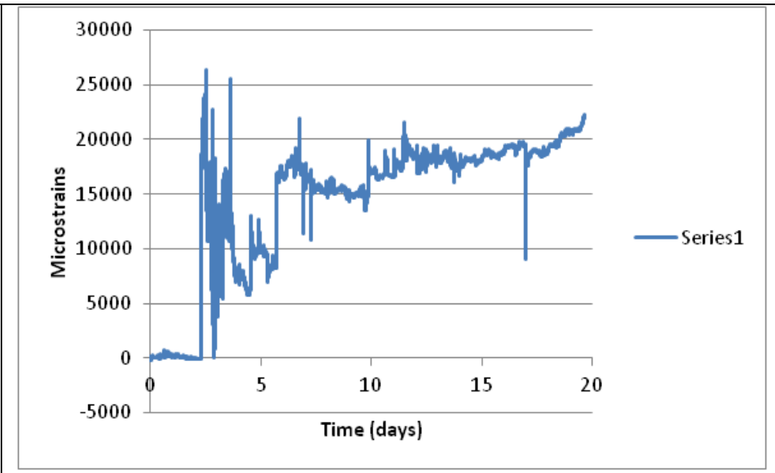
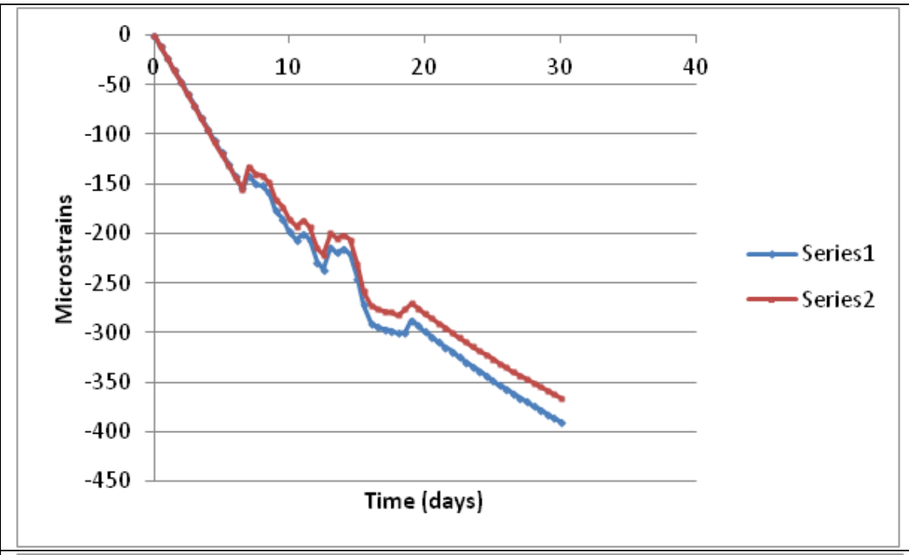
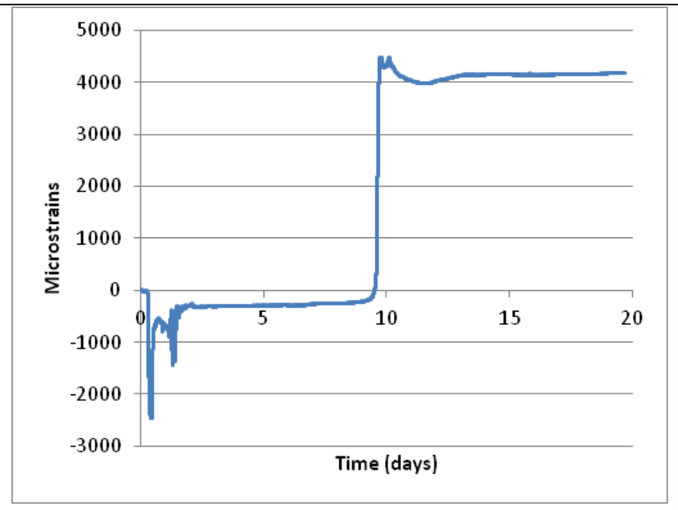
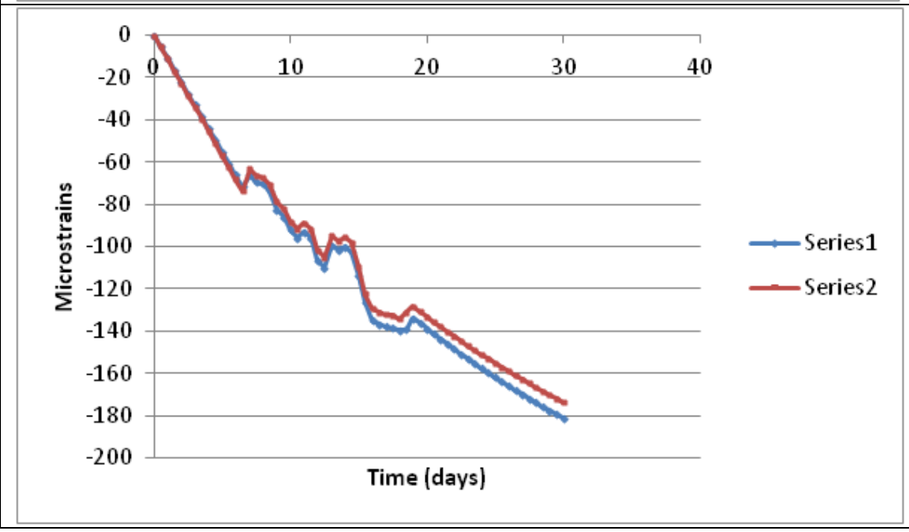
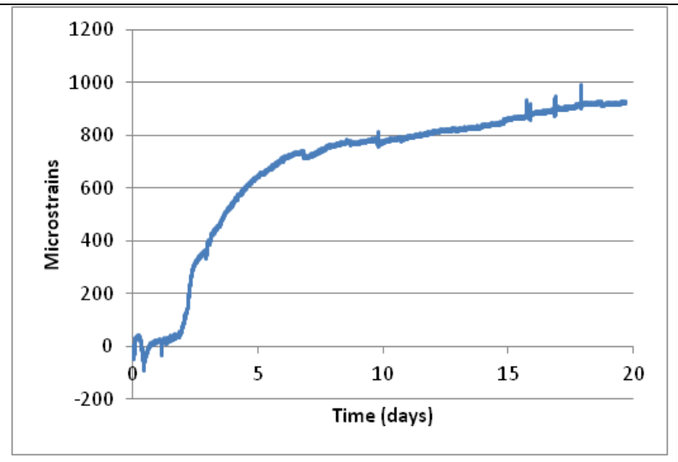
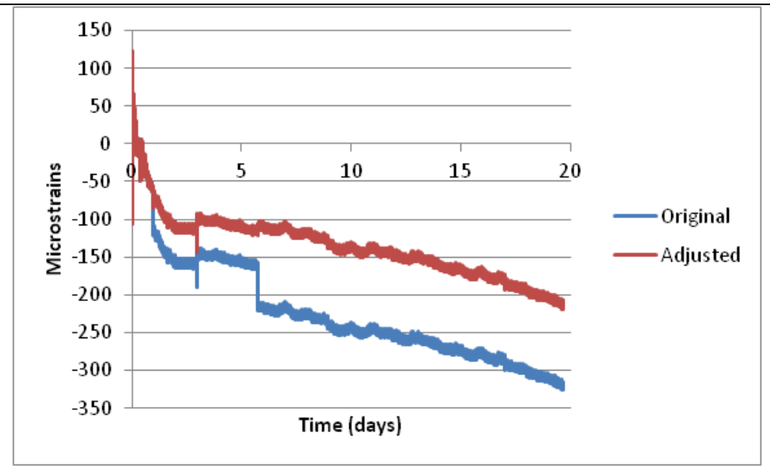
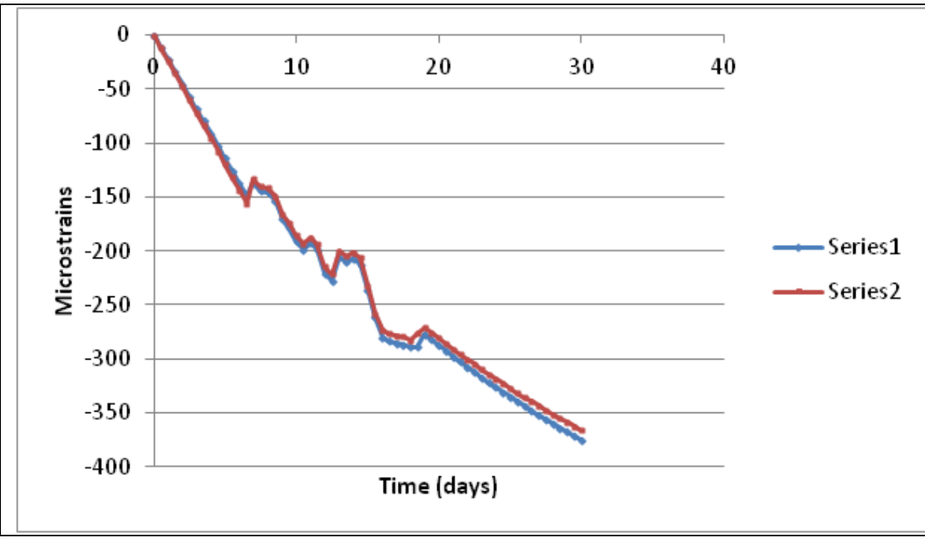






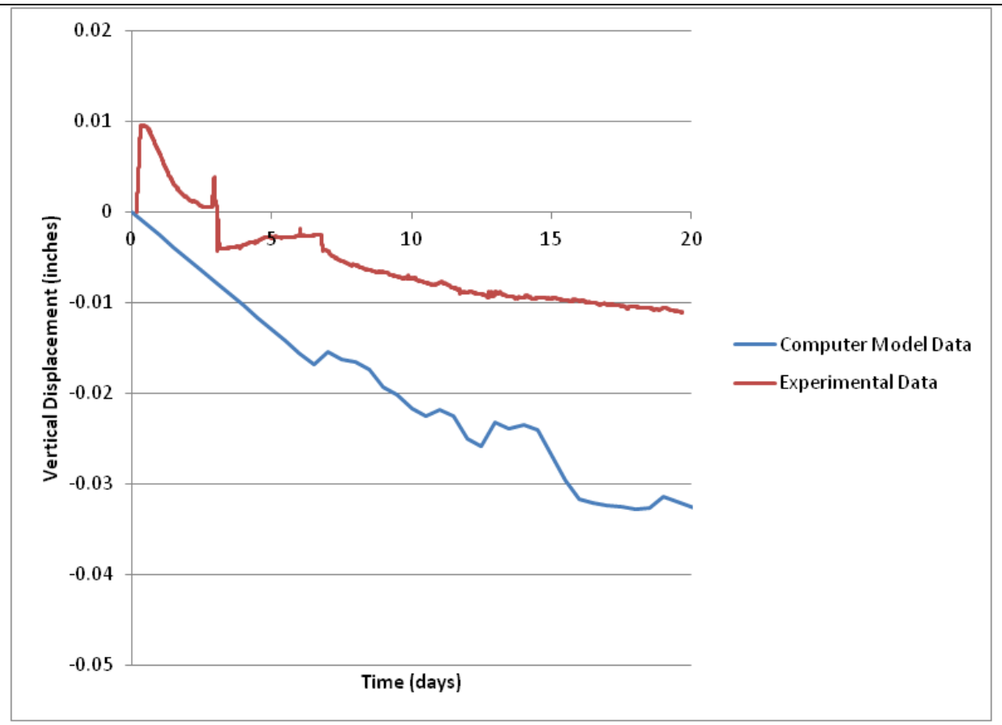
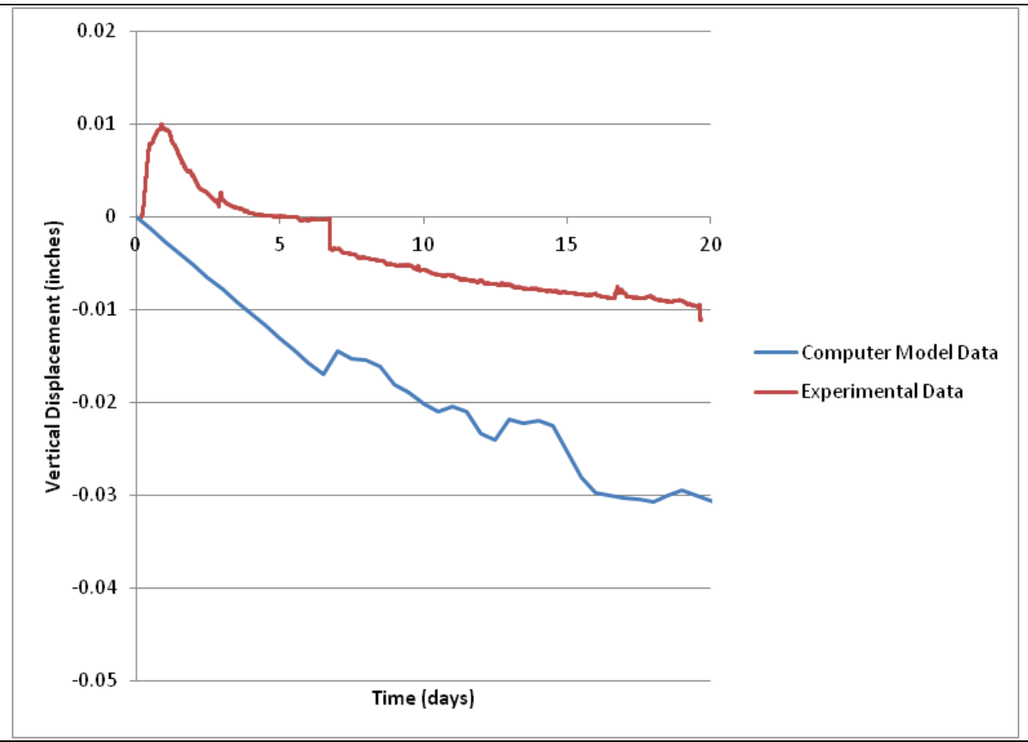
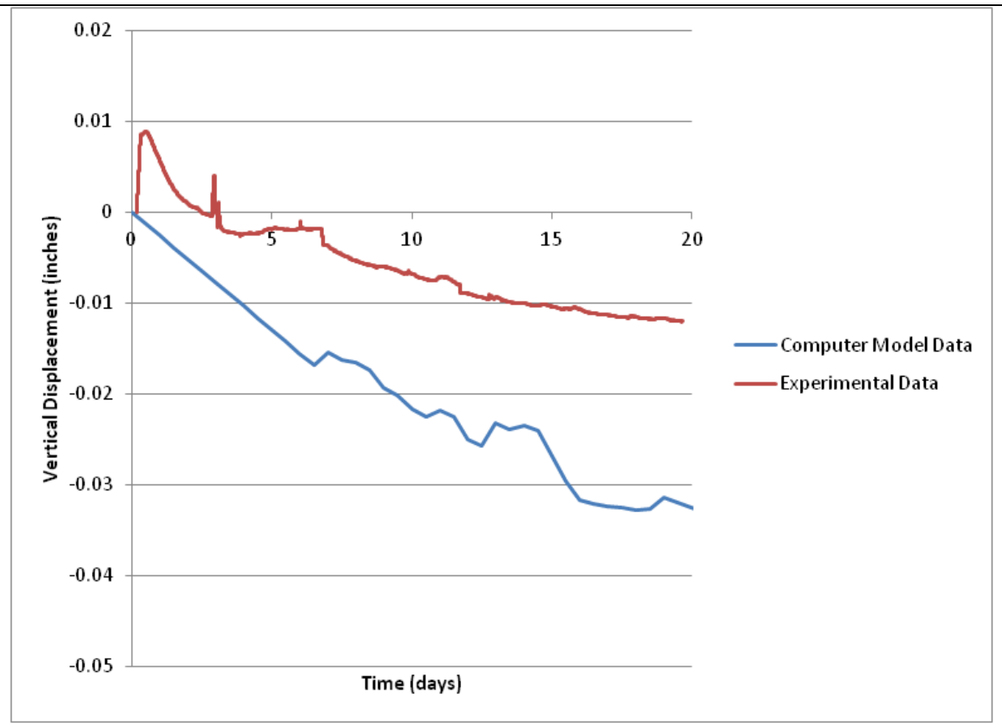
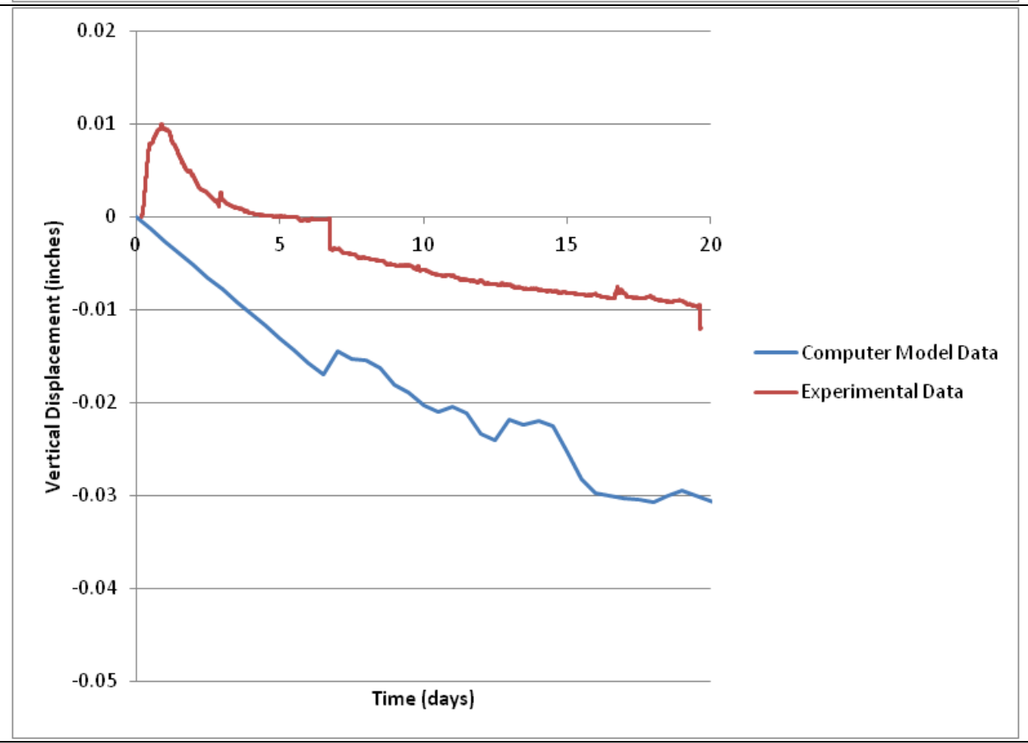
S-Bt-1/3-3/4-L			
S-Bt-G1-1/2-T			

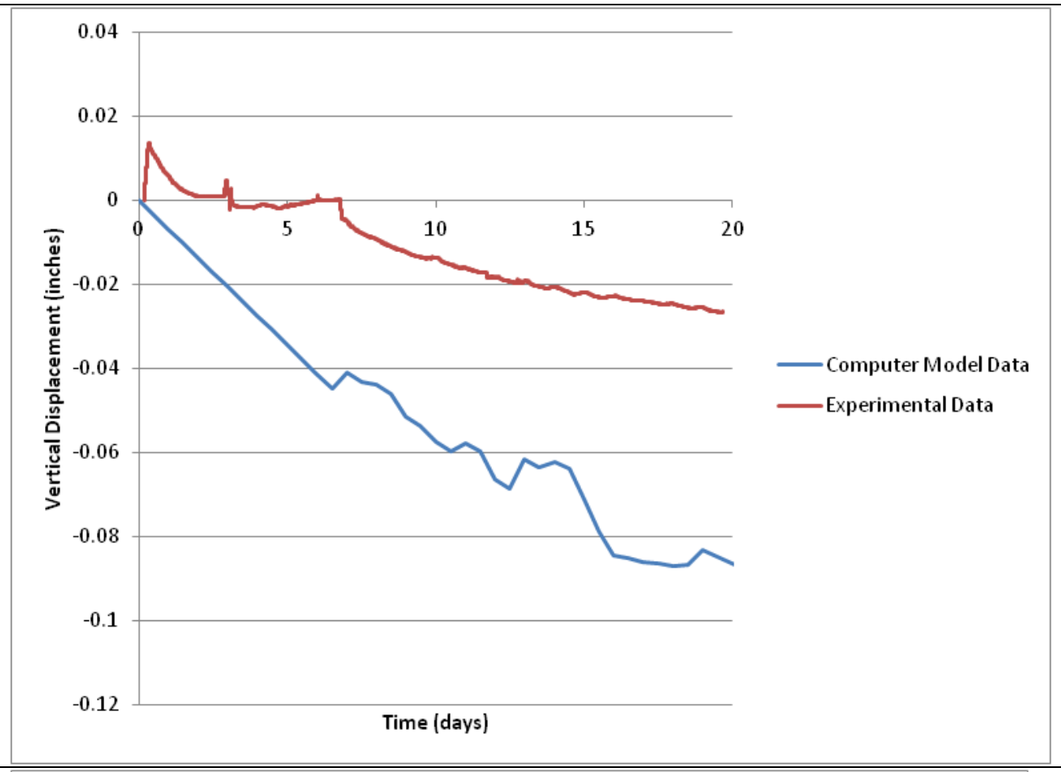
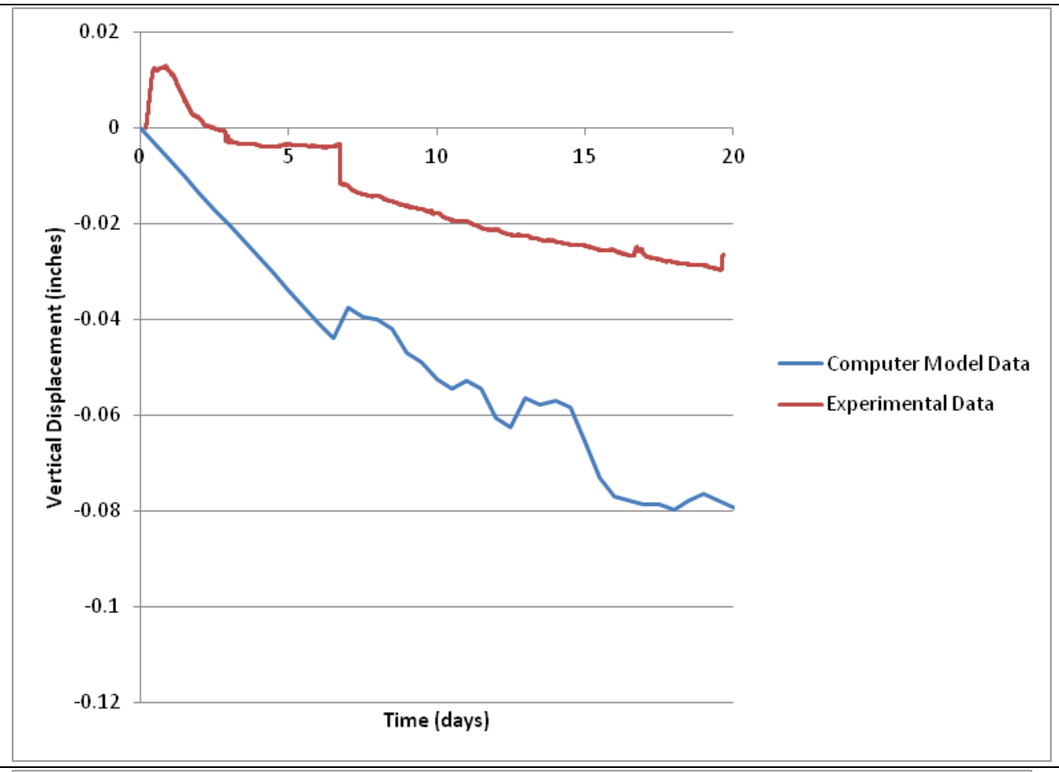
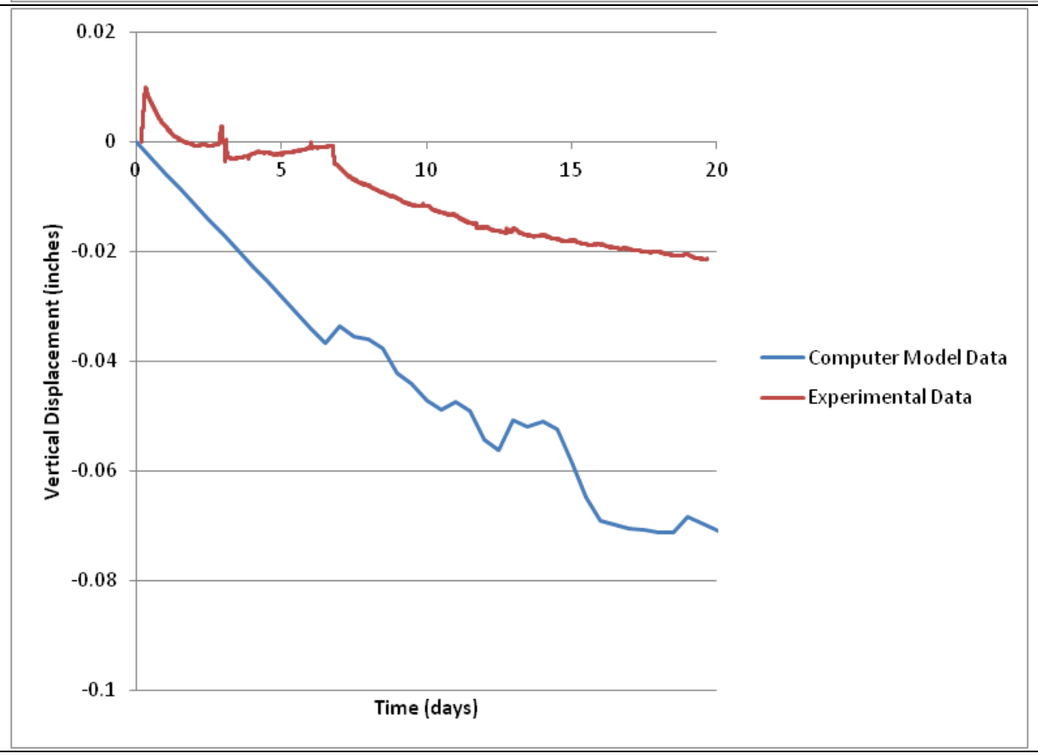
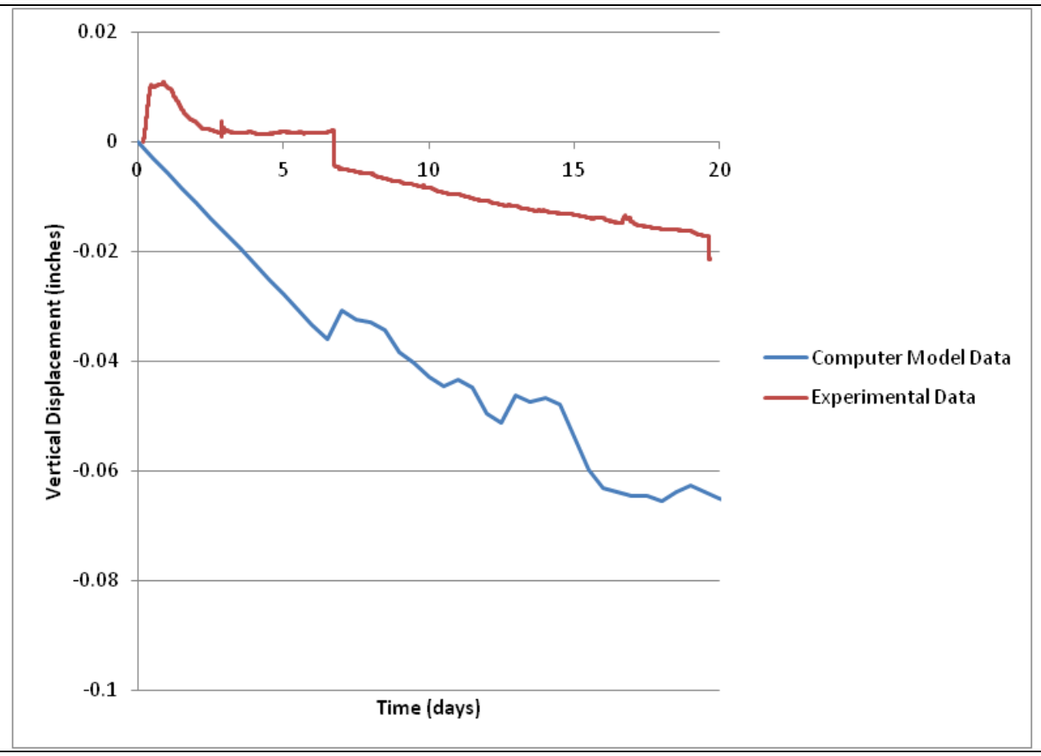
S-Bt-G1-1/2-L			
S-Bt-1/2-1/4-T			

