FEARS STRUCTURAL ENGINEERING LABORATORY

REPORT ON

STRESS MONITORING OF THE I-40 AND LAKE EUFAULA BRIDGE

by

Chris Ramseyer, Ph. D., P.E.
Assistant Professor,
University of Oklahoma

for

Oklahoma Department of Transportation (ODOT)

June 1, 2006

School of Civil Engineering and Environmental Science

University of Oklahoma

Norman, Oklahoma 73019

Table of Contents

1. SCOPE 1

2. OBJECTIVE 4

3. WORK PLAN 4

4. CONCLUSIONS AND RECOMMENDATIONS 9

APPENDIX A – Data Logger Graphs 10

APPENDIX B – Photographs of North Bridge Cracks 20

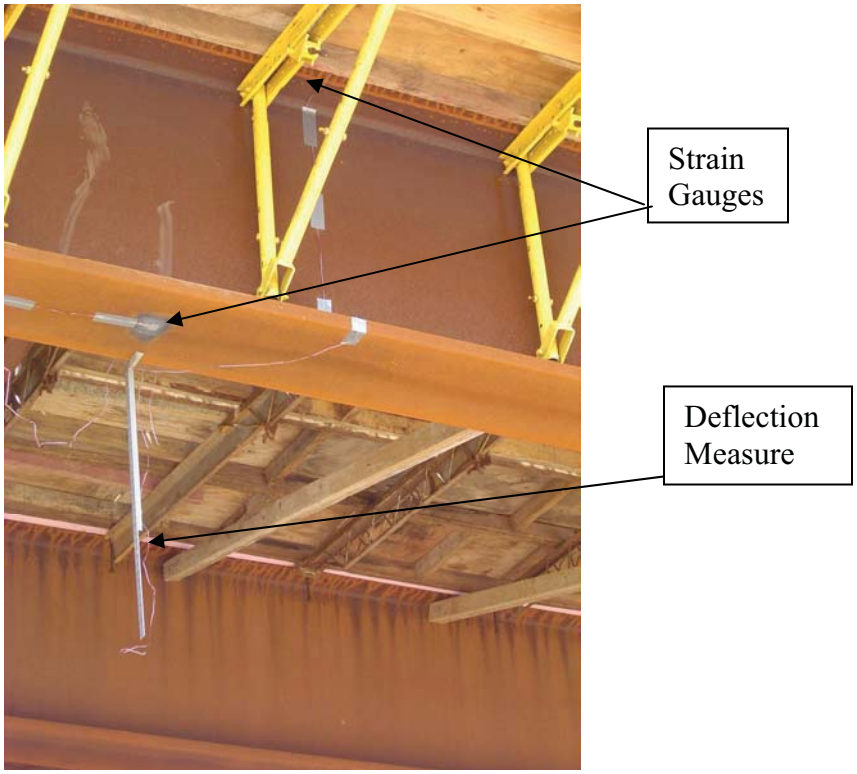
1. SCOPE

The north I-40 and Lake Eufaula Bridge is a composite steel beam with concrete deck, structure, consisting of multiple simple span sections, that was being built in the spring and summer of 2005. The steel beams were cambered at 3.5" and the deck is a standard 8 inch thick concrete made following the ODOT AA materials specification. After building the parapet walls it was noted that the finished span was deflecting excessively.

Visible deflection of North bridge girders – Note the sag in all girders

Pure mechanics suggests that this should not be occurring. This investigation is for monitoring the stress in the top and bottom flange of the first span of the south I-40 and Lake

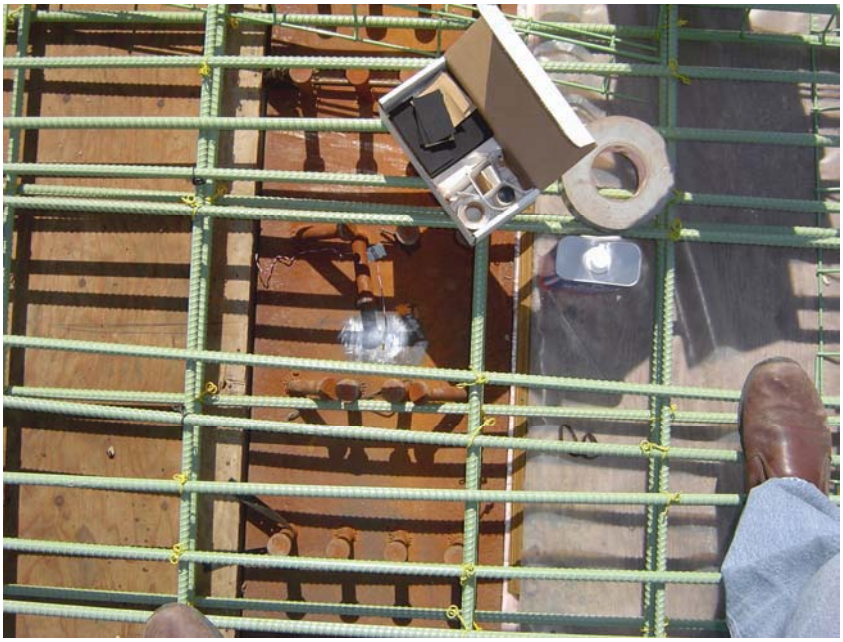
Eufaula Bridge. This bridge is a duplicate of the north bridge. The monitoring occurred on all four beams in the span, at mid-span for a period of six weeks.