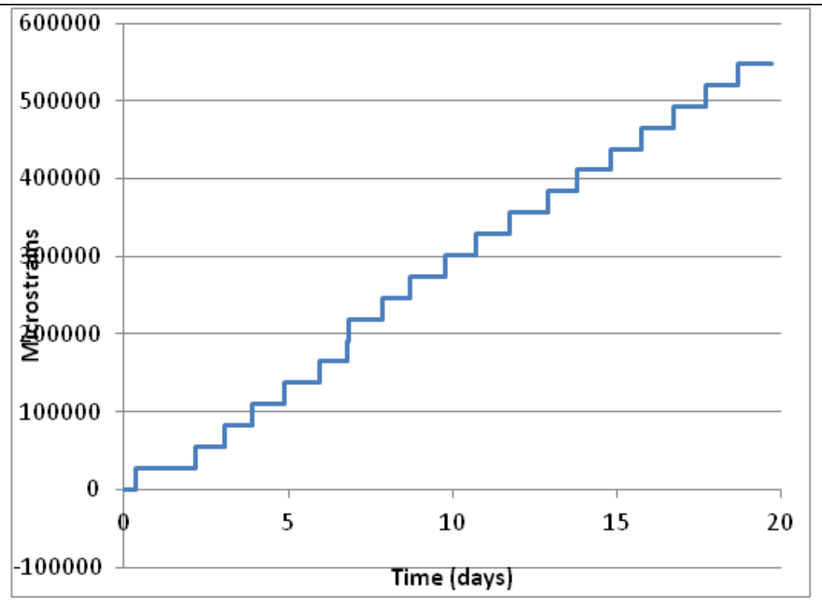
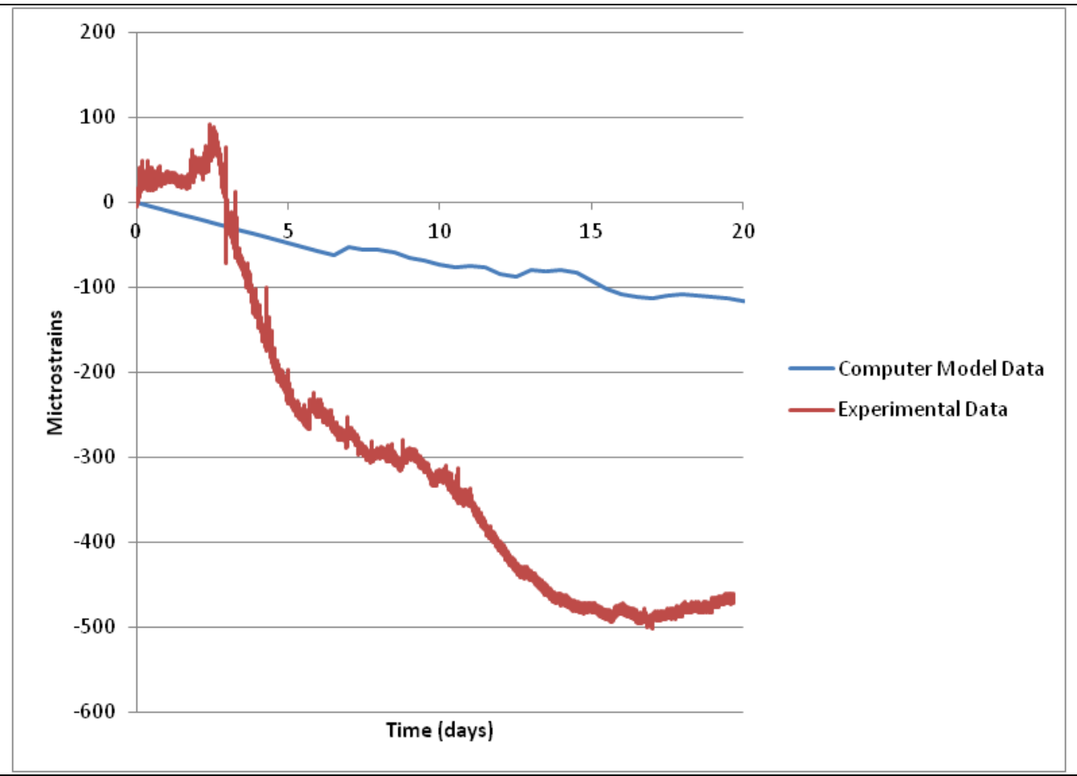
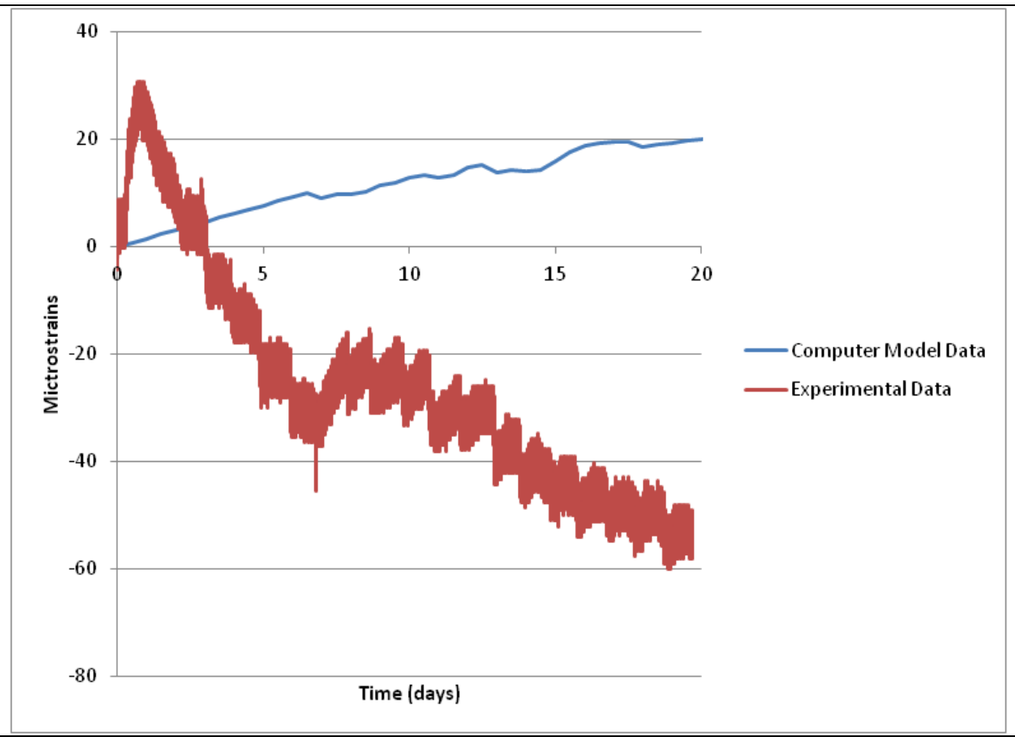
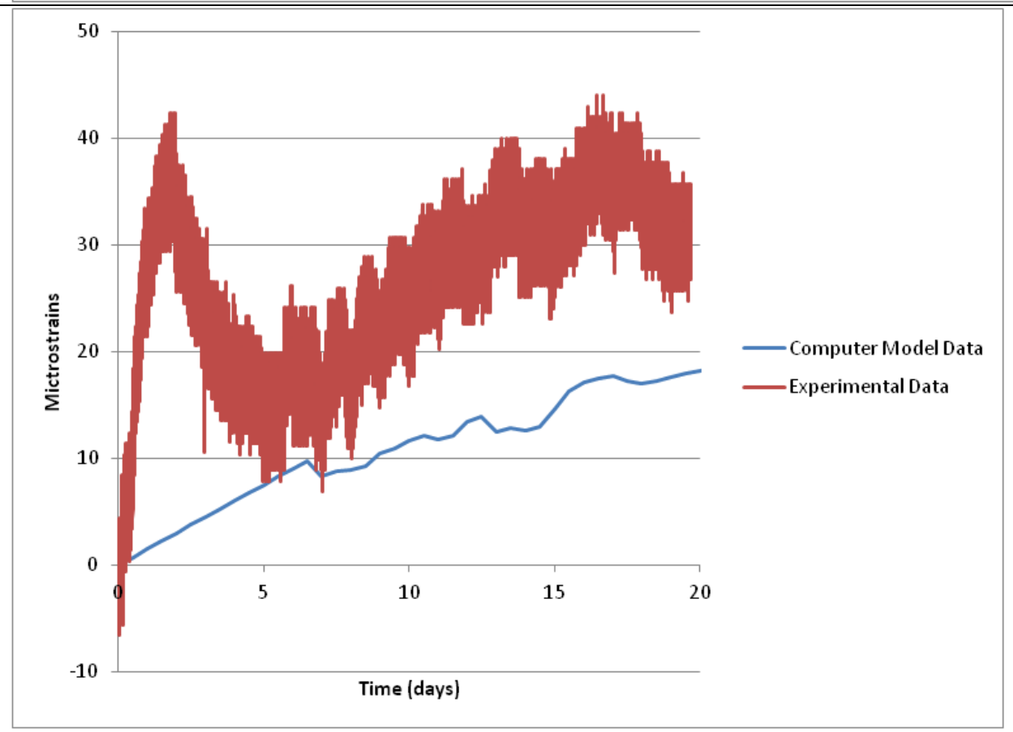
S-Bt-G1-3/4-L	 1200 1000 800 600 400 200 0 -200 Microstrains 0 5 10 15 20 Time (days)	 150 100 50 0 -50 -100 -150 -200 -250 -300 -350 Microstrains 0 5 10 15 20 Time (days) Original Adjusted	 0 -50 -100 -150 -200 -250 -300 -350 -400 Microstrains 0 10 20 30 40 Time (days) Series1 Series2

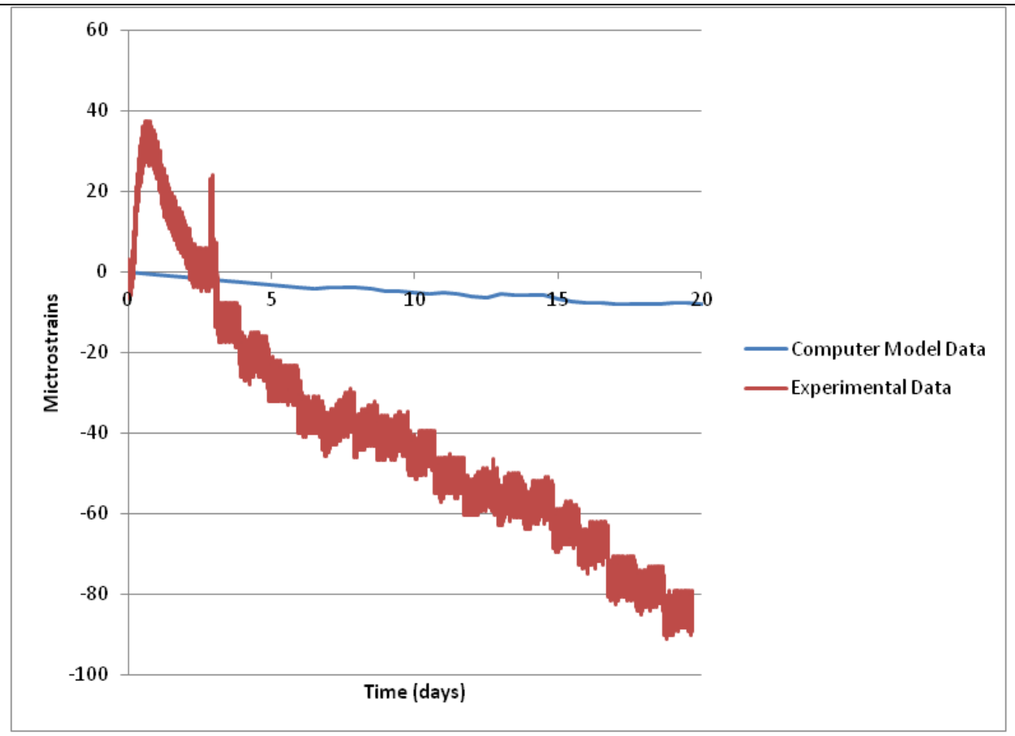
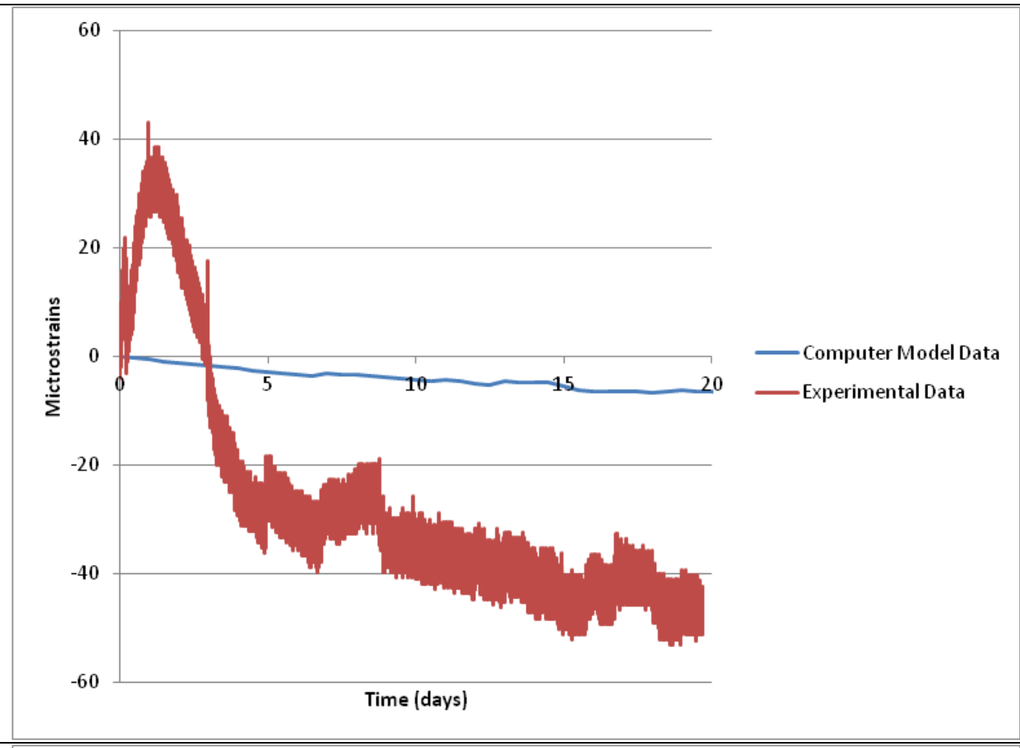
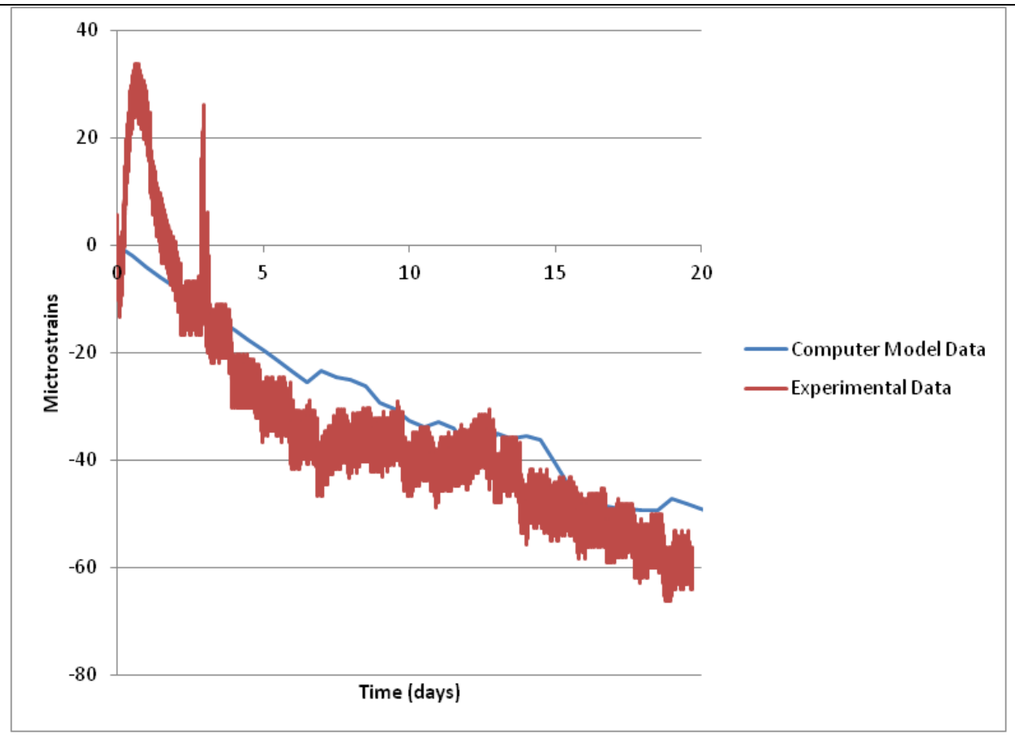
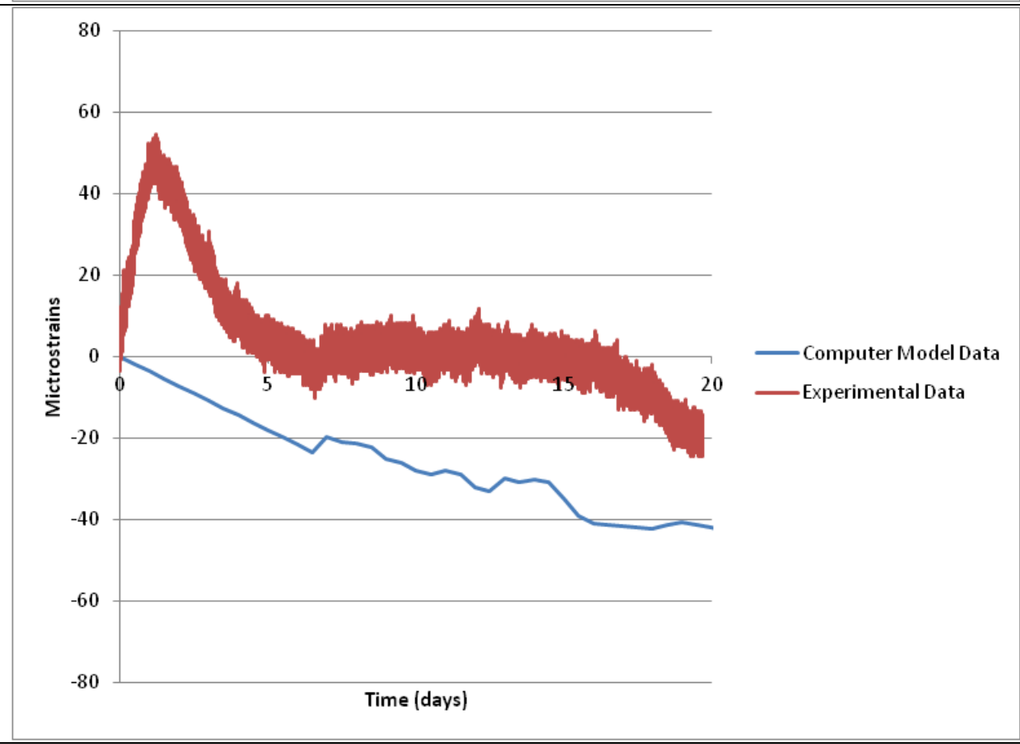
Appendix D

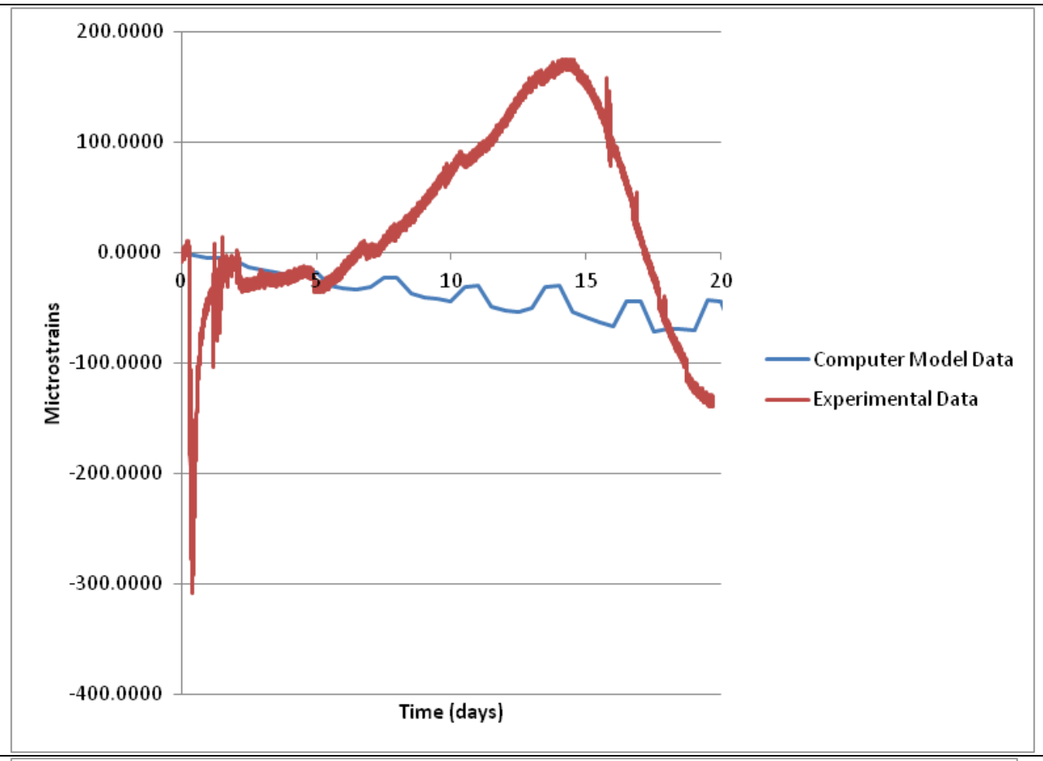
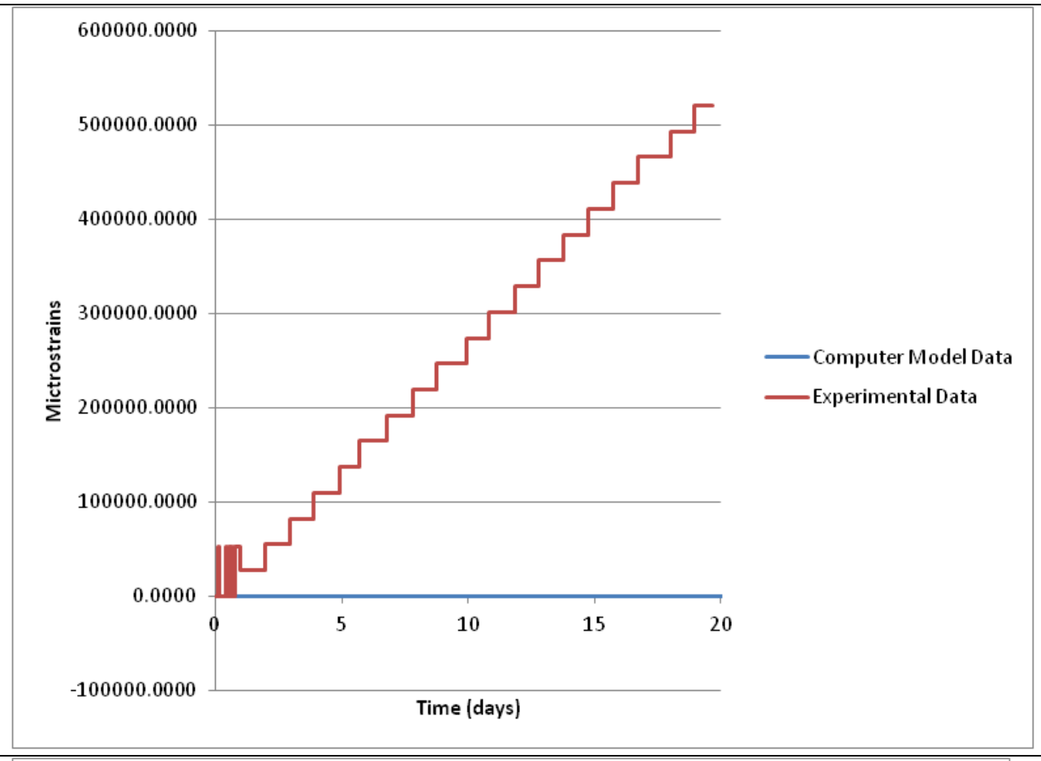
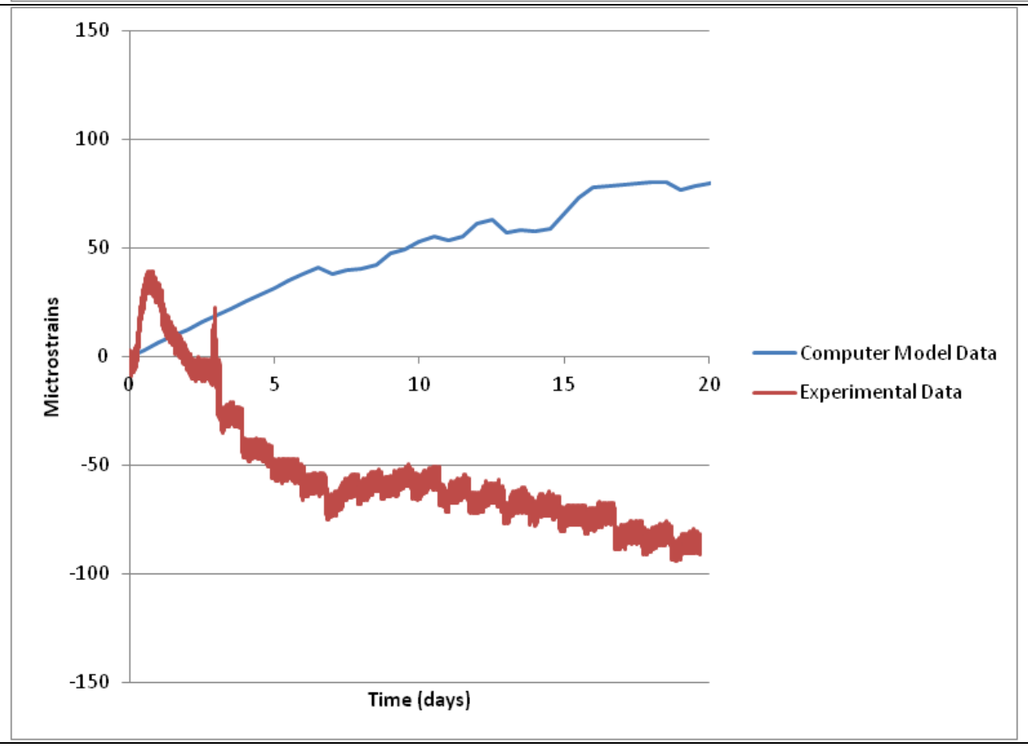
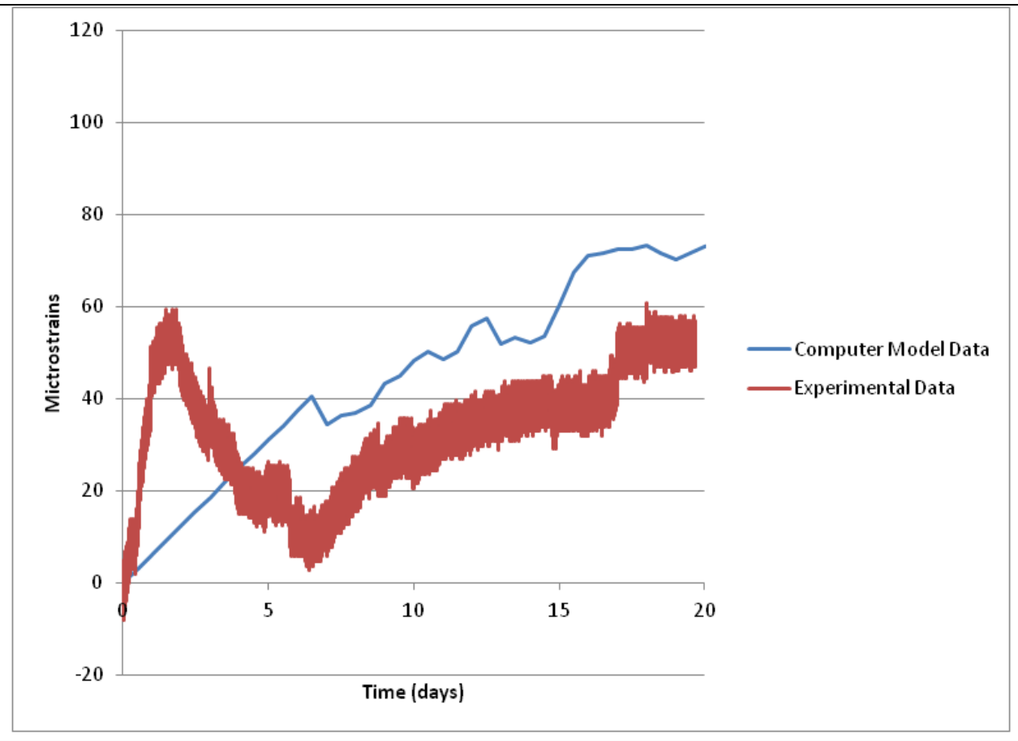
Laboratory Full Data Comparison to Experimental Data

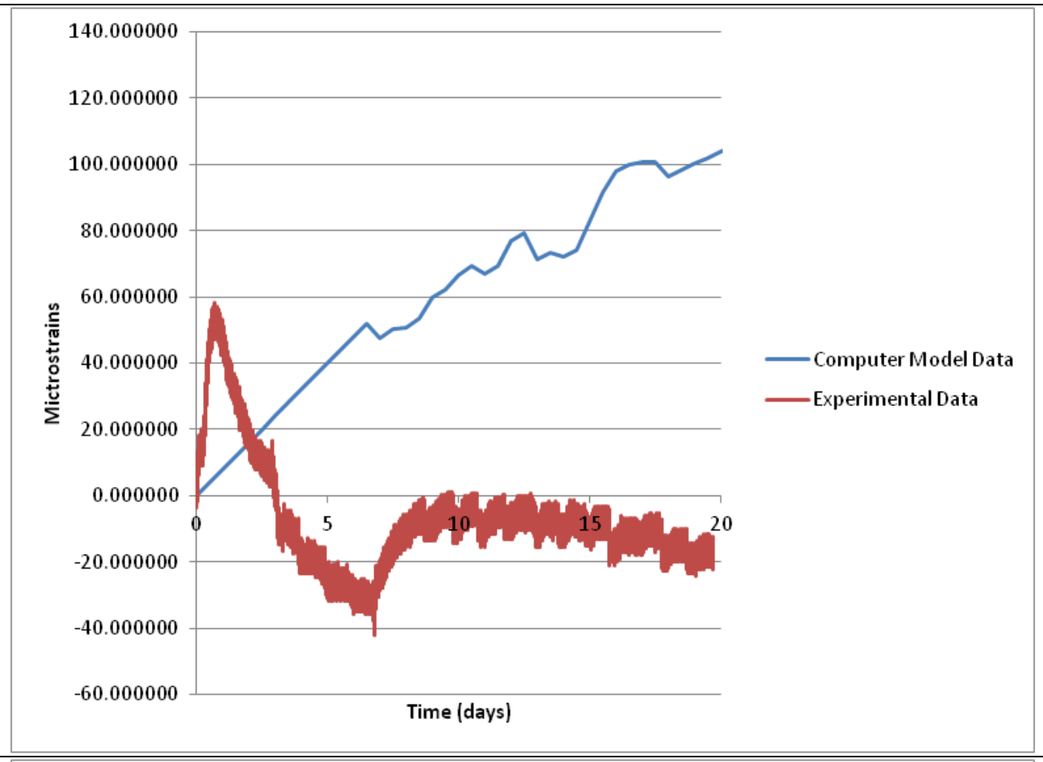
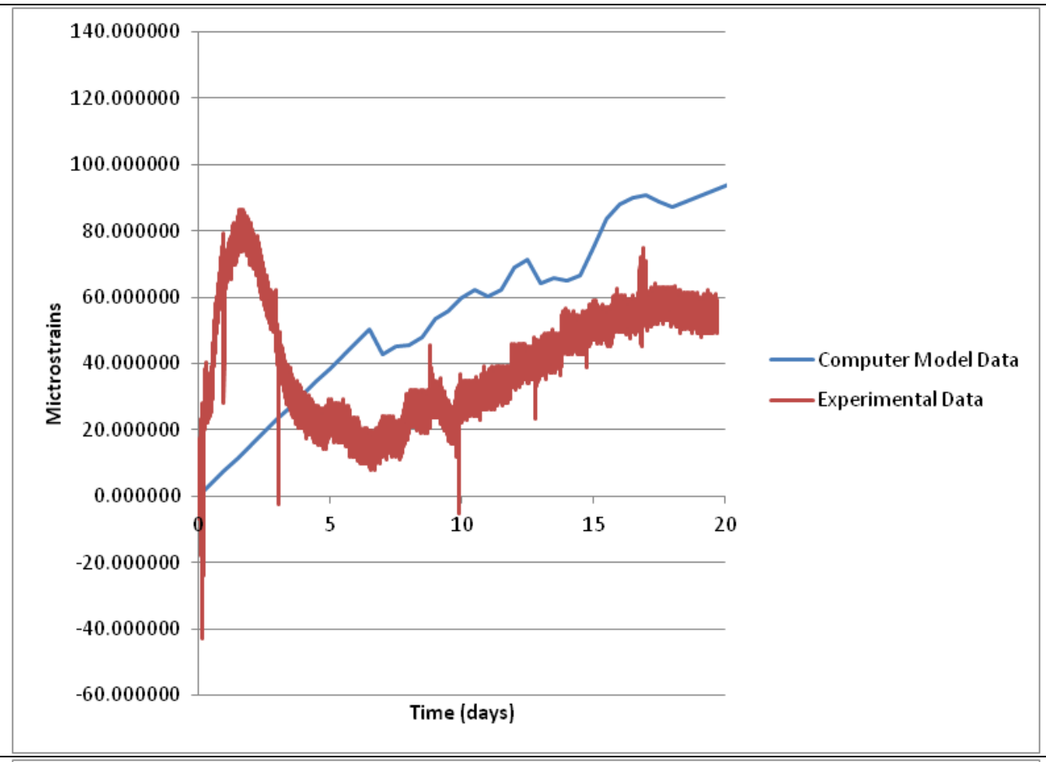
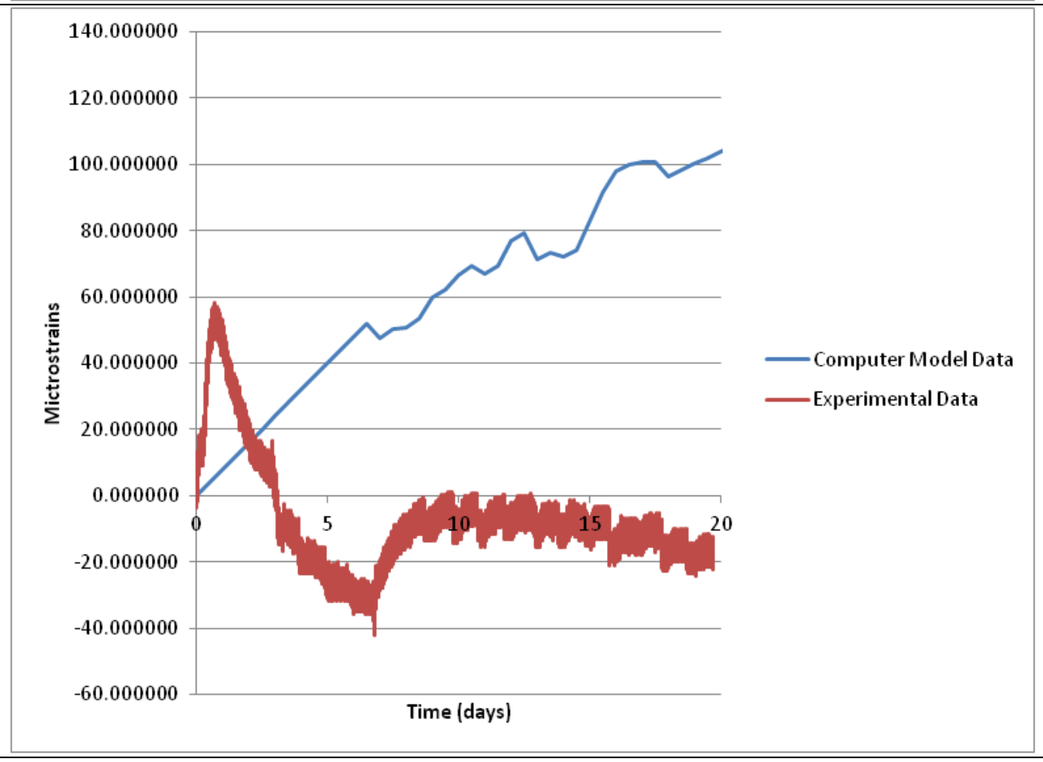
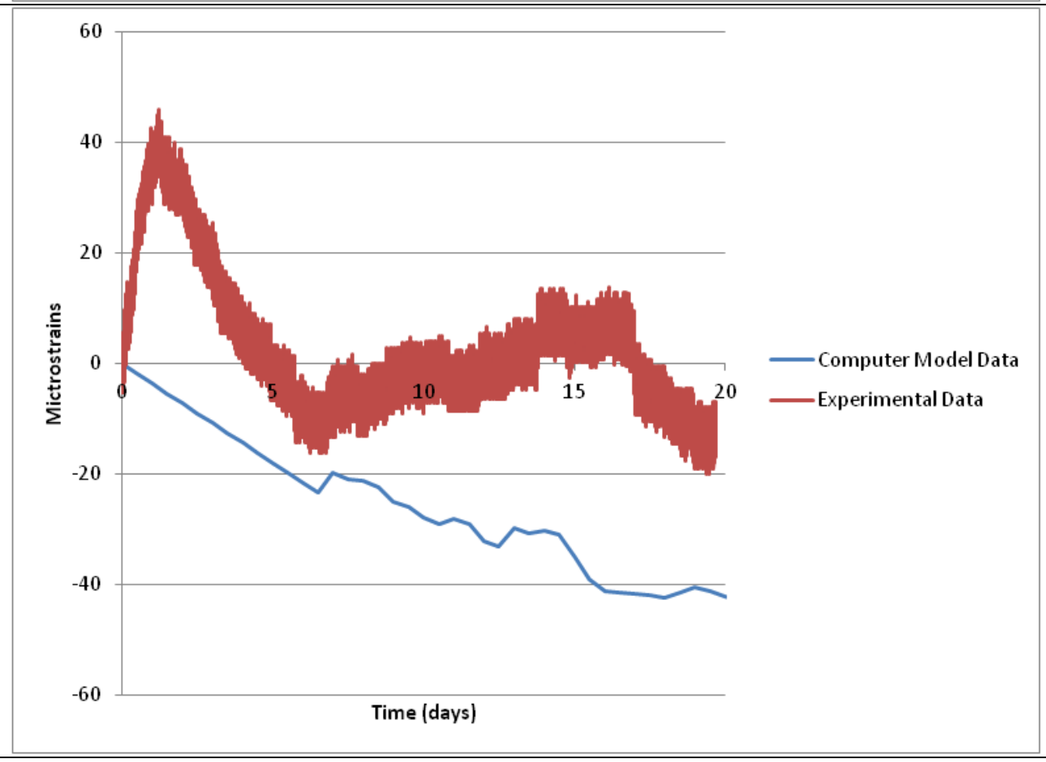
Instrumentation ID	Test Unit 3	Test Unit 4
L-G1-1/2		
L-G2-1/2		

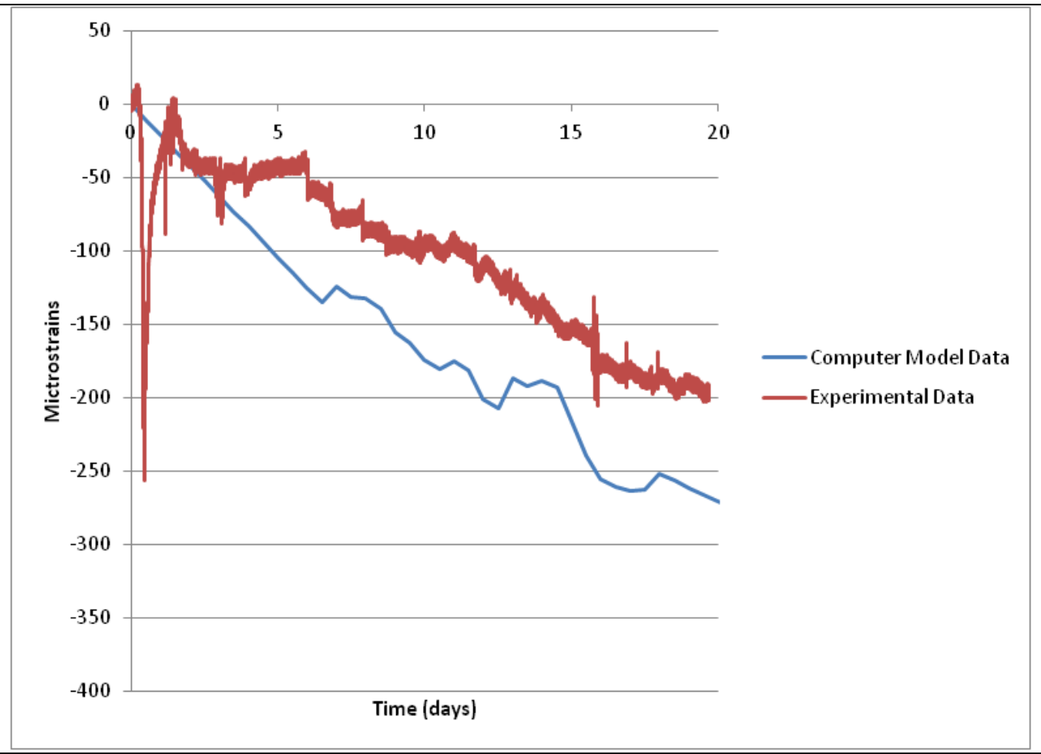
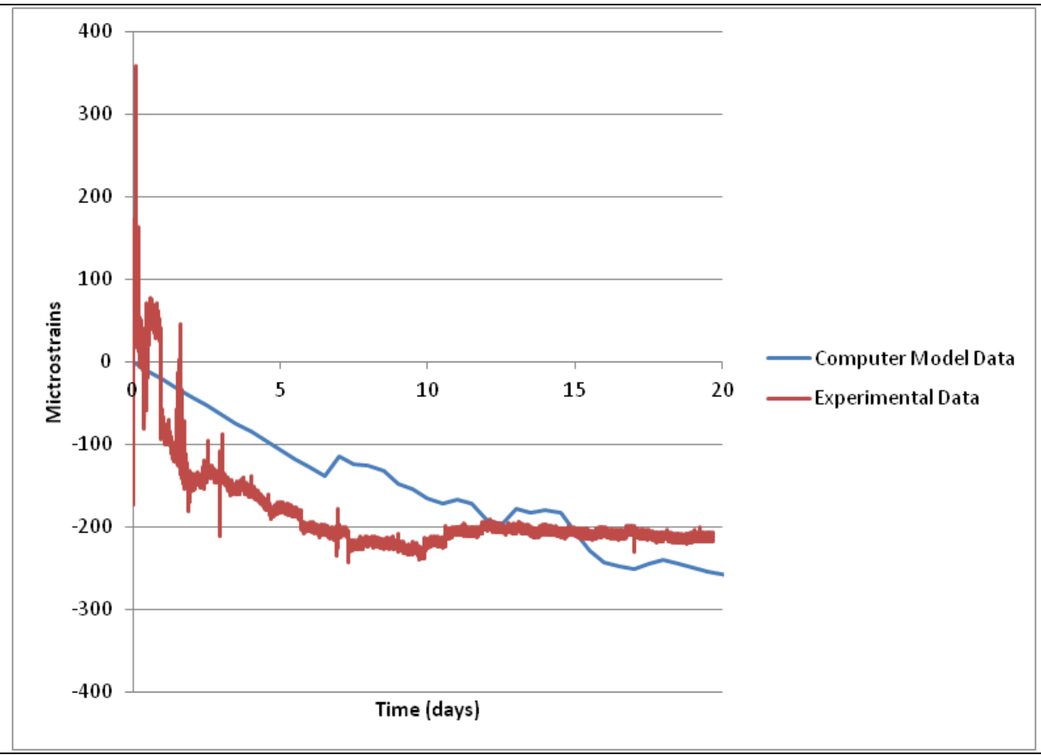
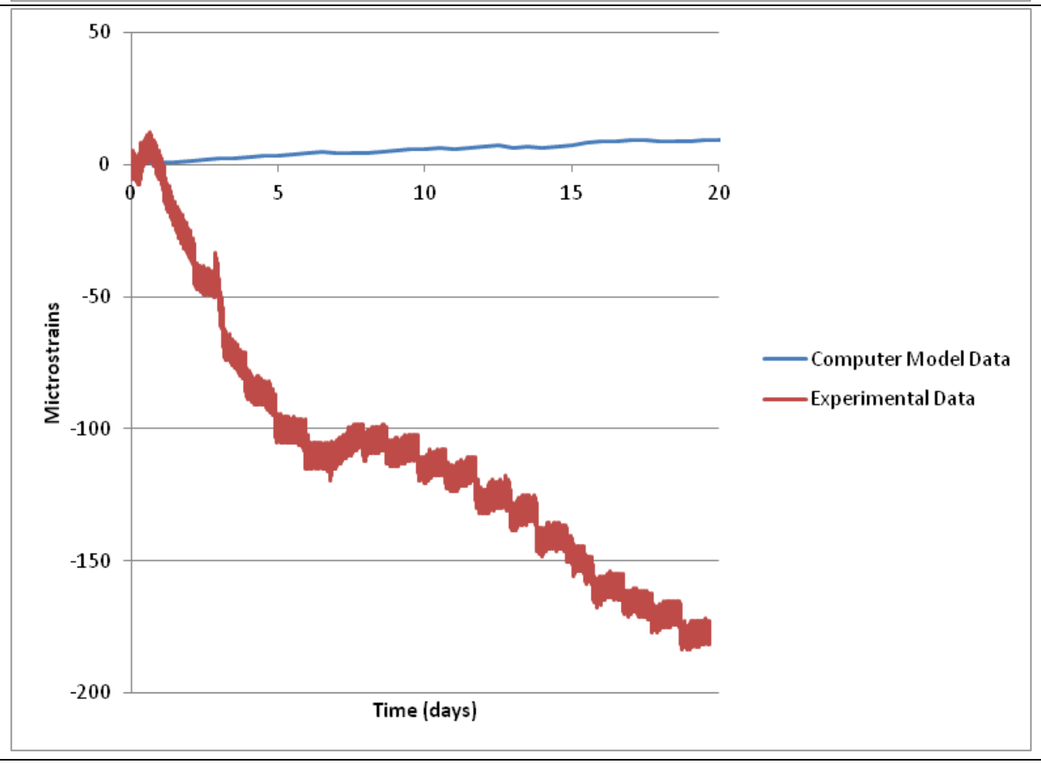
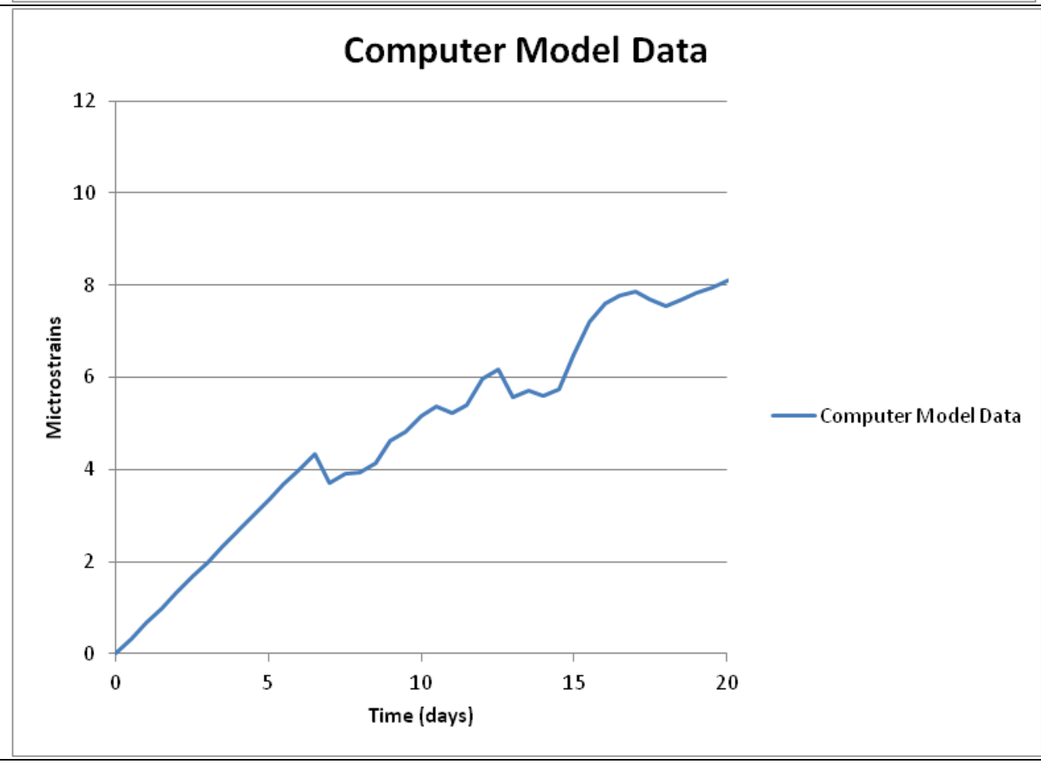
L-1/2-1/2	 0.04 0.02 0 -0.02 -0.04 -0.06 -0.08 -0.1 -0.12 0 5 10 15 20 Vertical Displacement (inches) Time (days) Computer Model Data Experimental Data	 0.02 0 -0.02 -0.04 -0.06 -0.08 -0.1 -0.12 0 5 10 15 20 Vertical Displacement (inches) Time (days) Computer Model Data Experimental Data
L-1/2-3/4	 0.02 0 -0.02 -0.04 -0.06 -0.08 -0.1 0 5 10 15 20 Vertical Displacement (inches) Time (days) Computer Model Data Experimental Data	 0.02 0 -0.02 -0.04 -0.06 -0.08 -0.1 0 5 10 15 20 Vertical Displacement (inches) Time (days) Computer Model Data Experimental Data