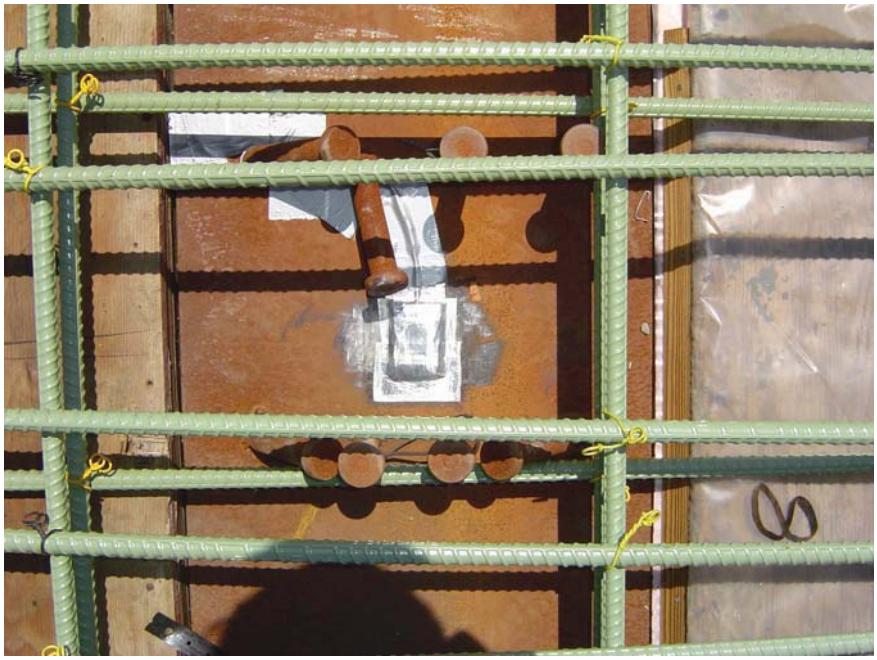
Test equipment at mid-span of girder

A data logger was located in a security box at the abutment and collected data for the entire period. All gages were mounted for long term durability with temperature compensation.

Data Acquisition Equipment in Security box under the bridge



Strain Gauge mounted and ready for protective coatings



Strain Gauge encapsulated in protective coatings.