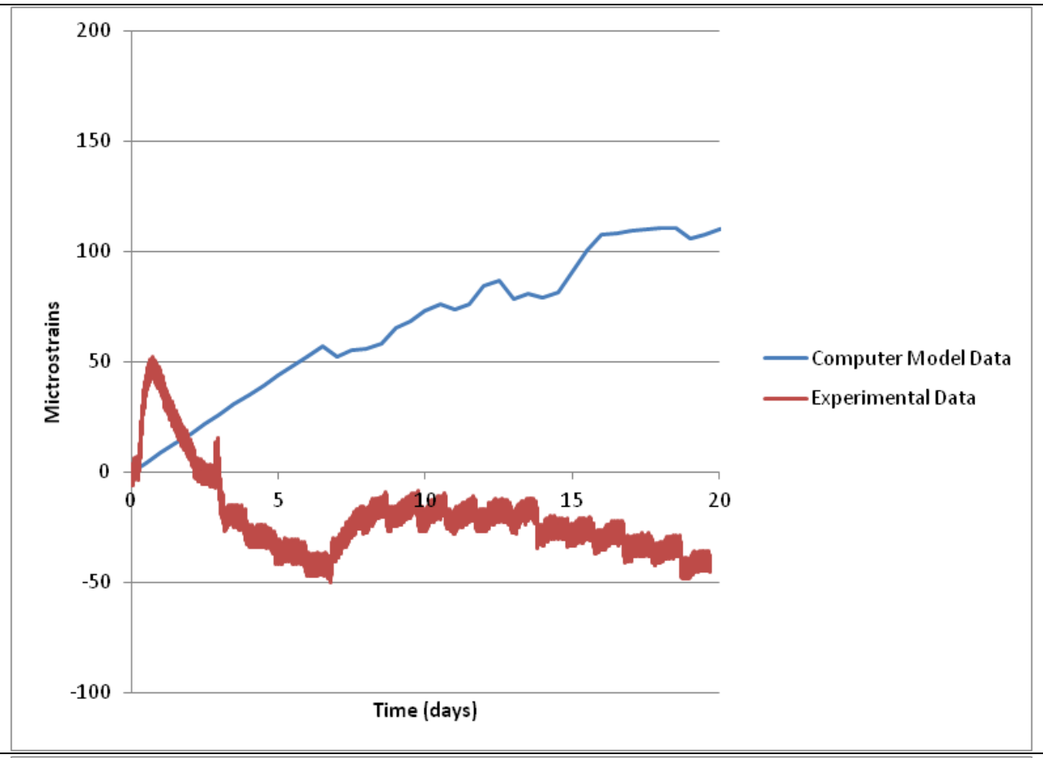
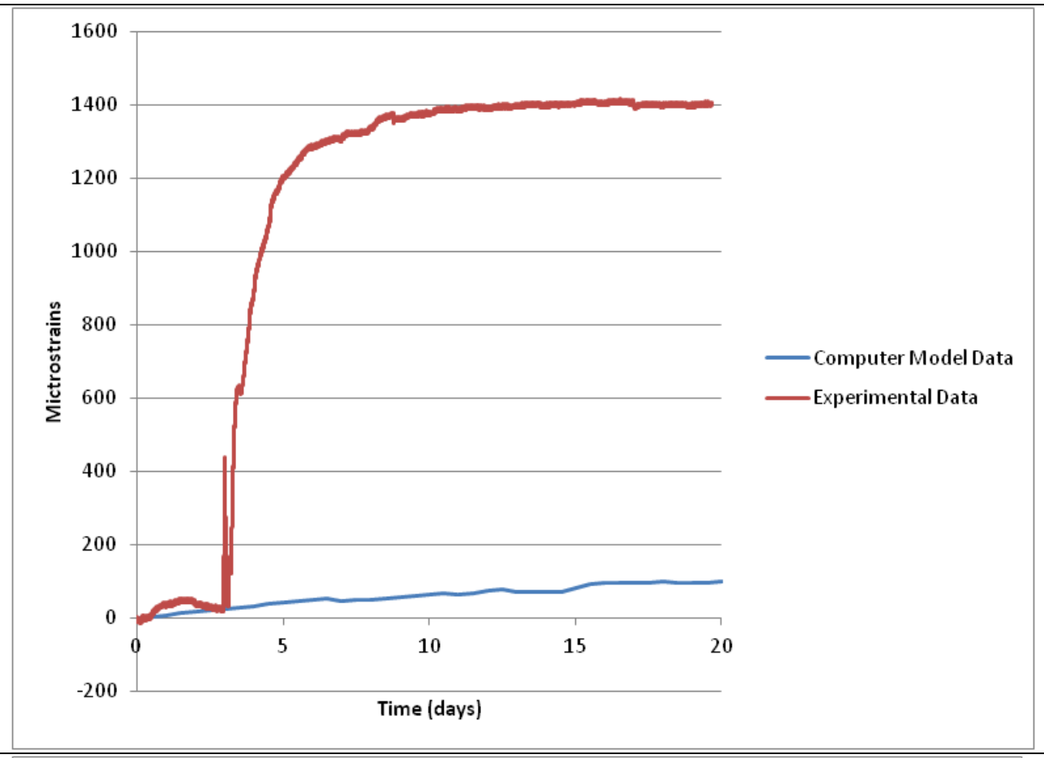
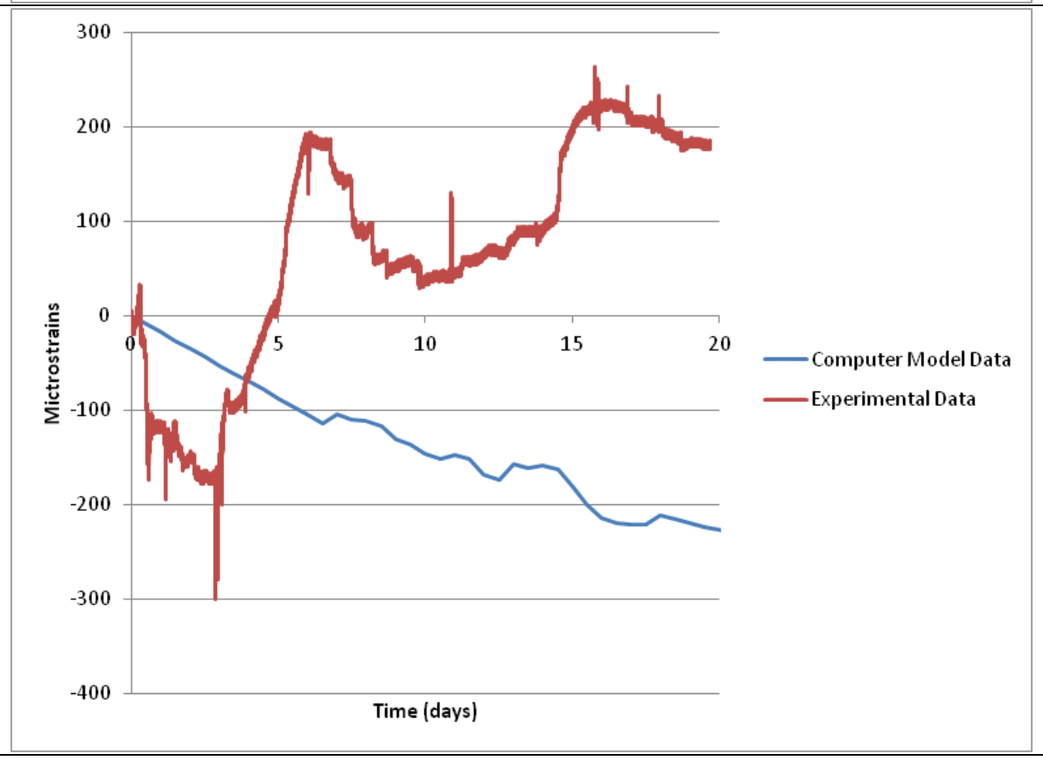
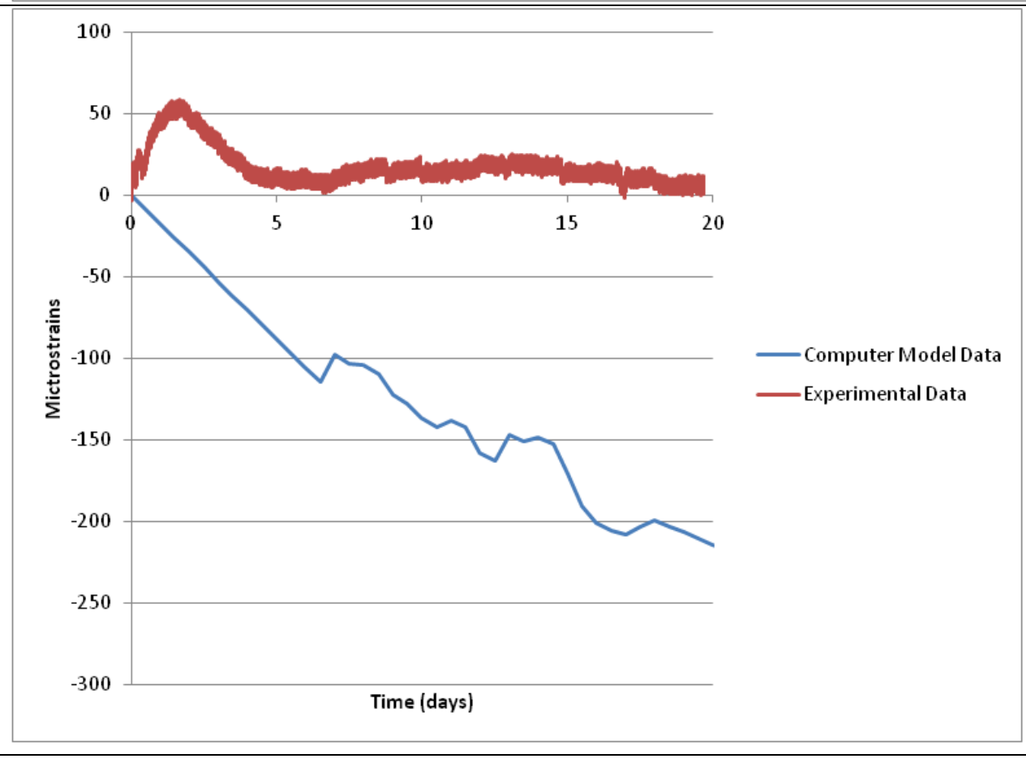
S-G1-Tf-M-3/4-L		
S-G1-Bf-M-3/4-L		

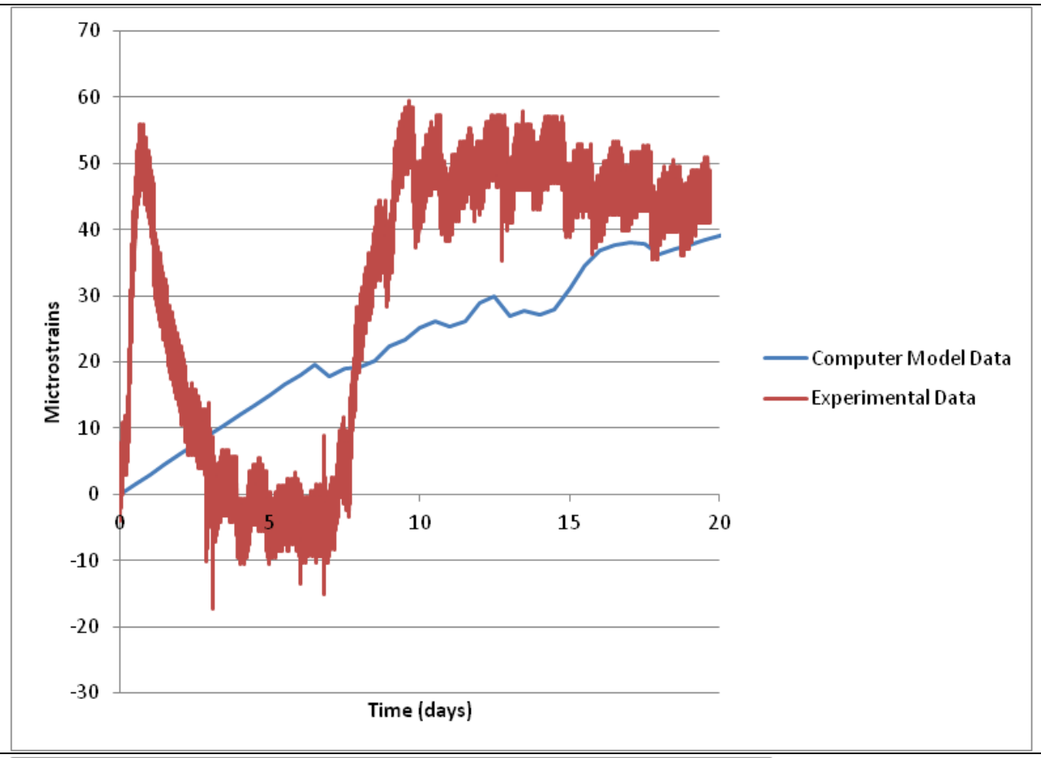
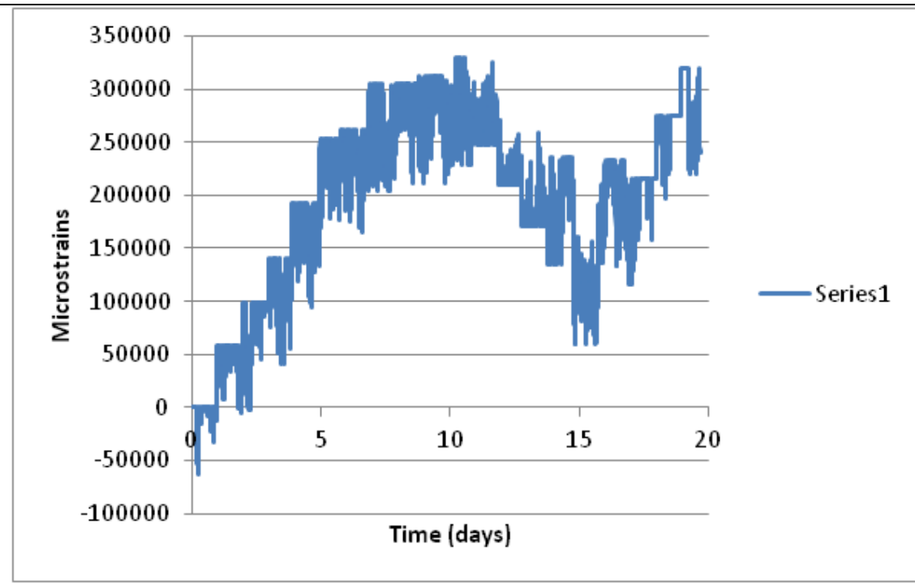
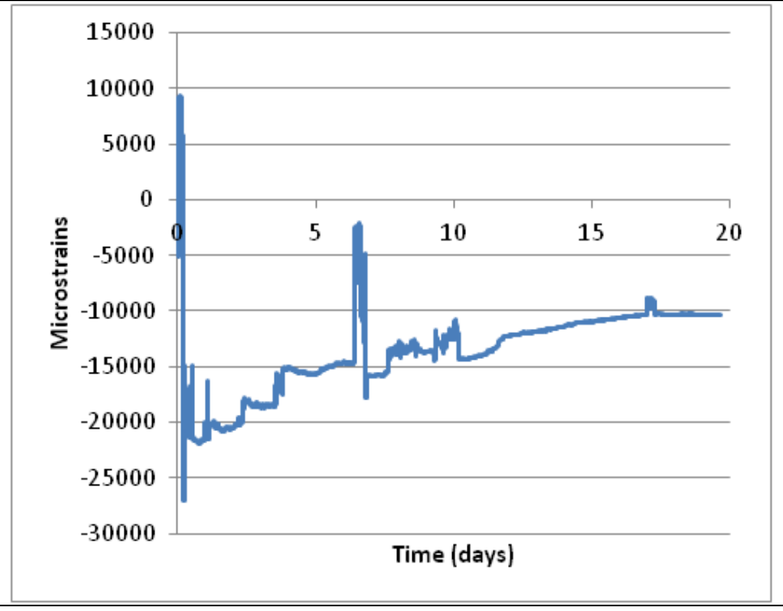
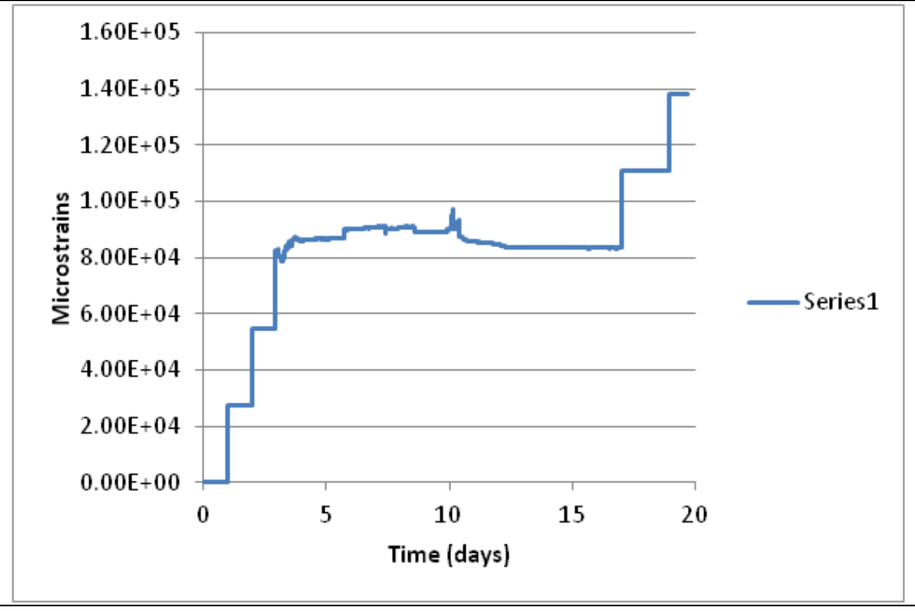
S-G1-W-O-3/4-L		
S-G1-W-O-1/2-L		

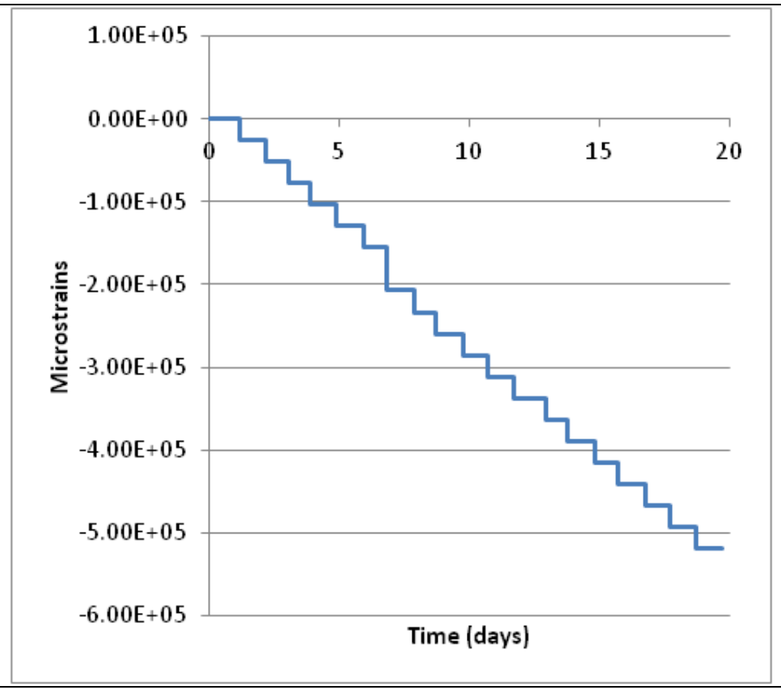
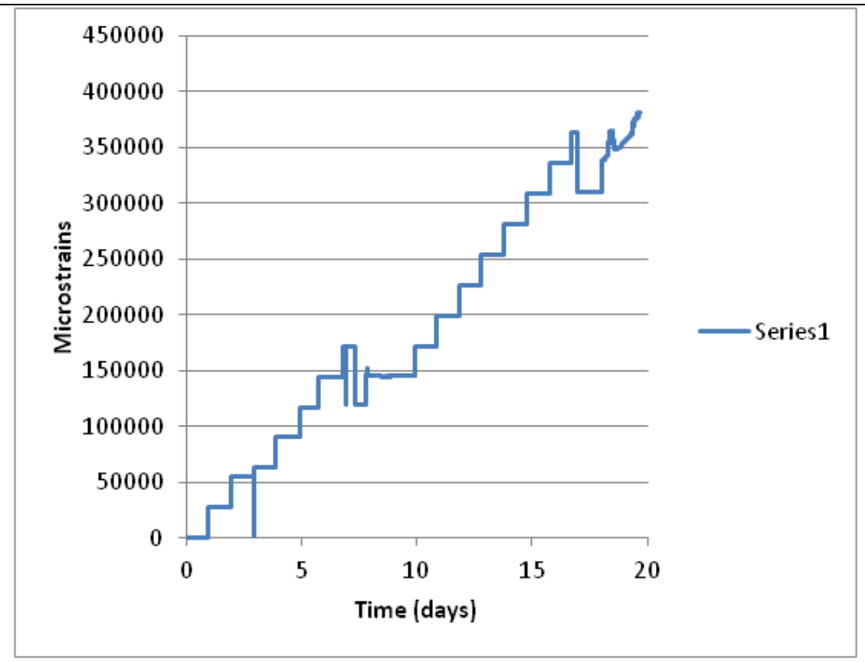
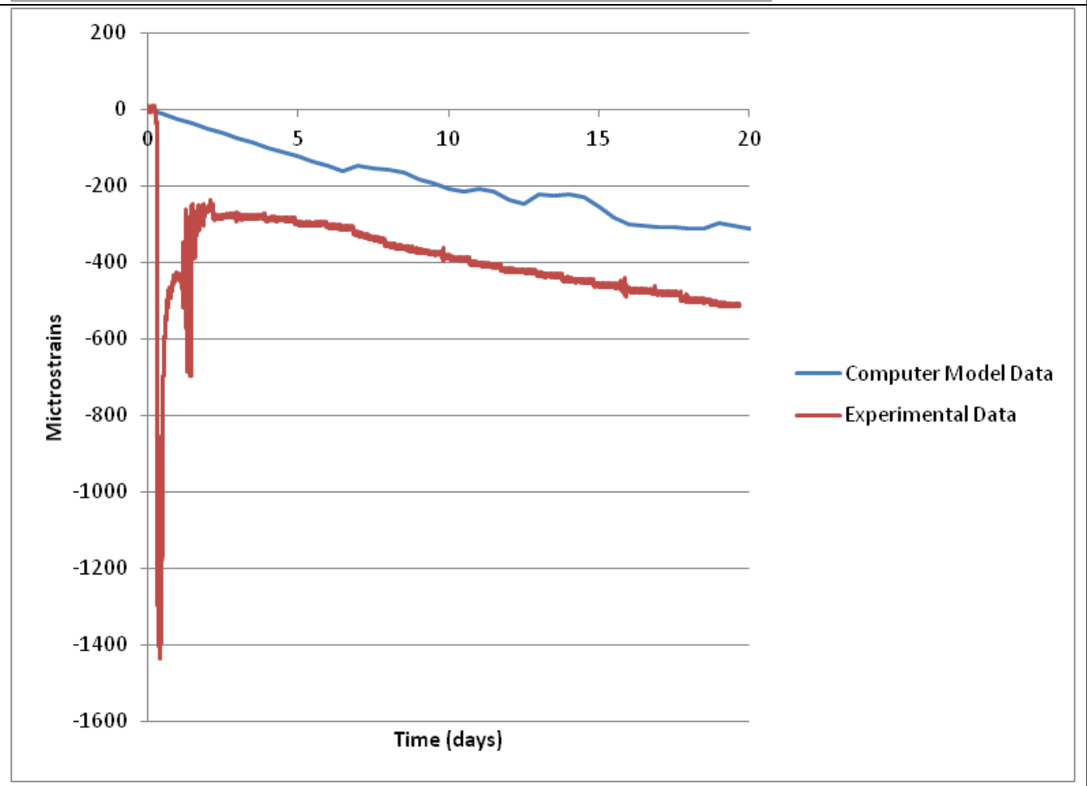
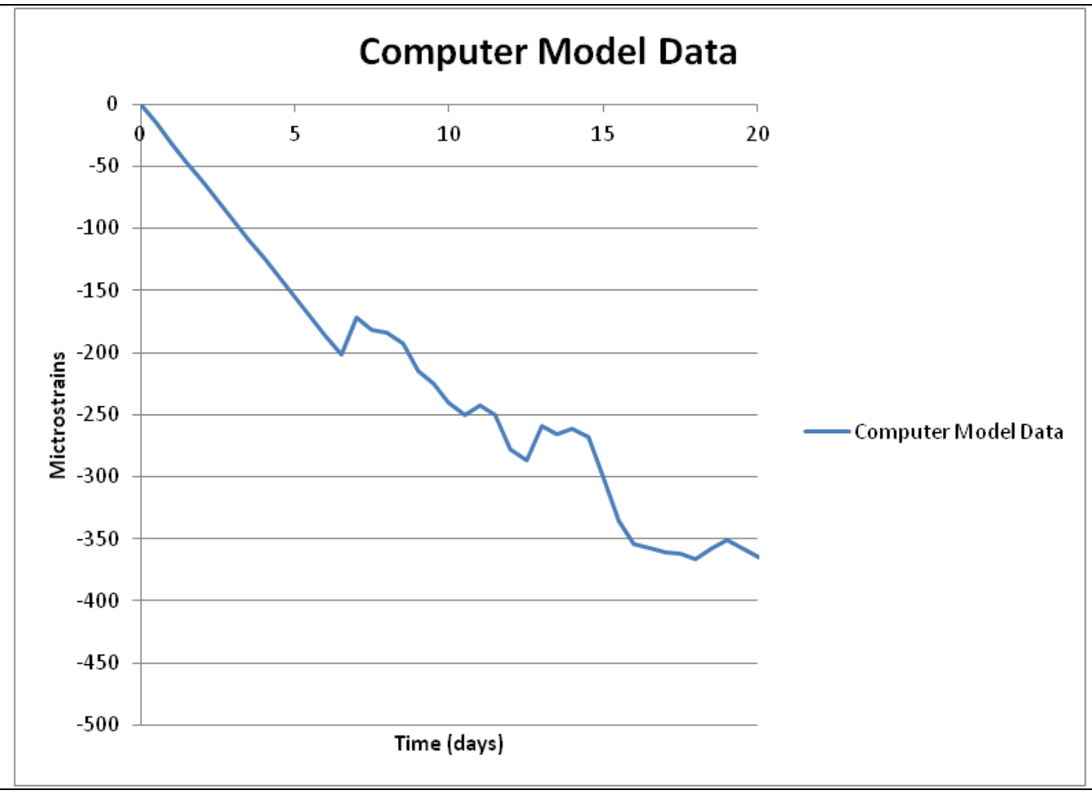
S-G1-Tf-M-1/4-L		
S-G1-Bf-I-1/2-L		

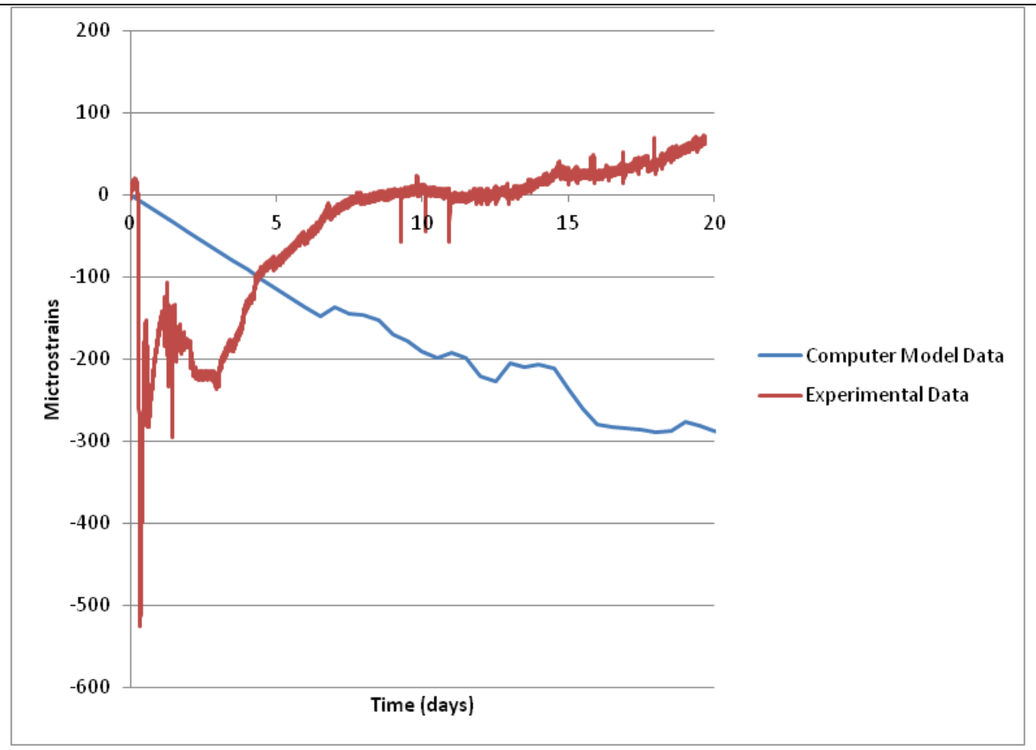
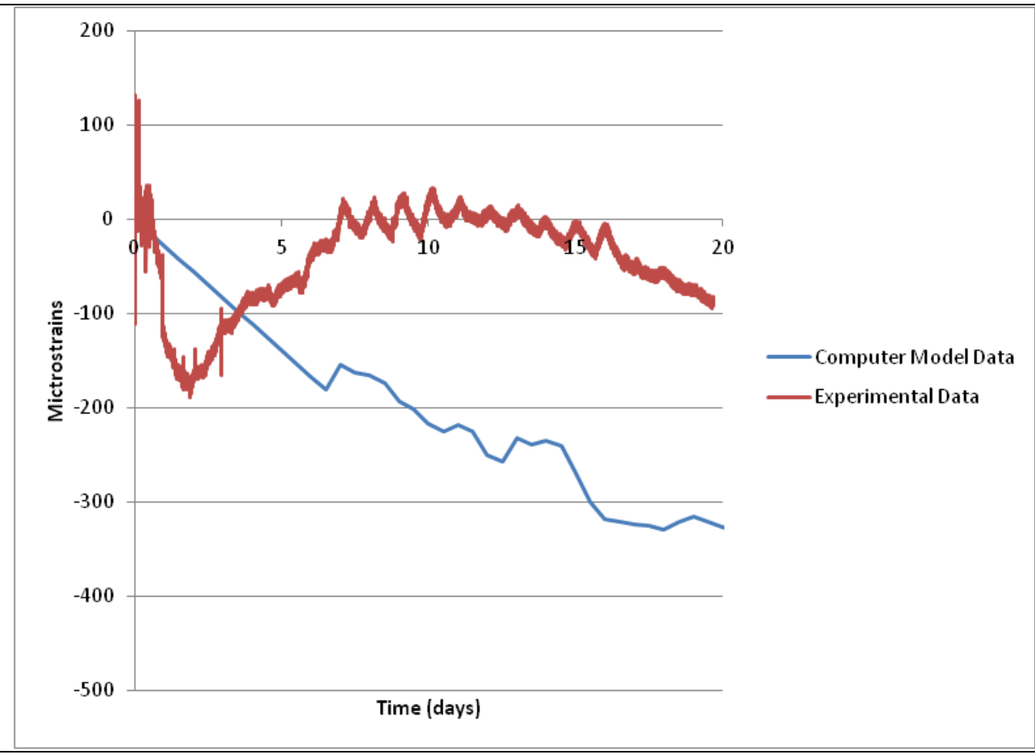
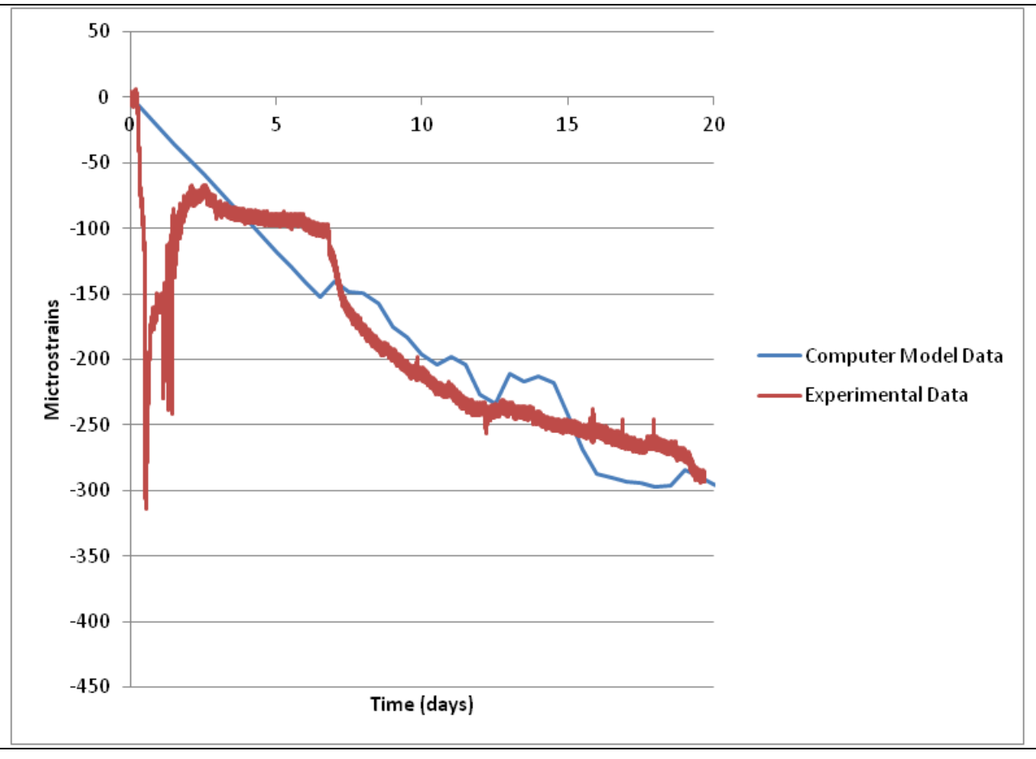
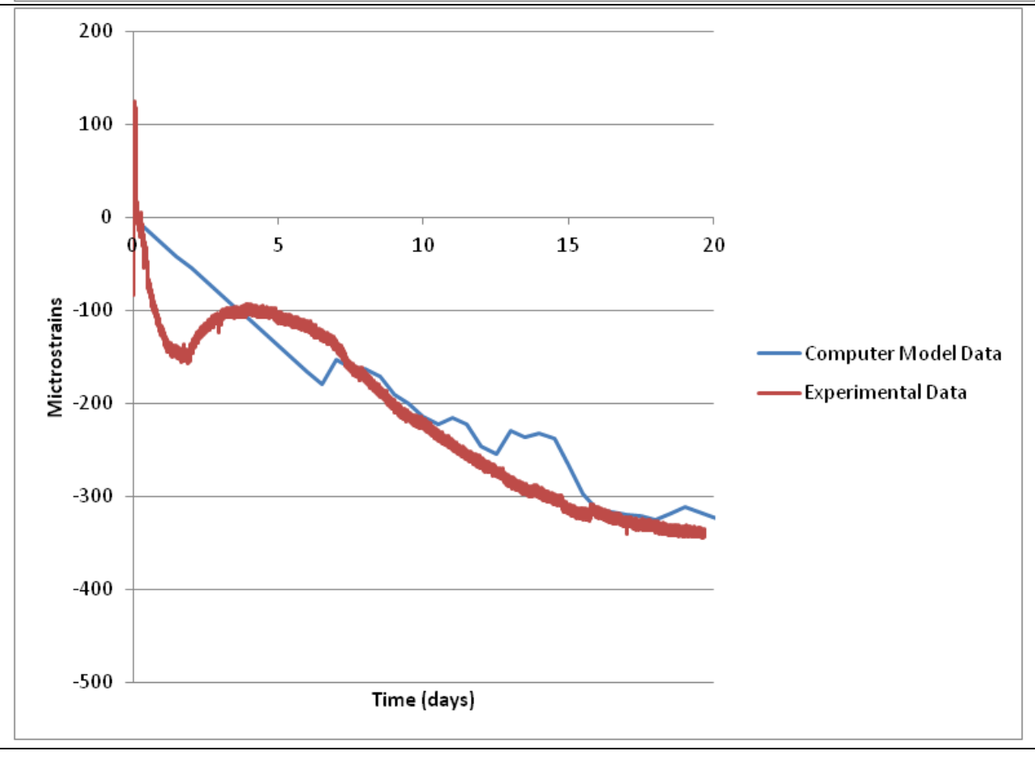
S-G1-Bf-M-1/2-L		
S-G1-W-I-1/2-L		

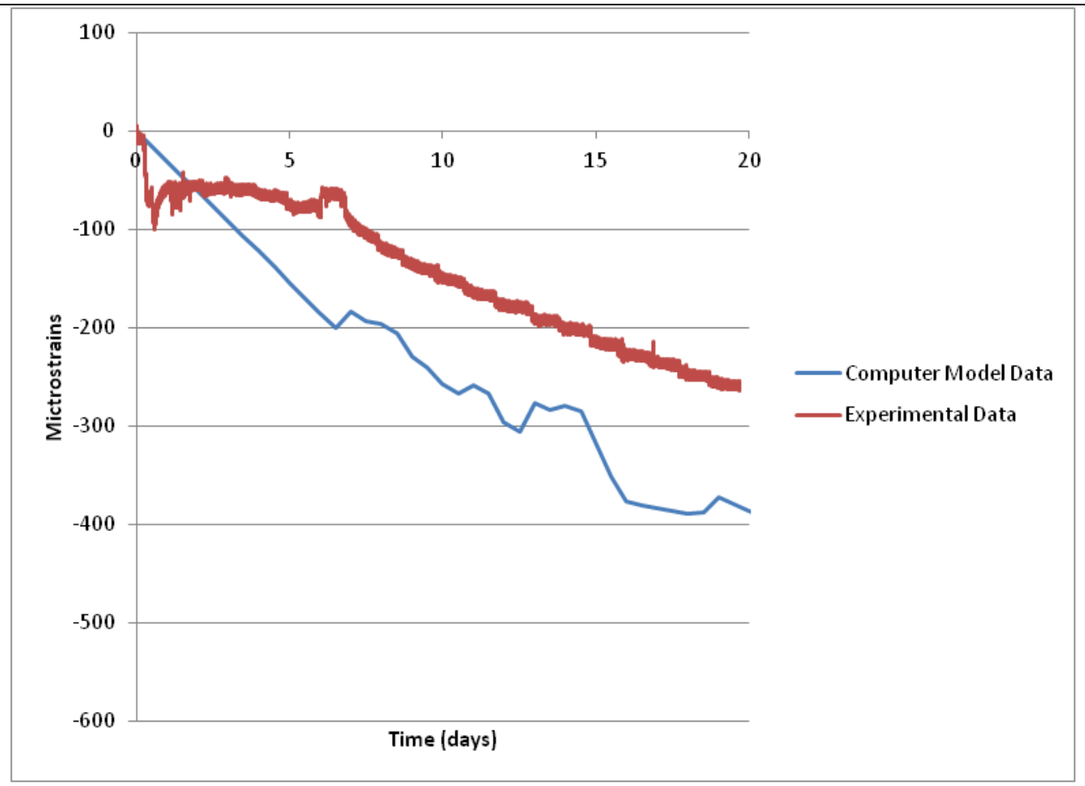
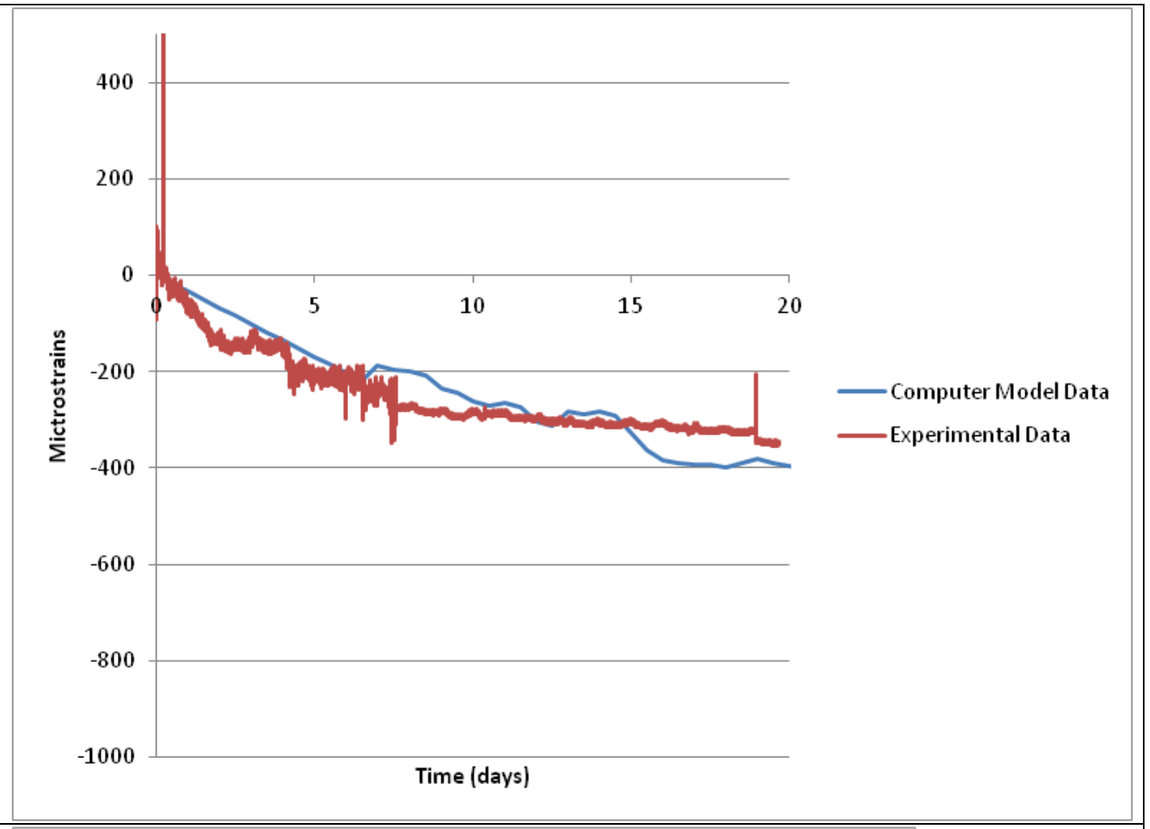
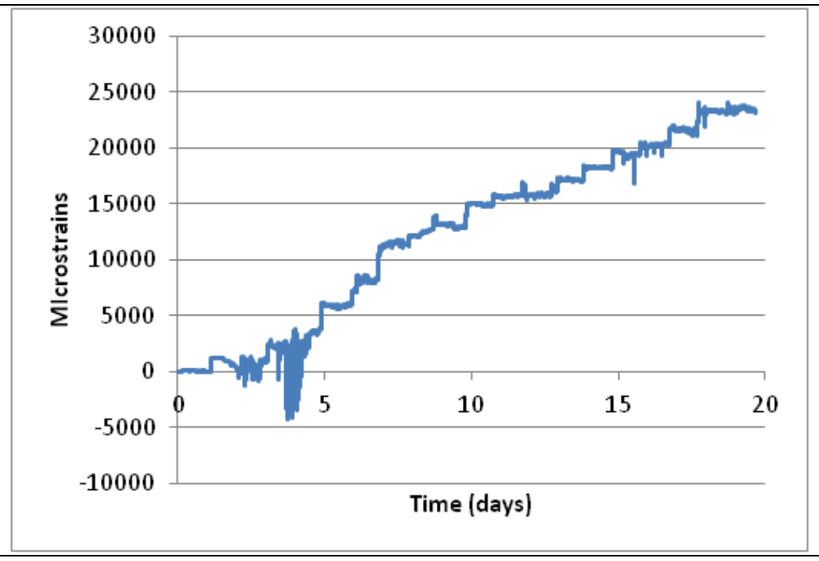
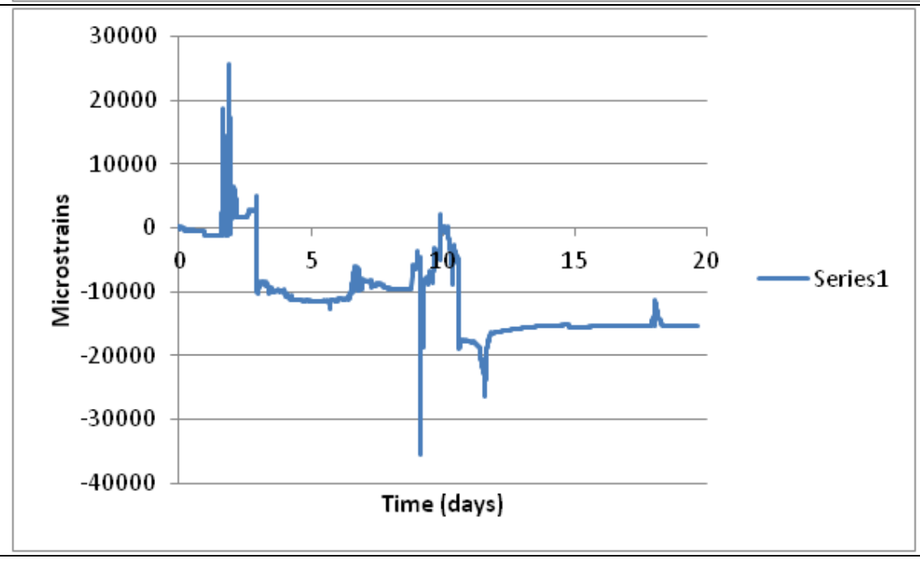
S-G1-Tf-M-1/2-L		
S-G1-Bf-M-1/4-L		