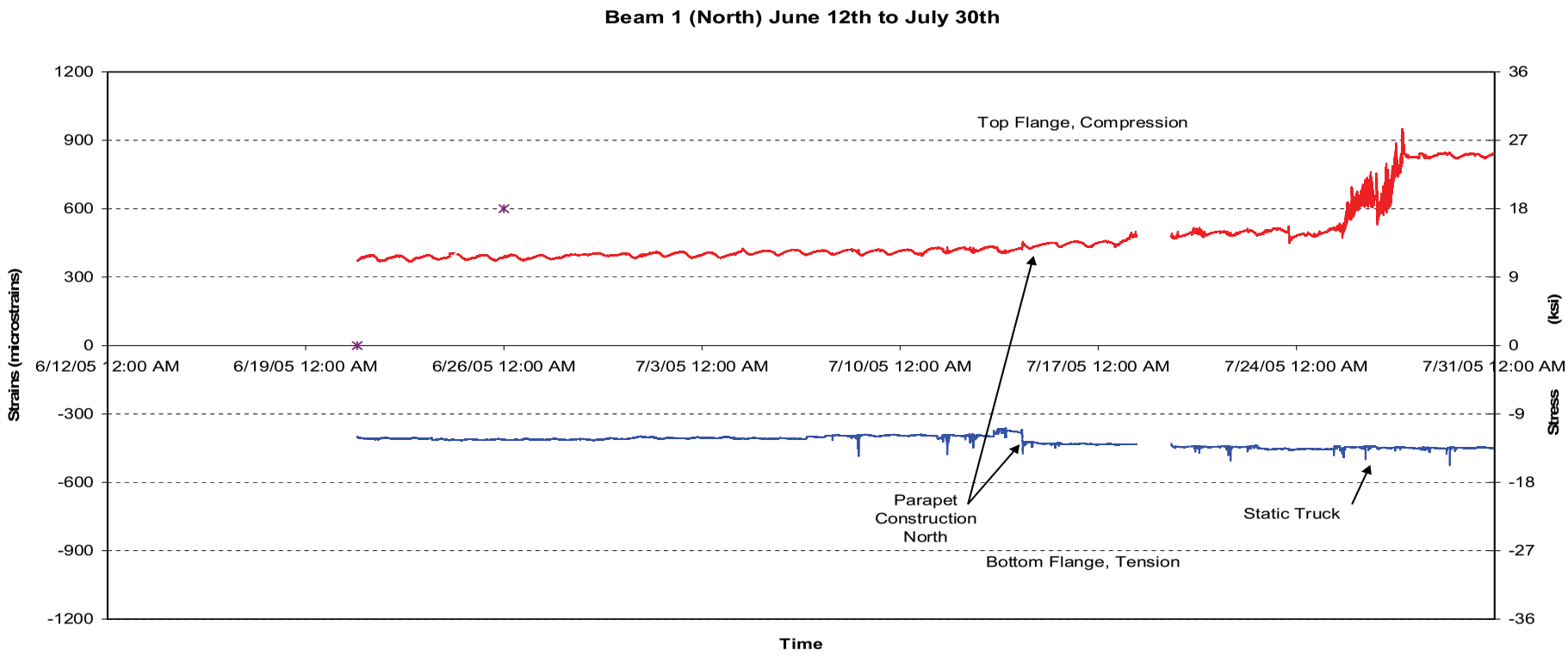
2. OBJECTIVE

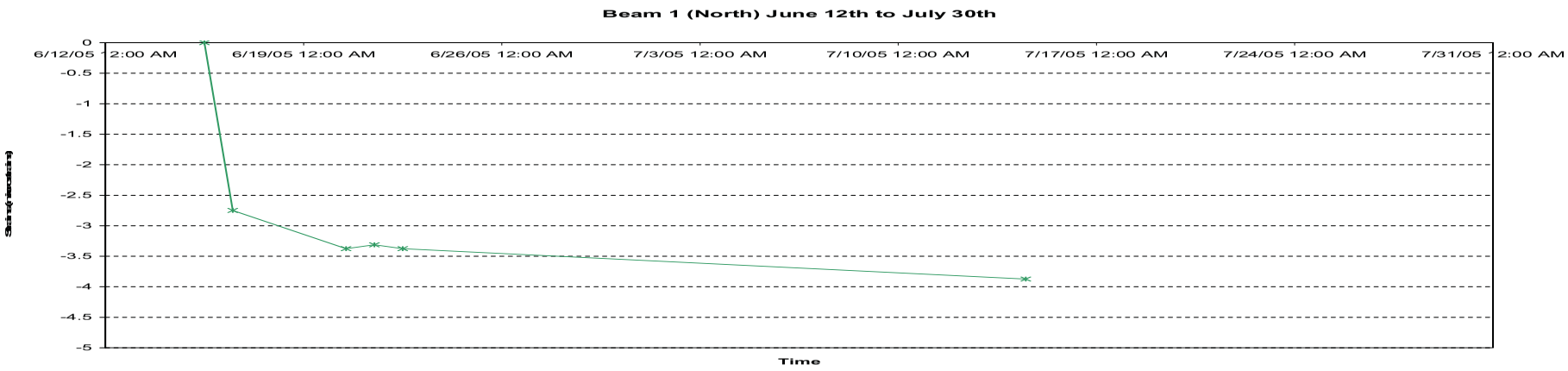
The objective of the proposed testing is to experimentally determine the stress in the top and bottom cord of the steel beams during construction and post construction.