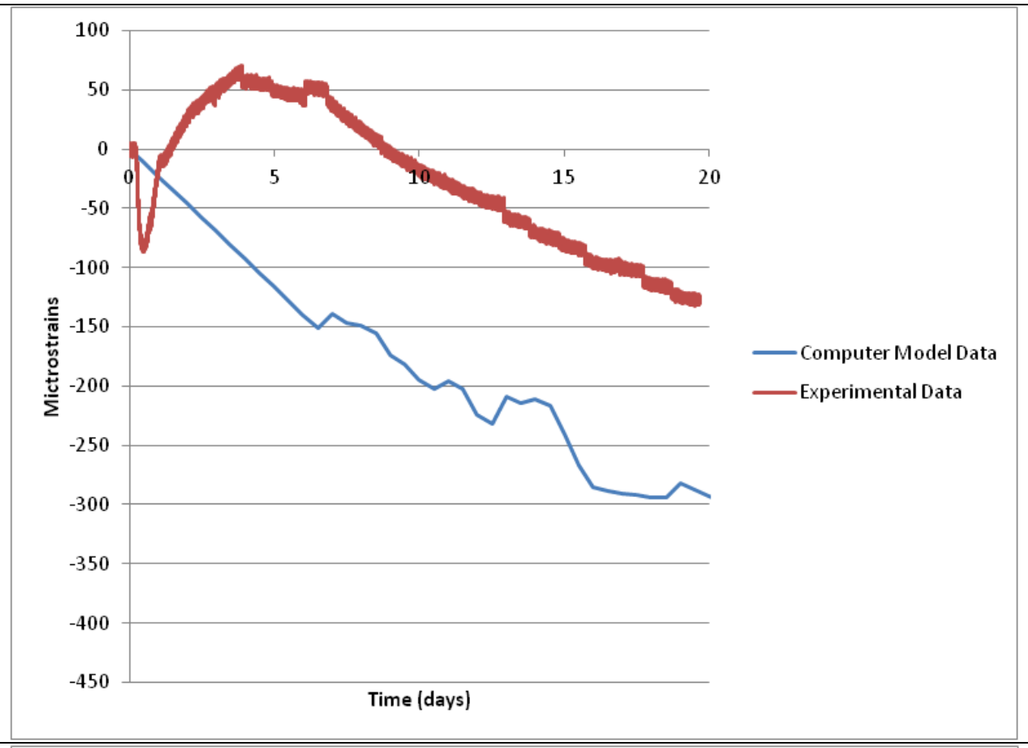
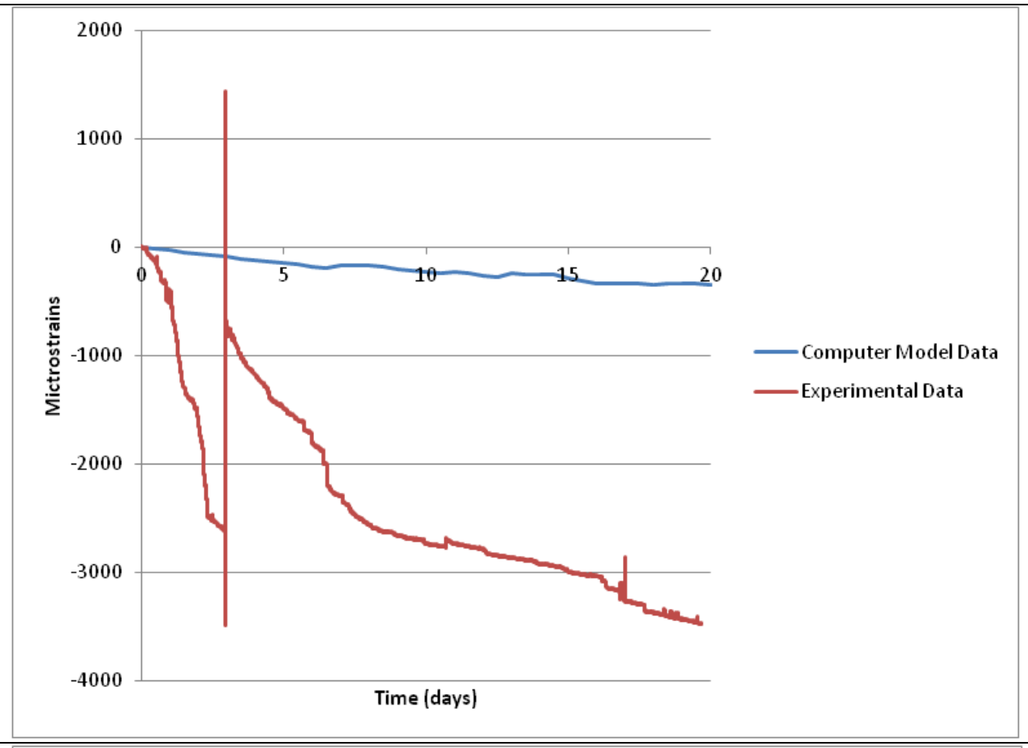
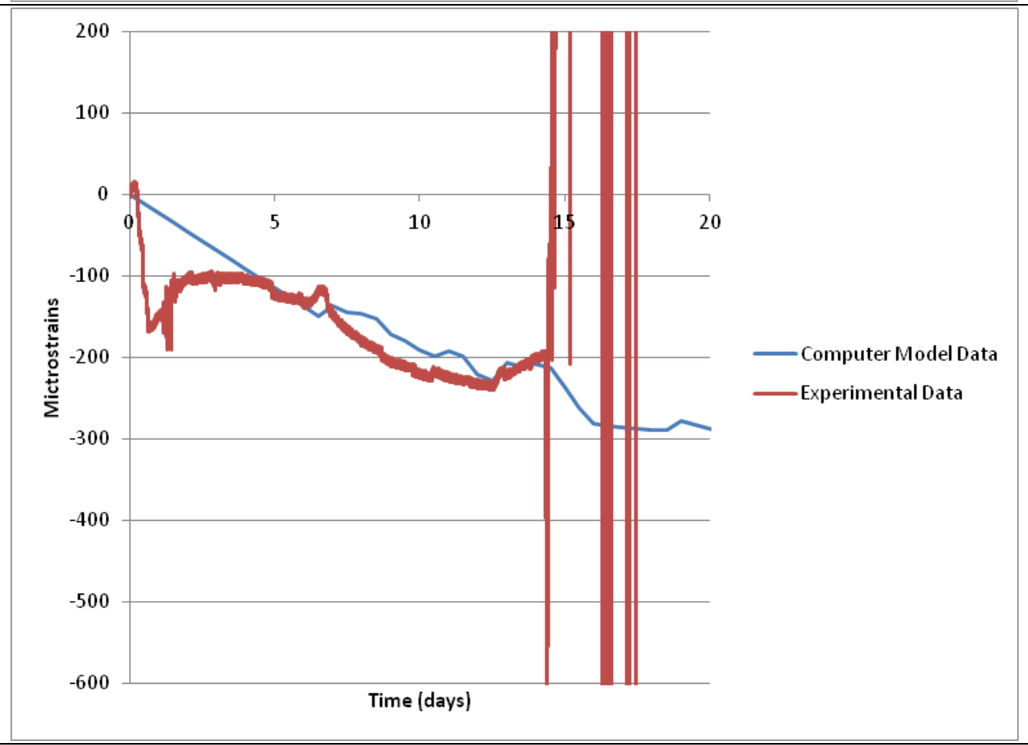
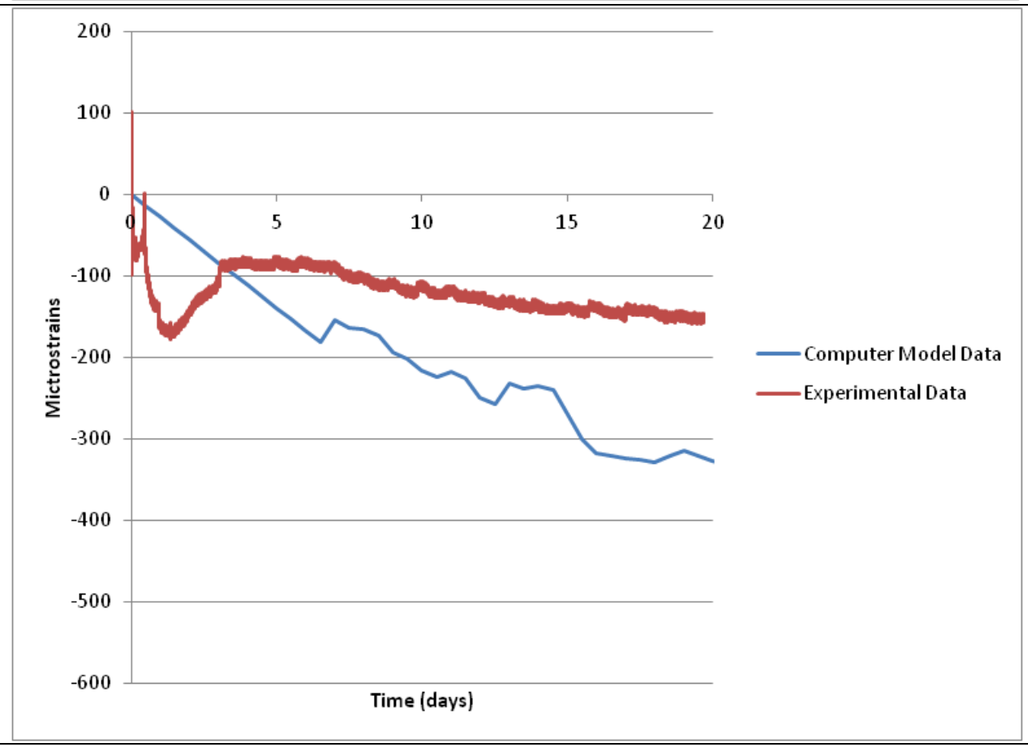
S-G1-Bf-O-1/2-L		
S-G2-Tf-M-1/2-L		

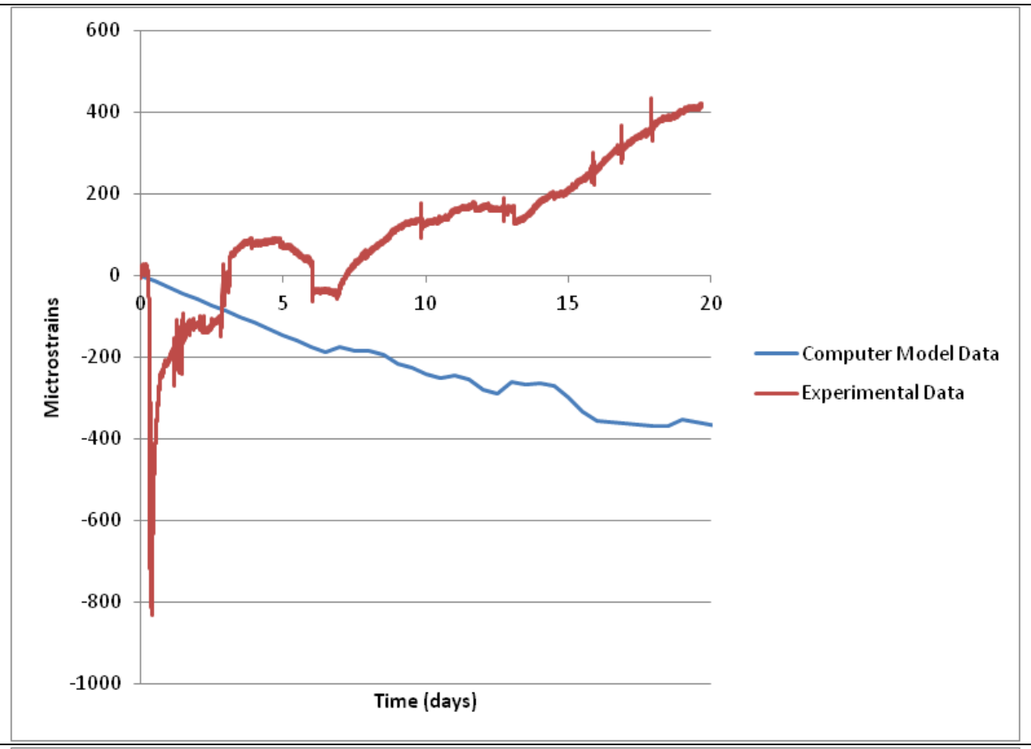
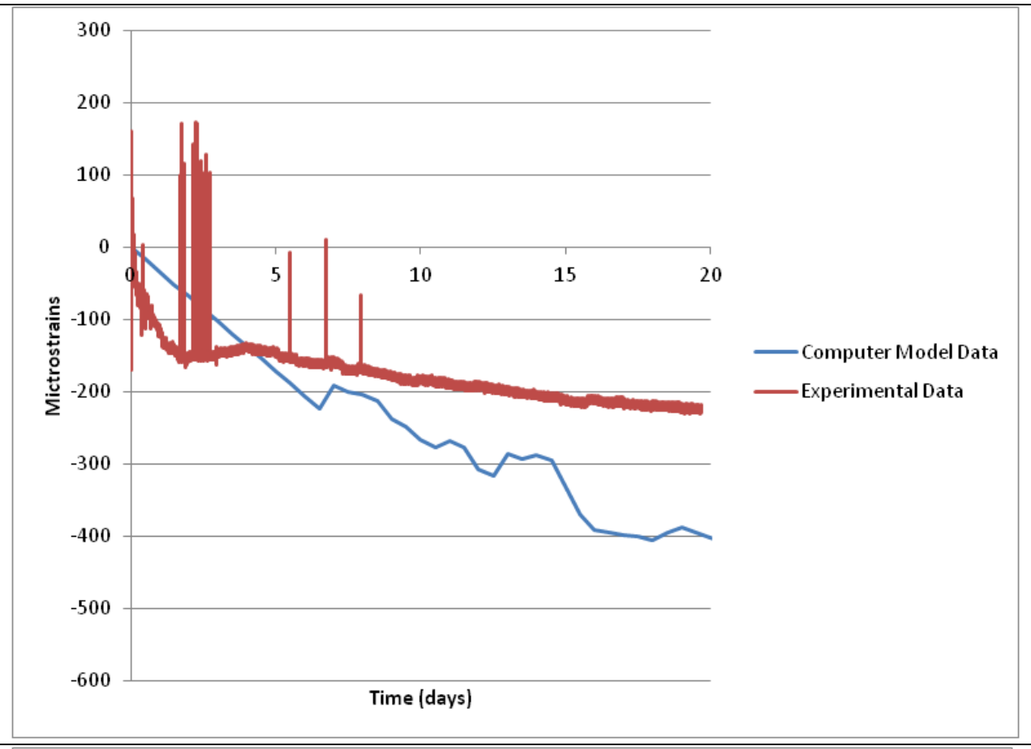
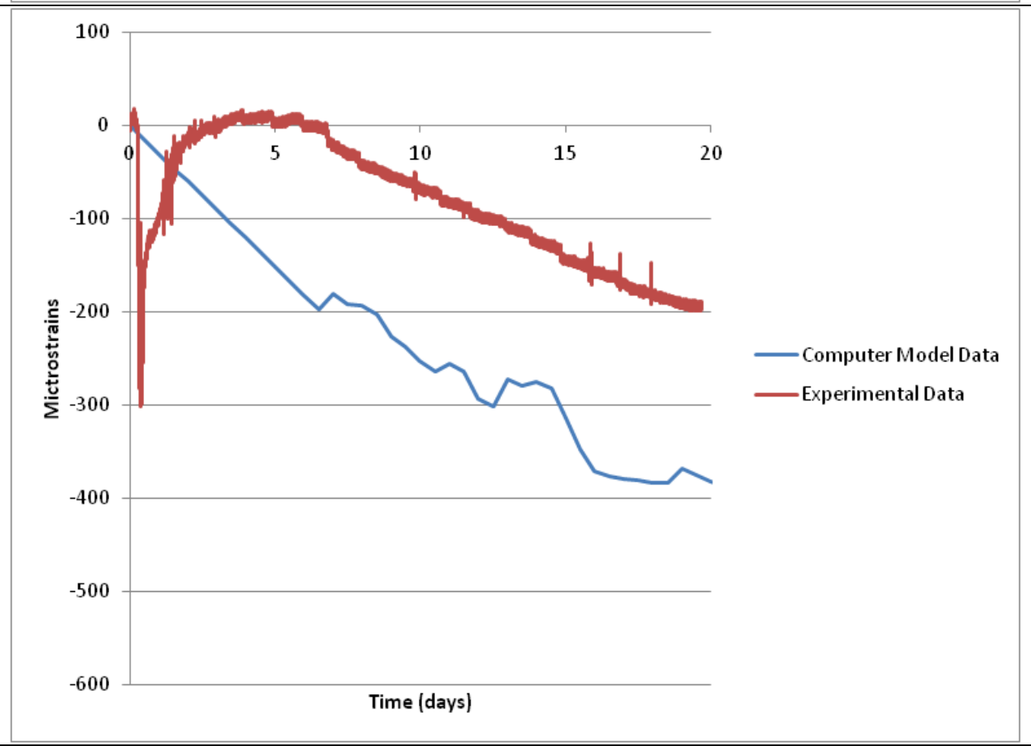
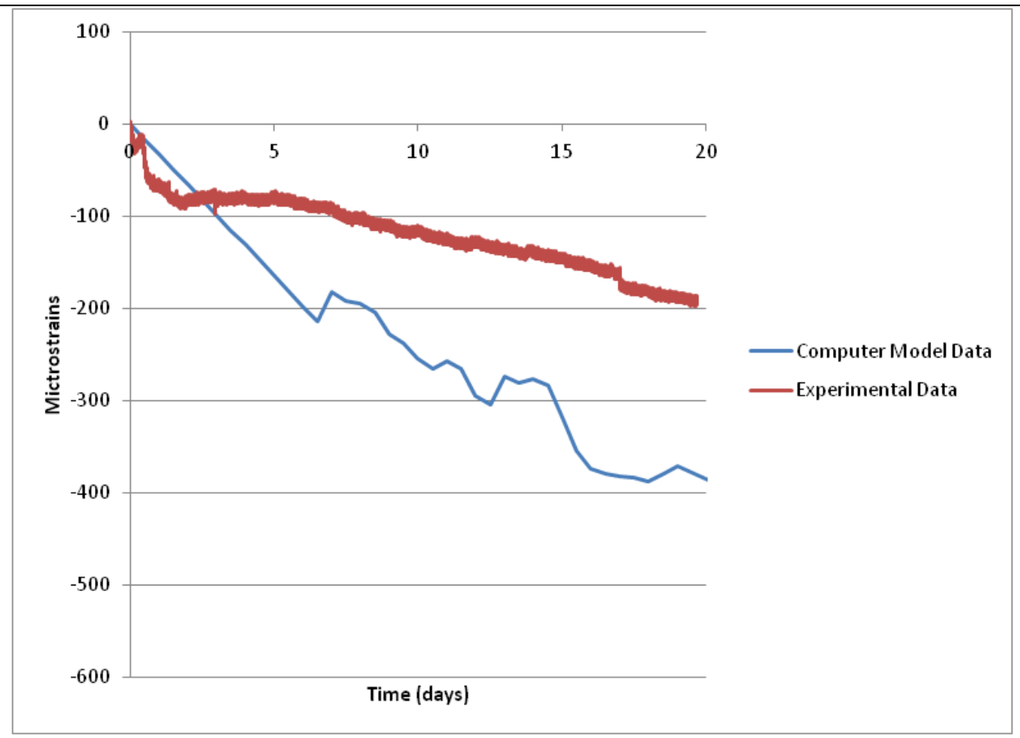
S-G2-Bf-M-1/2-L		
S-Tp-G1-1/2-L		

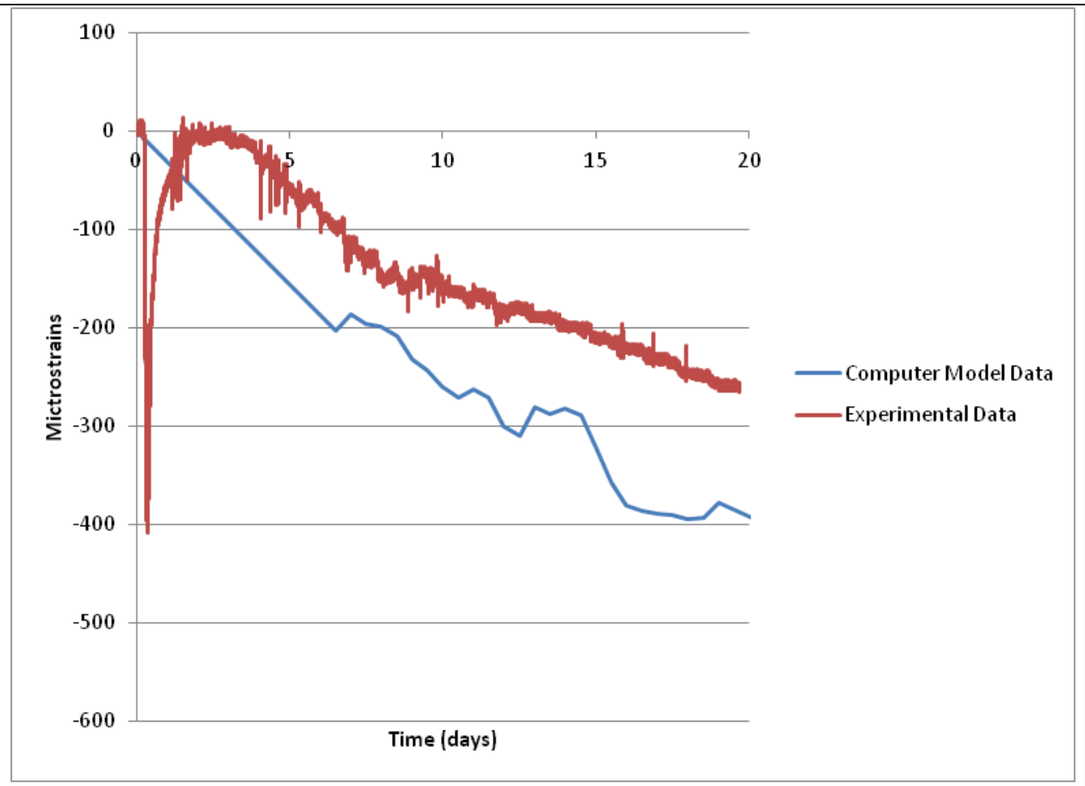
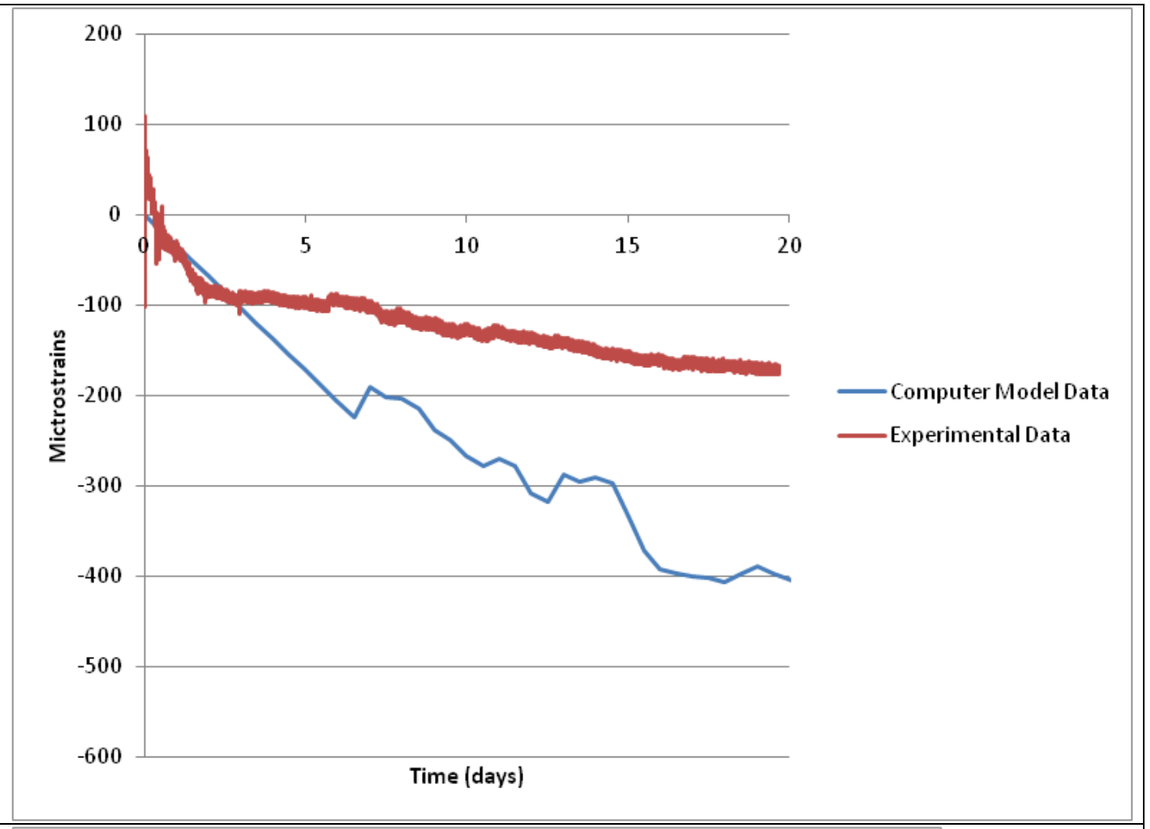
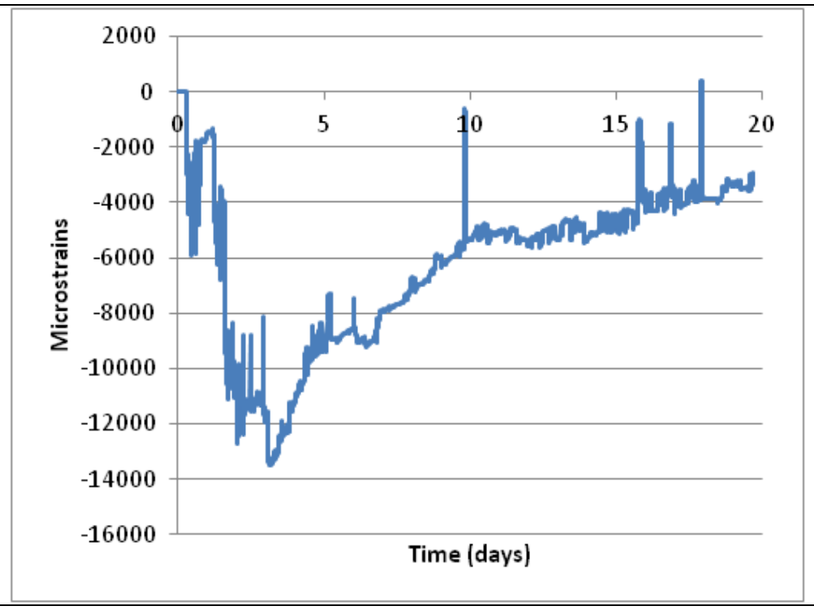
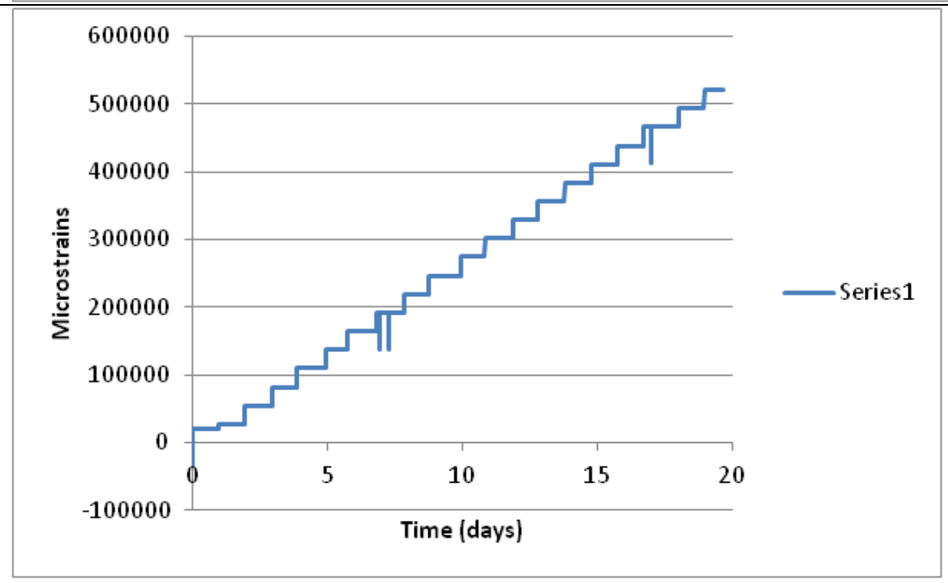
S-Tp-1/2-1/2-T		
S-Tp-1/2-1/4-T		

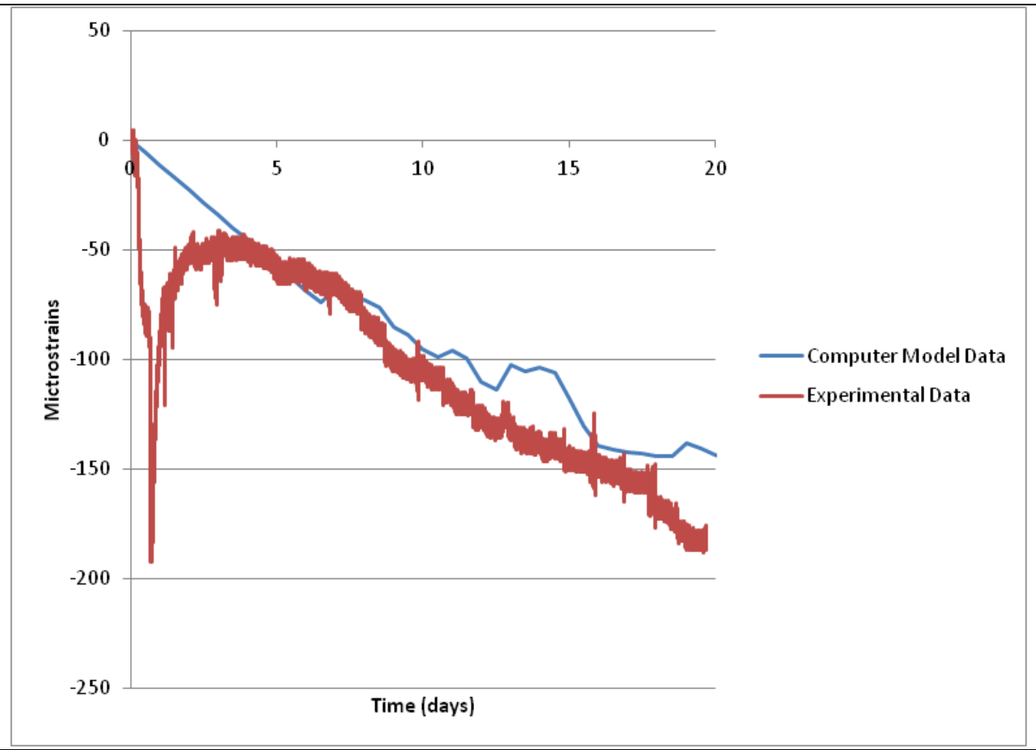
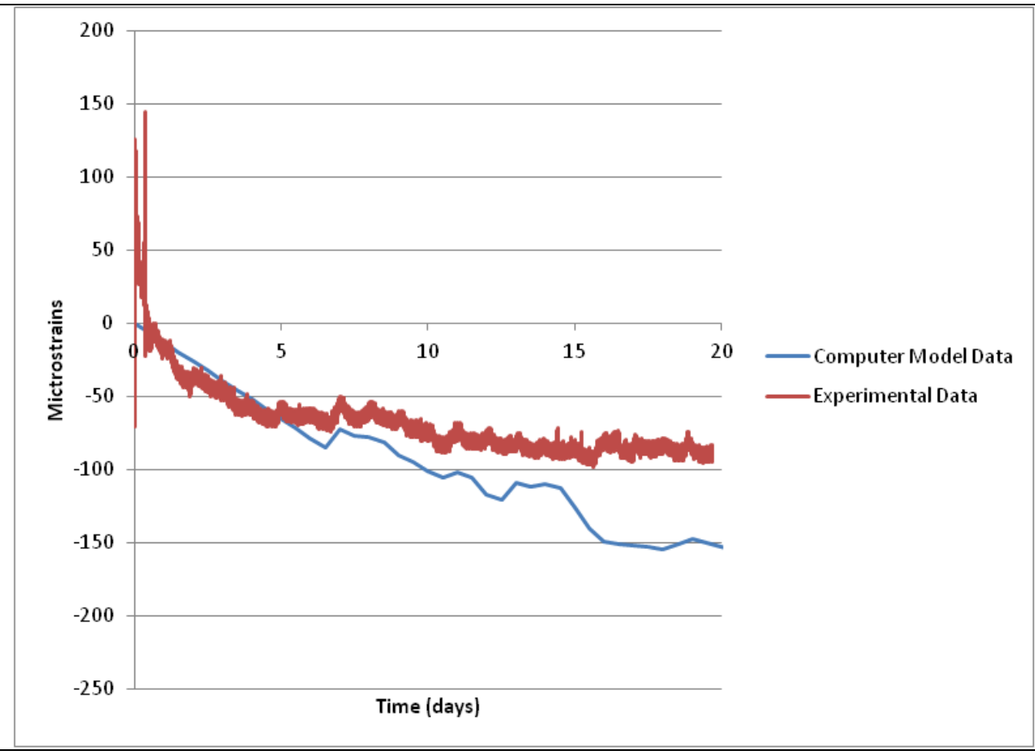
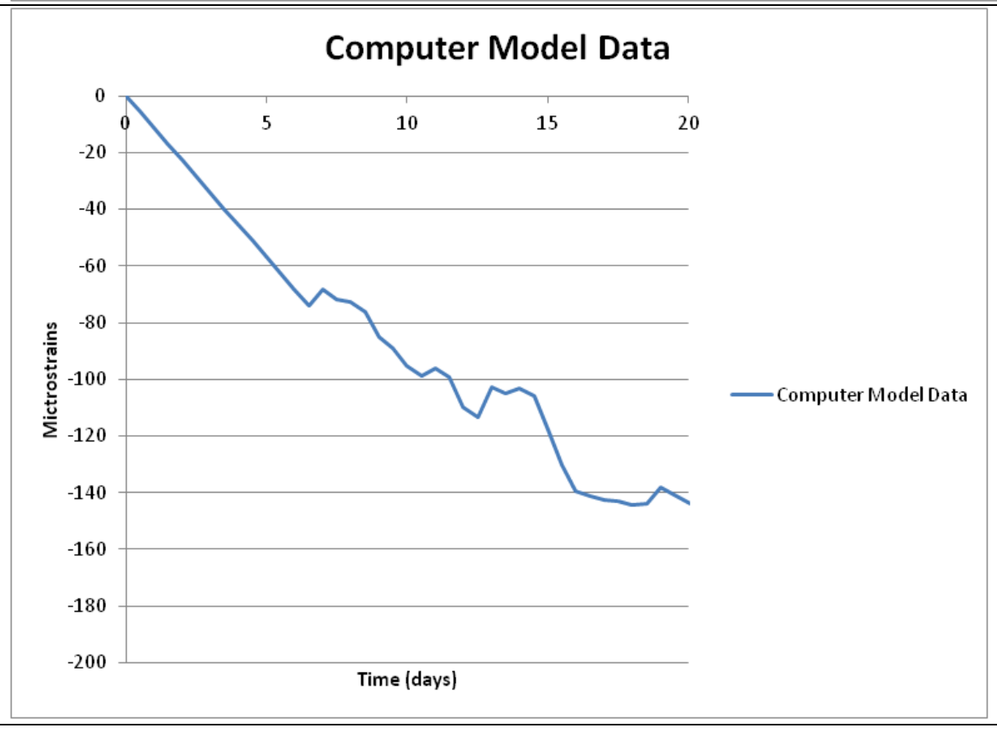
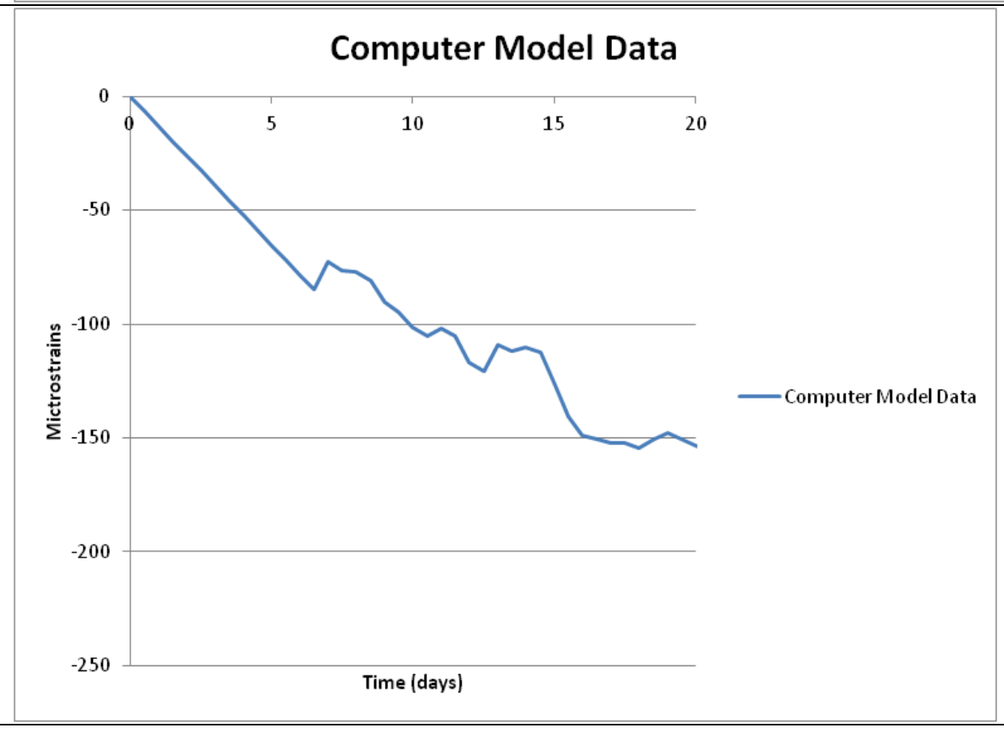
S-Tp-1/2-3/4-L		
S-Tp-1/2-1/2-L		

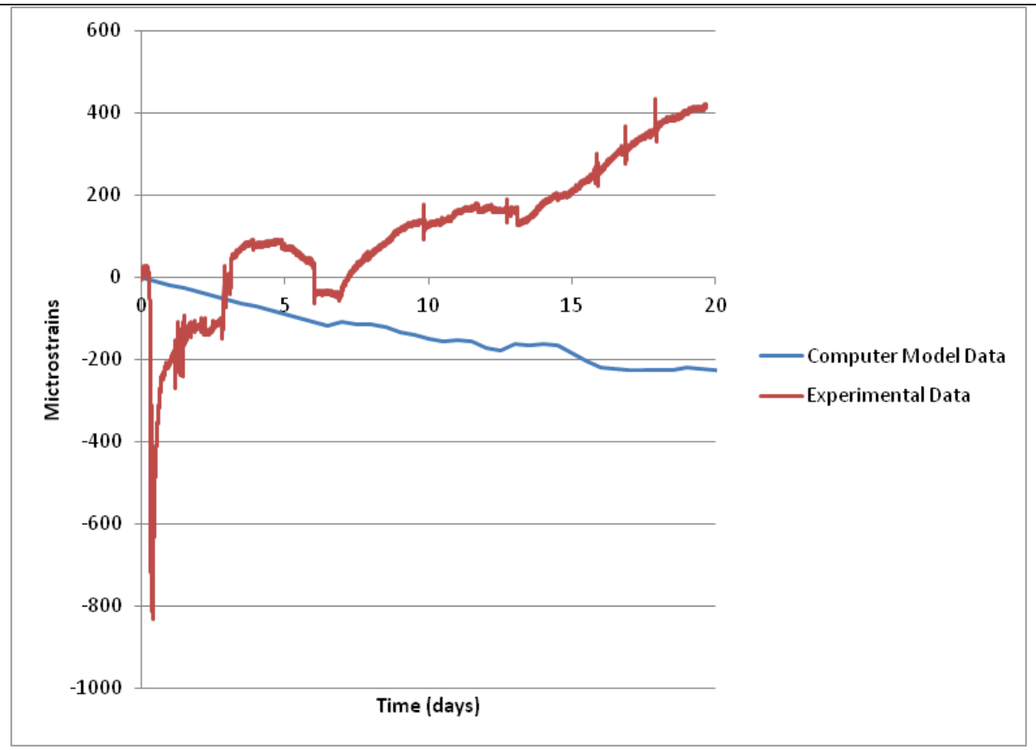
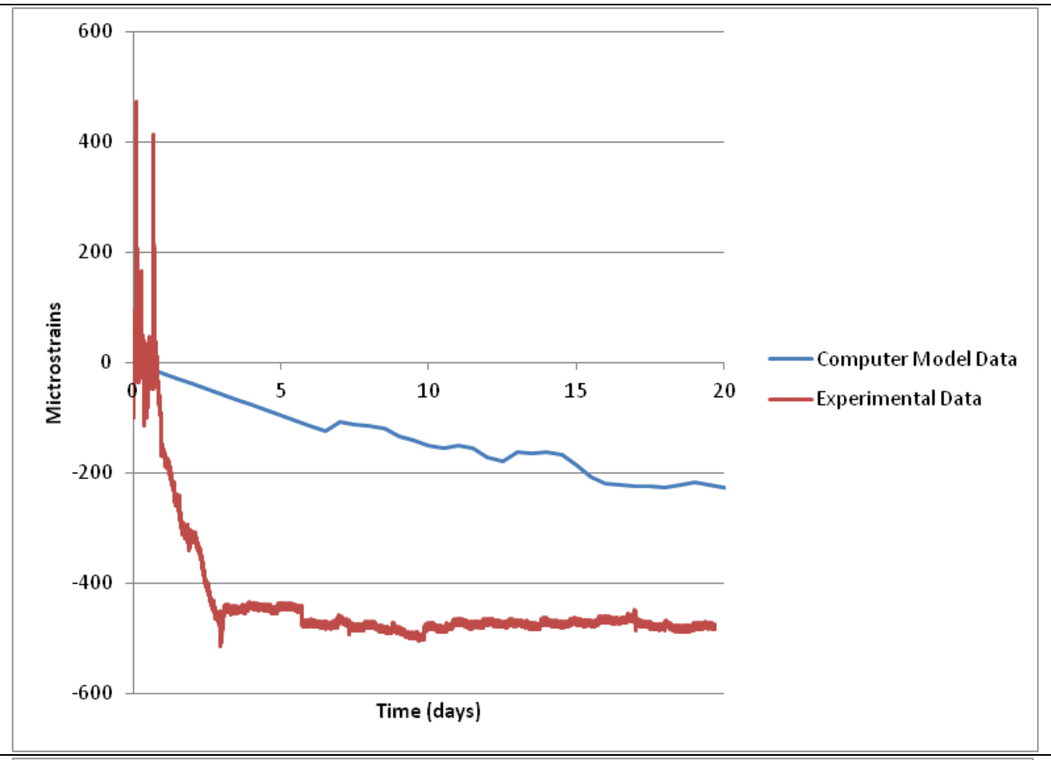
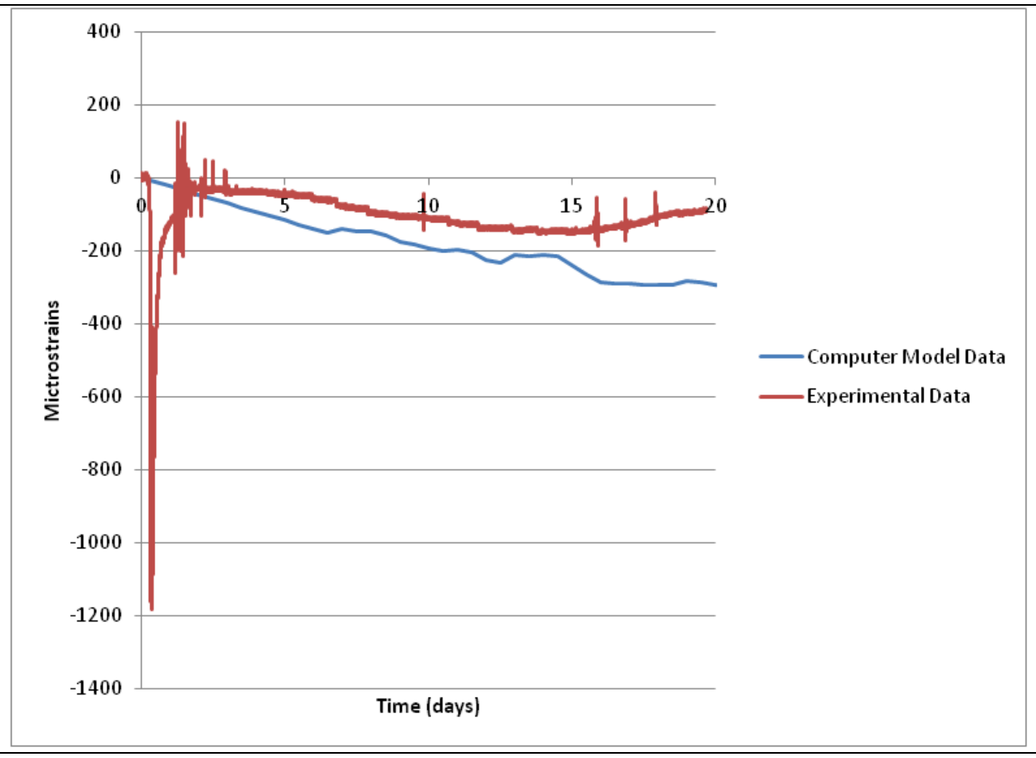
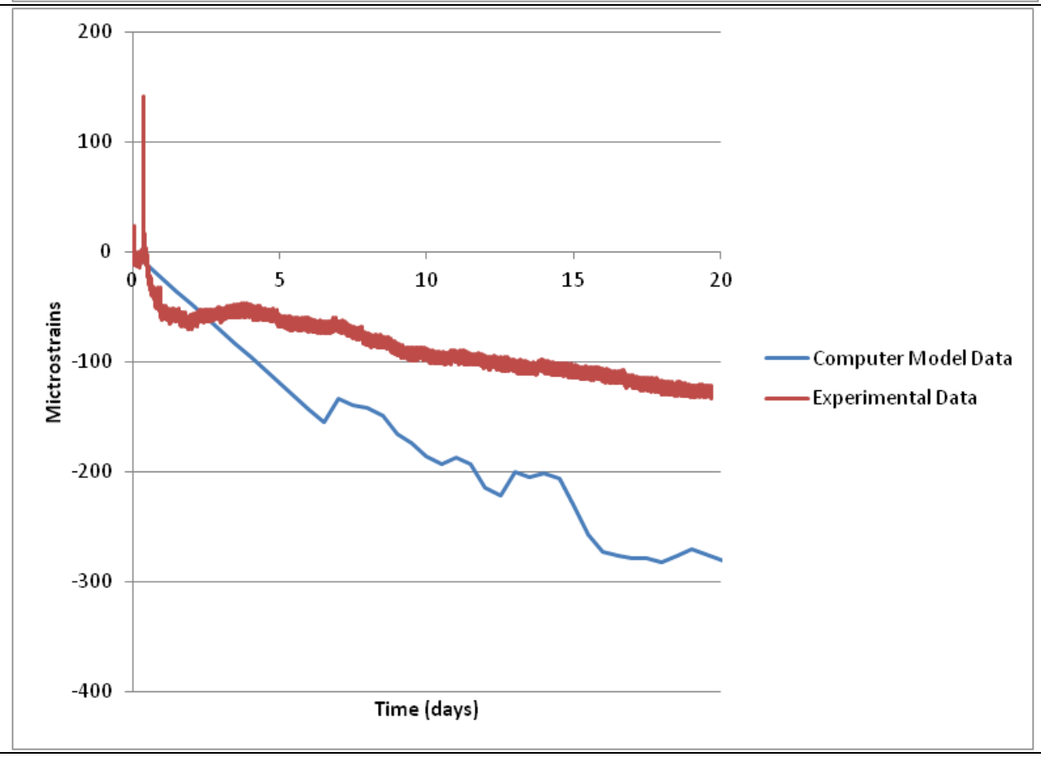
S-Tp-G2-1/2-L		
S-Tp-G1-3/4-L		

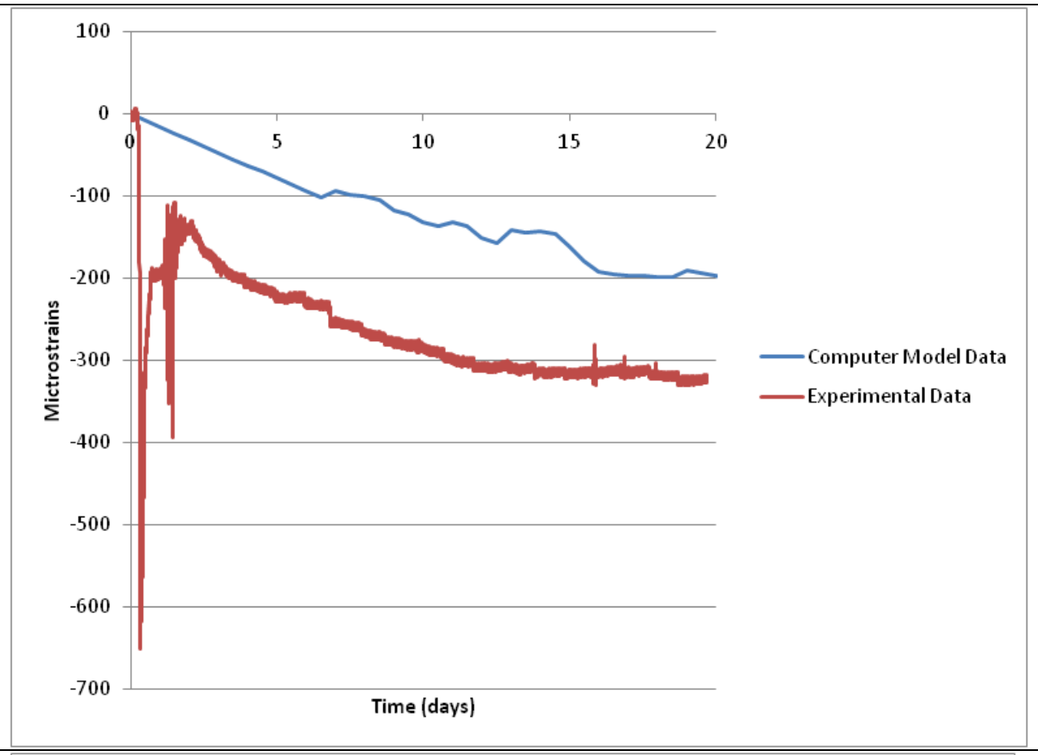
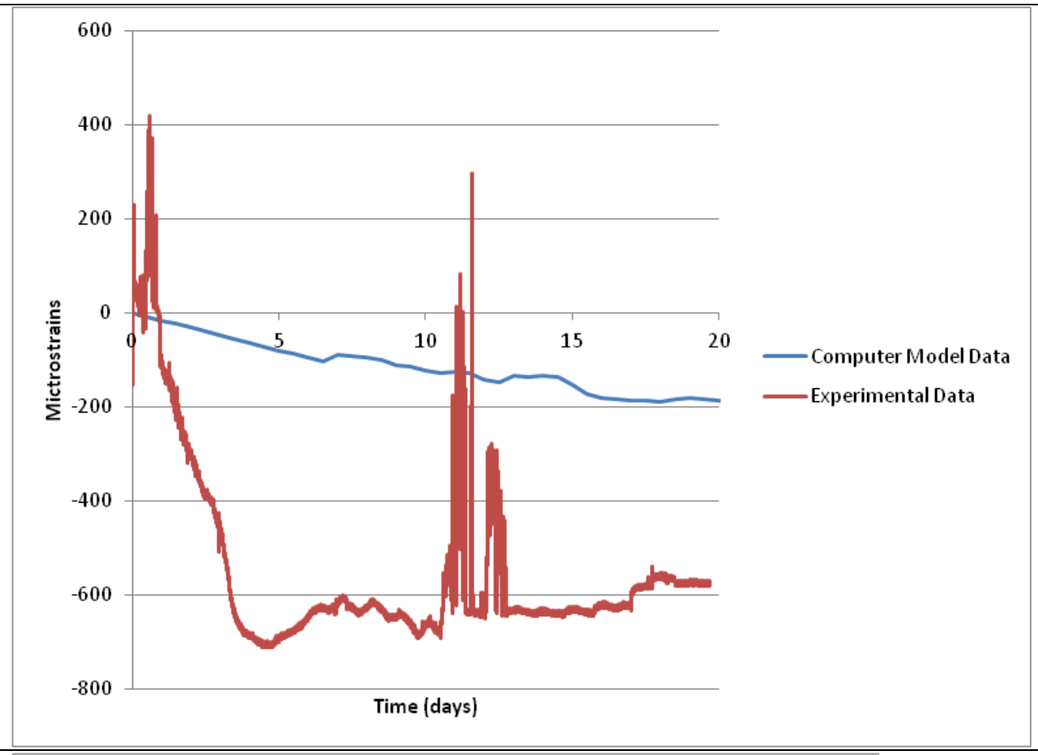
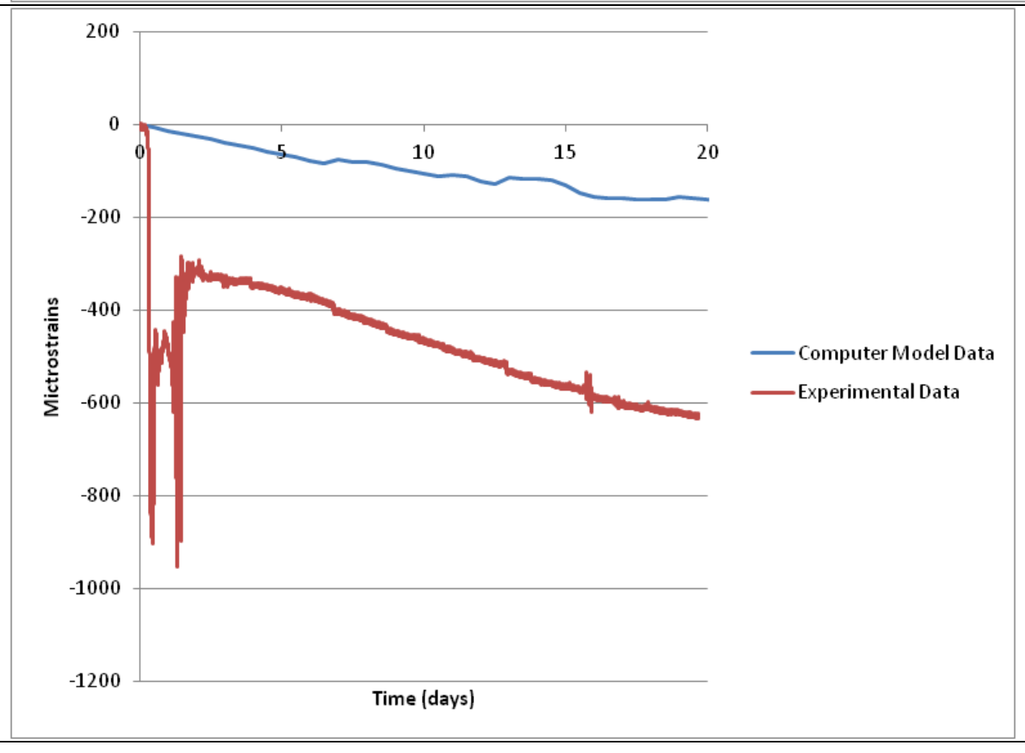
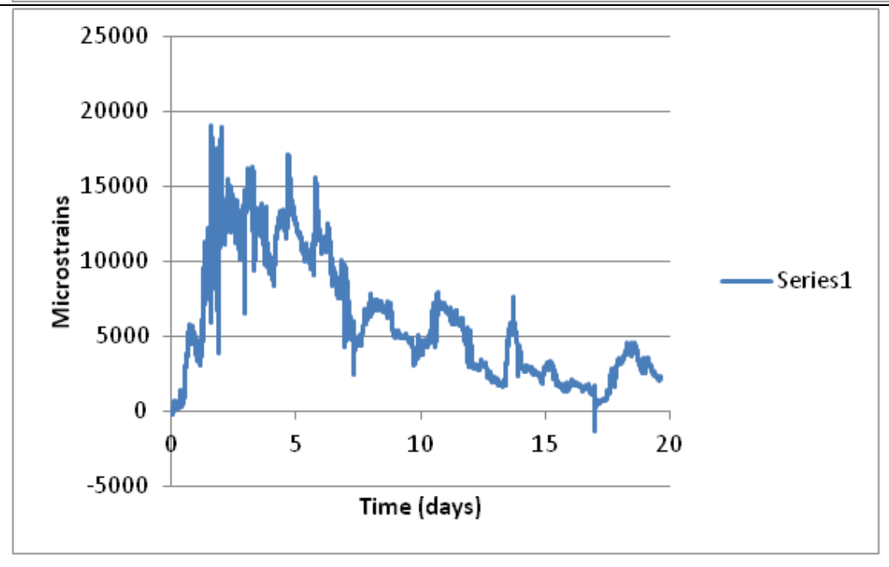
S-Tp-1/3-3/4-L		
S-Tp-1/2-1/4-L		

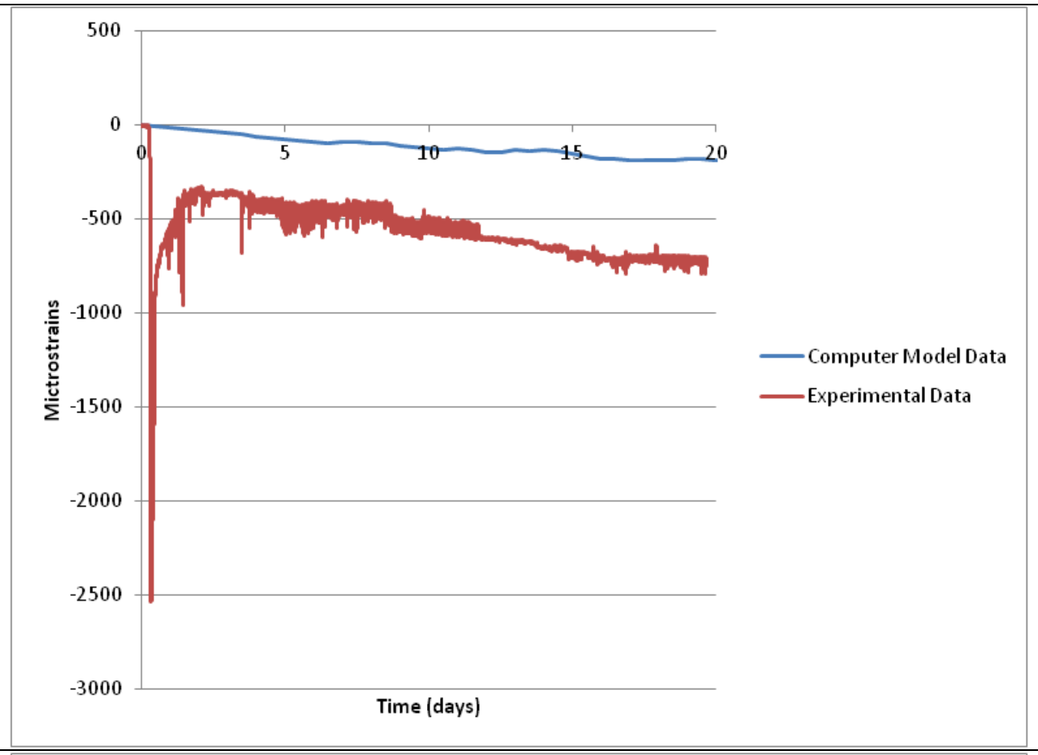
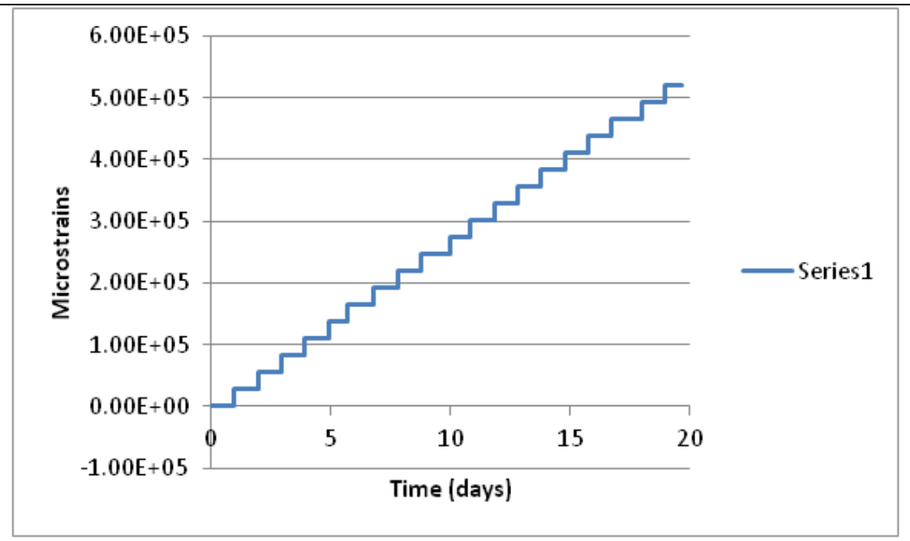
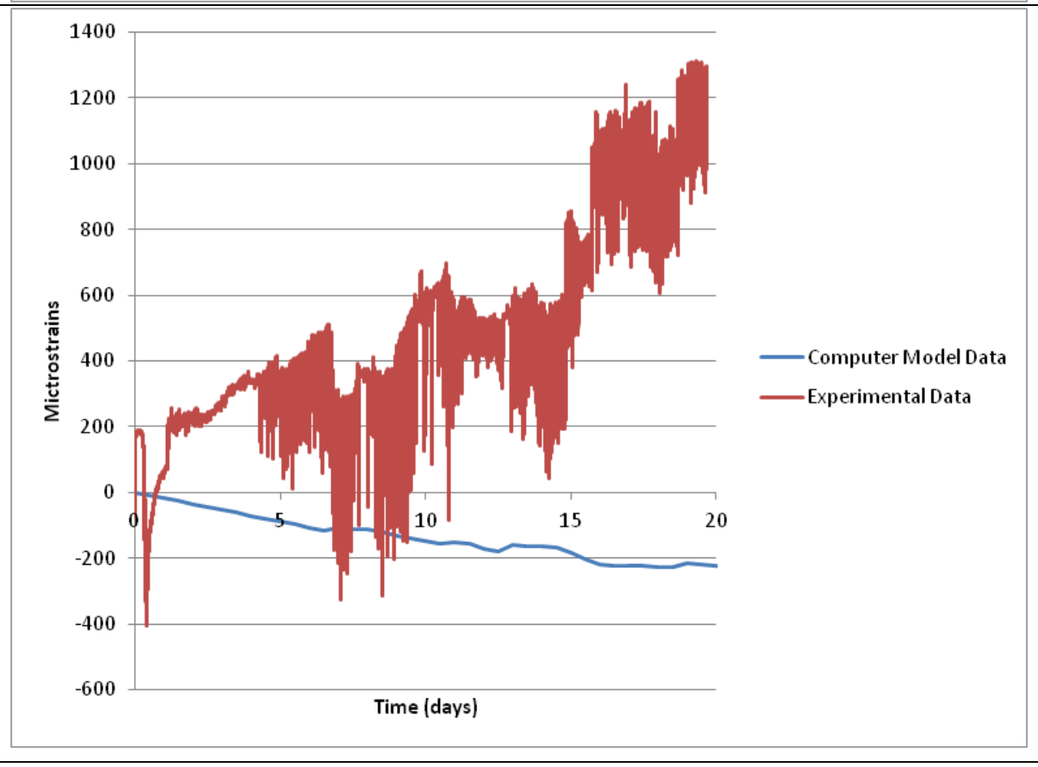
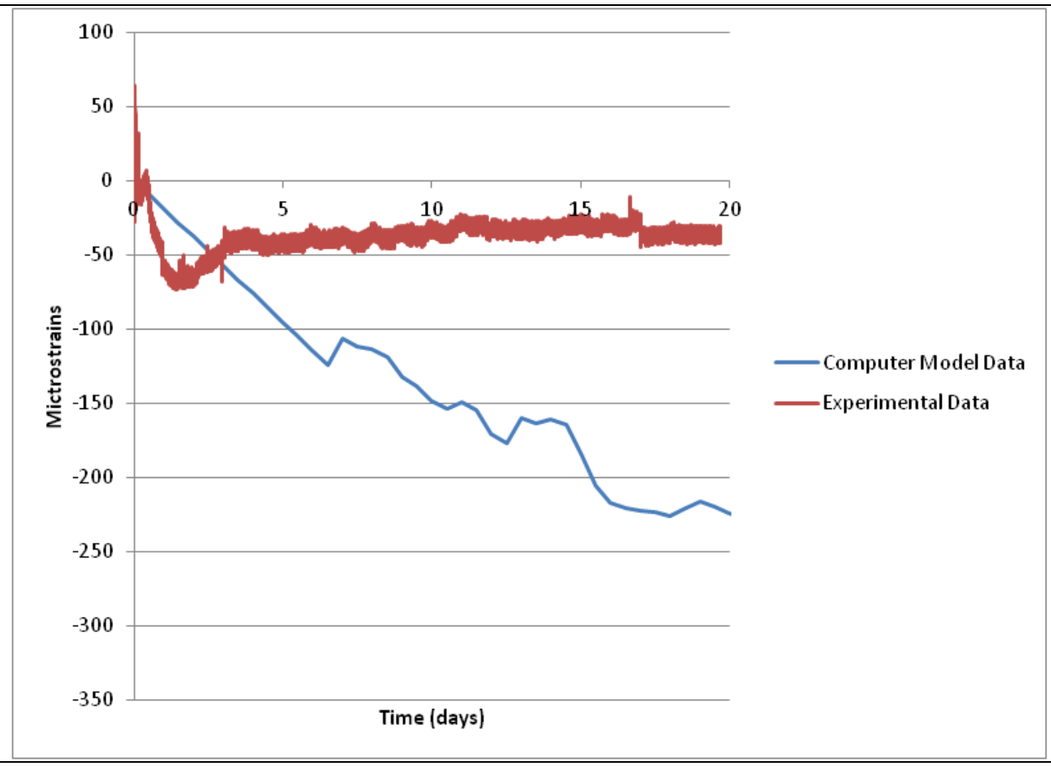
S-Tp-G1-1/4-T		
S-Tp-G1-1/2-T		

S-Tp-G1-1/4-L		
S-Bt-1/2-1/2-T		

S-Bt-G2-1/2-L		
S-Bt-1/2-3/4-L		

S-Bt-G1-1/4-T		
S-Bt-G1-1/4-L		

S-Bt-1/2-1/2-L		
S-Bt-1/2-1/4-L		

S-Bt-1/3-3/4-L		
S-Bt-G1-1/2-T		

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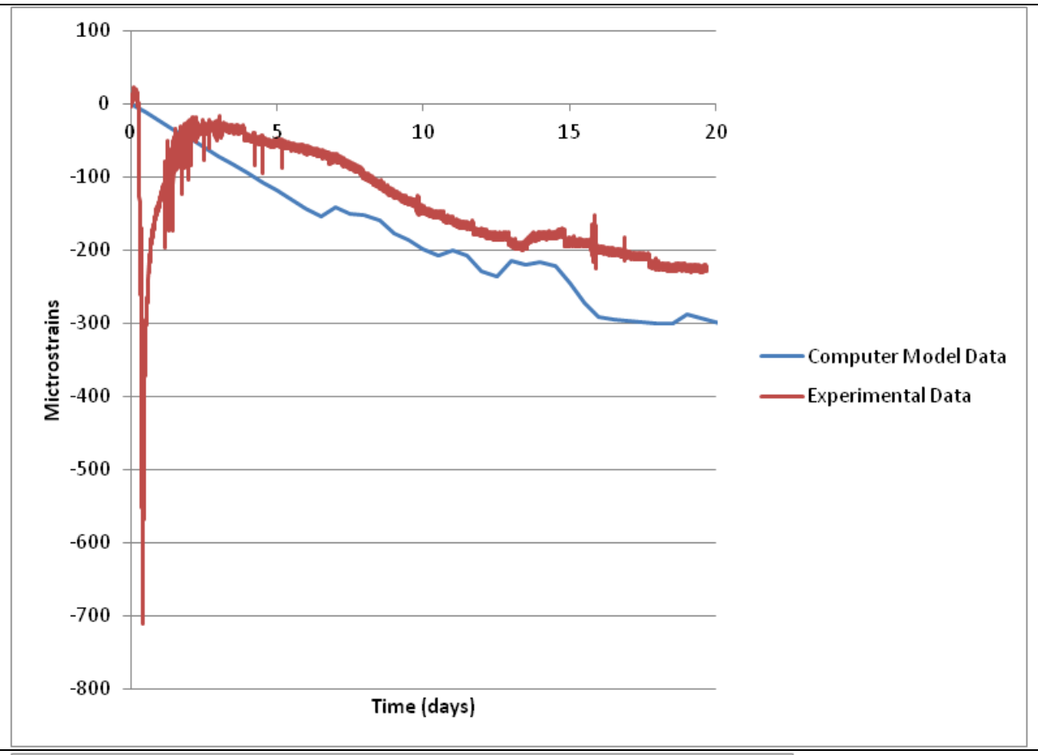

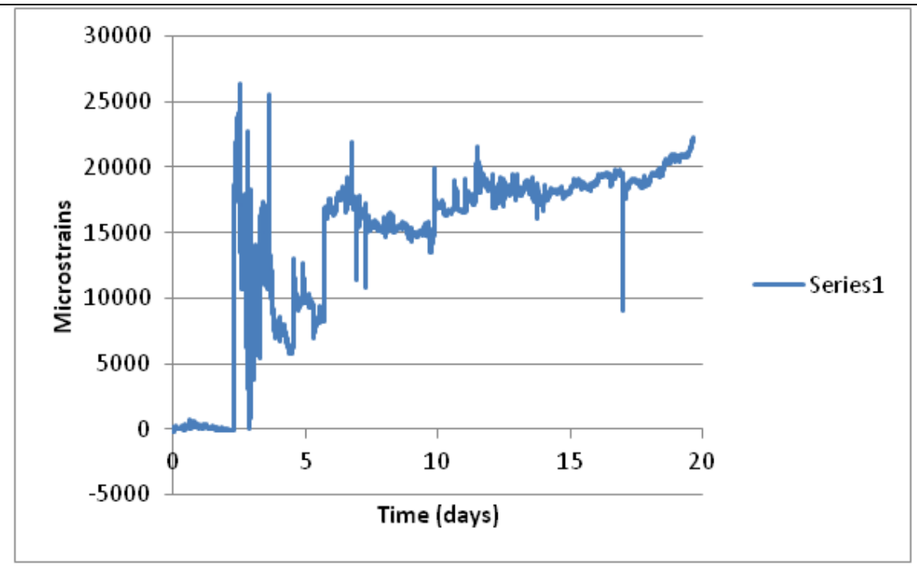

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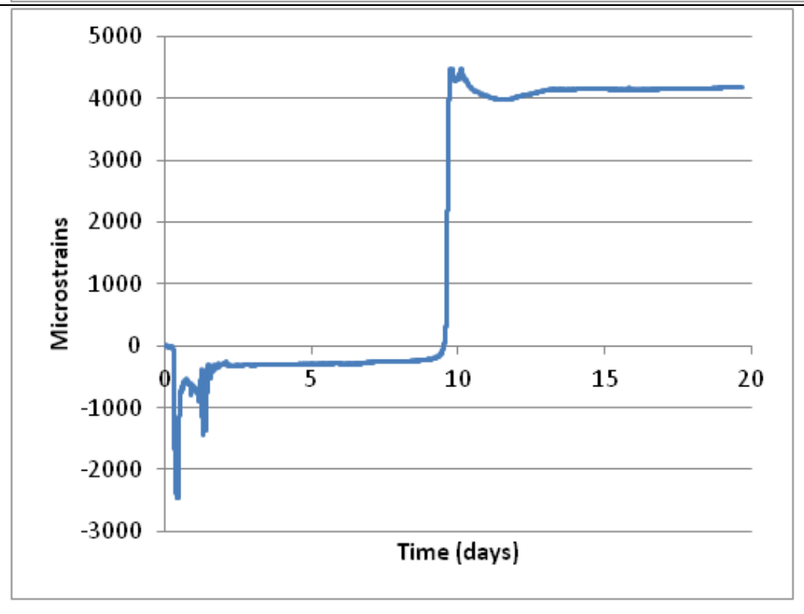
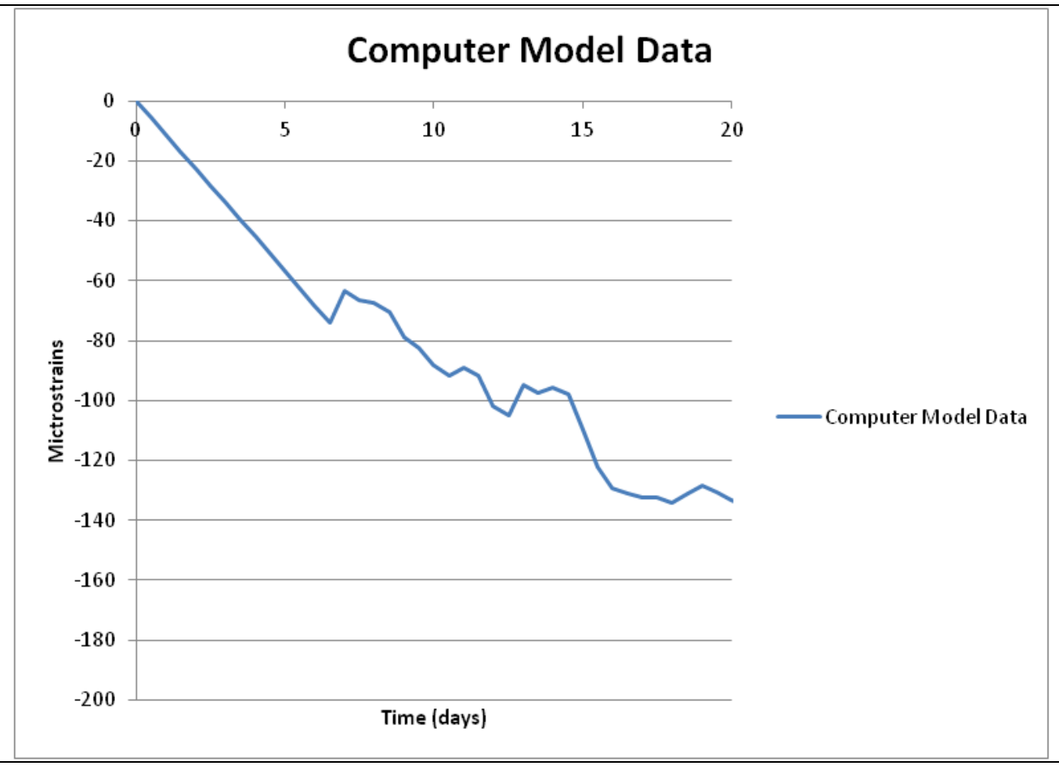
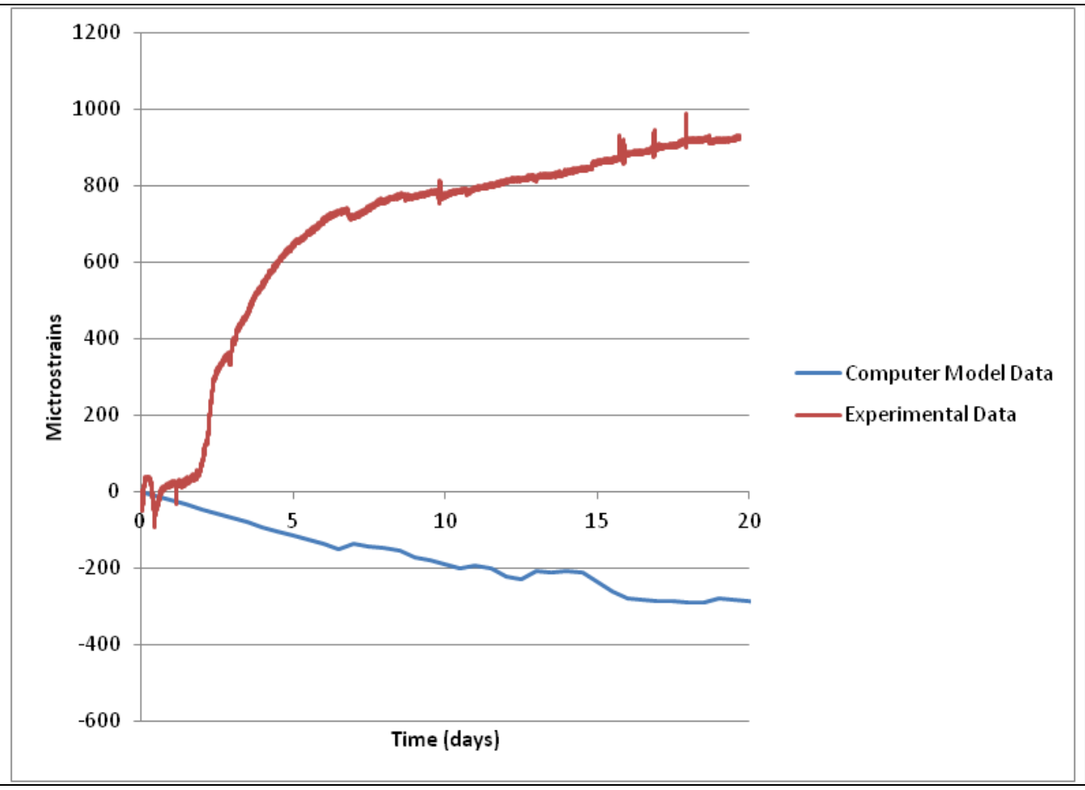
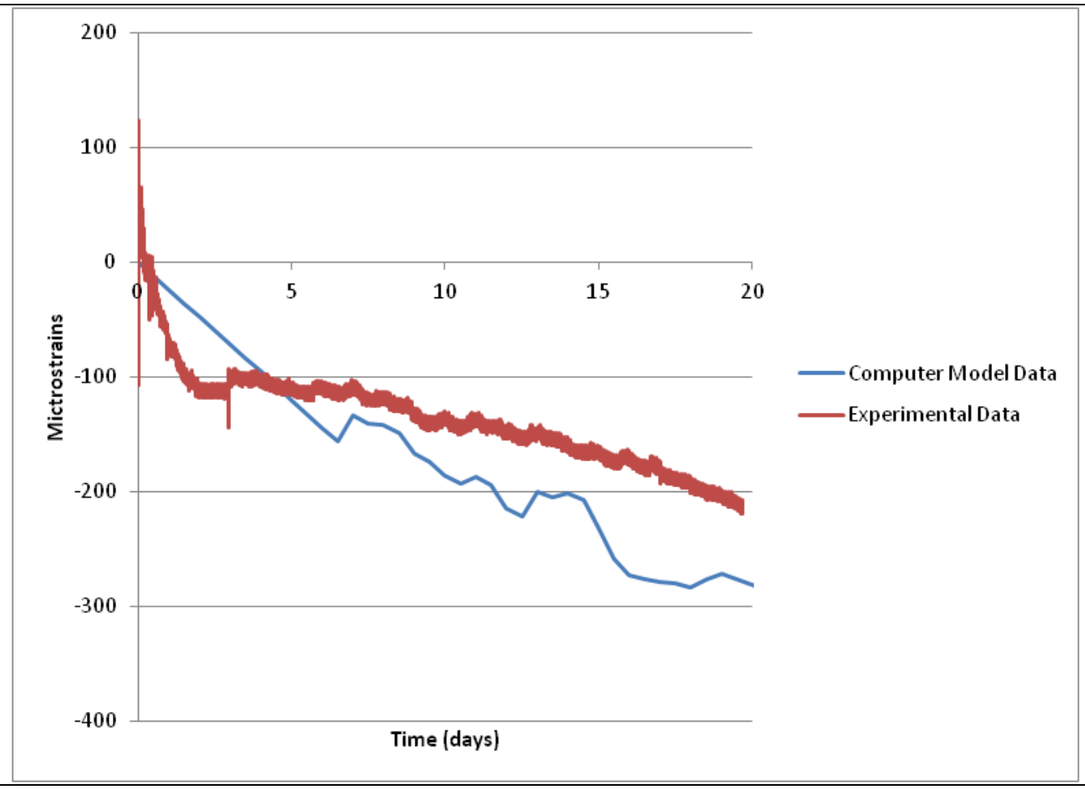




S-Bt-G1-3/4-L	 1200 1000 800 600 400 200 0 -200 -400 -600 Mictrostrains 0 5 10 15 20 Time (days) Computer Model Data Experimental Data	 200 100 0 -100 -200 -300 -400 Mictrostrains 0 5 10 15 20 Time (days) Computer Model Data Experimental Data