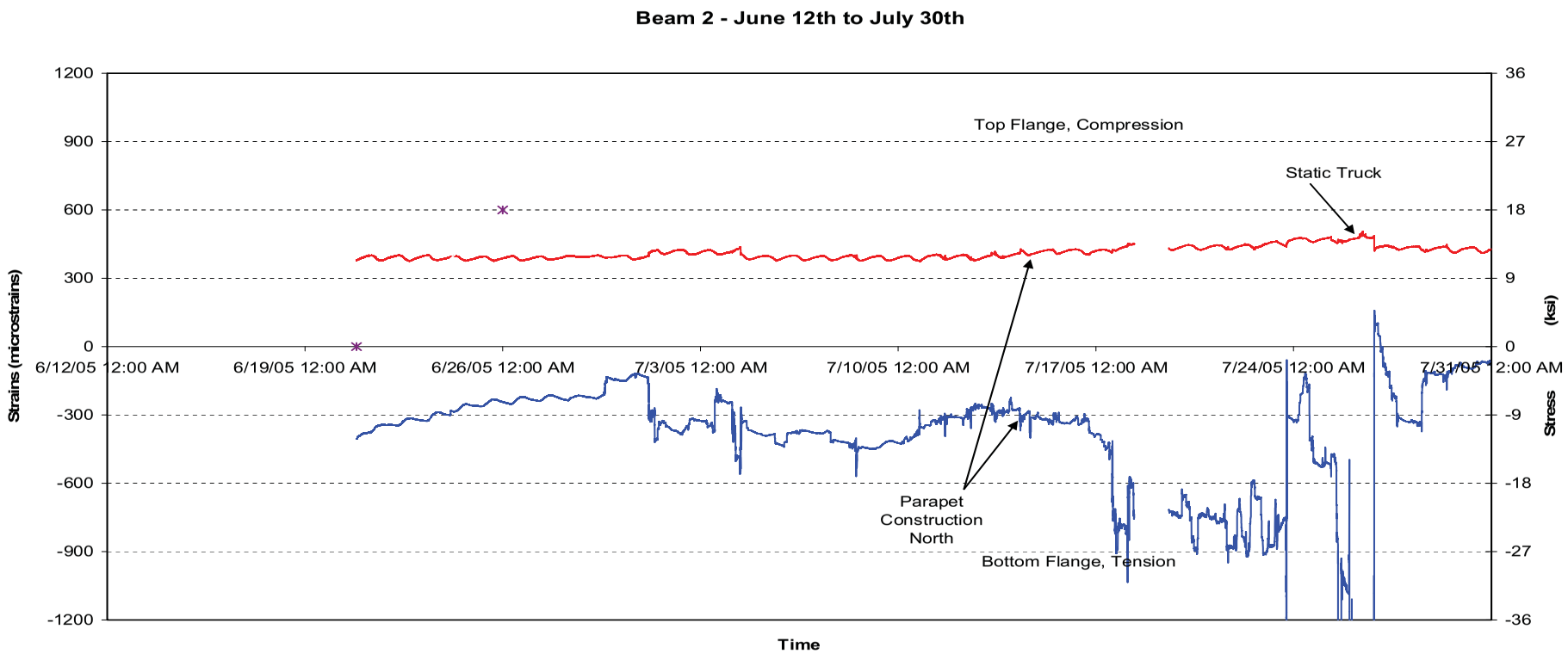
3. WORK PLAN

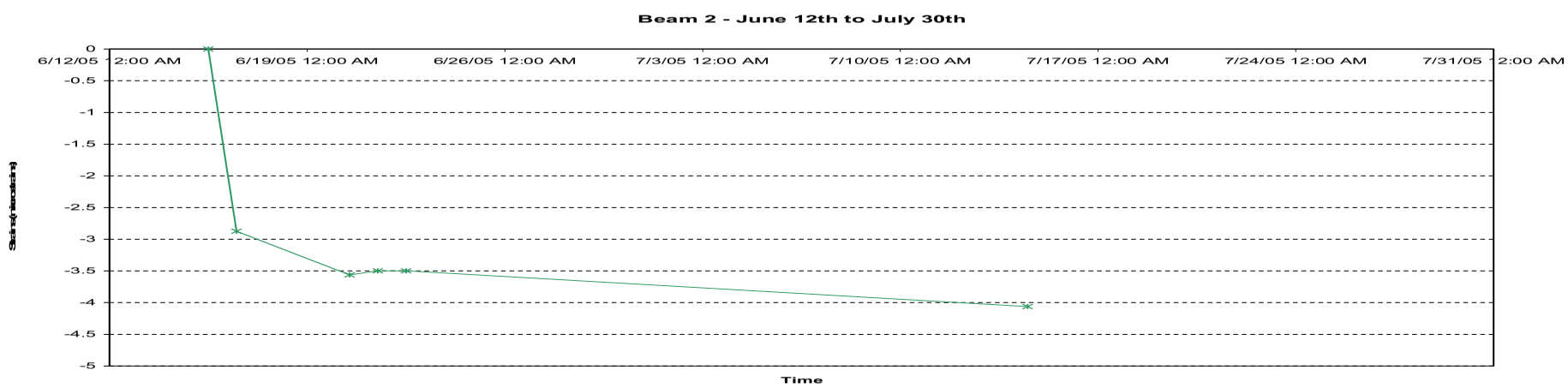
The work plan consisted of measuring strain at a total of 8 locations for six weeks. The monitoring occurred on all four beams at mid-span. A data logger was located in a security box at the abutment and collected data for the entire period. All gages were mounted for long term durability with temperature compensation. The researcher was present and actively monitoring the stress gradients during all construction (deck and parapet casting). Span 1, the western most span, of the south bridge had its deck cast on 6/15/05. The stress at each of the 8 locations was determined over the entire test period. Due to problems with the data acquisition equipment, automatic data collection did not start until 6/20/05. Early age stains were measured using a Vishay strain monitoring device. All automatic data collection was taken using a Somat eDAQ lite.

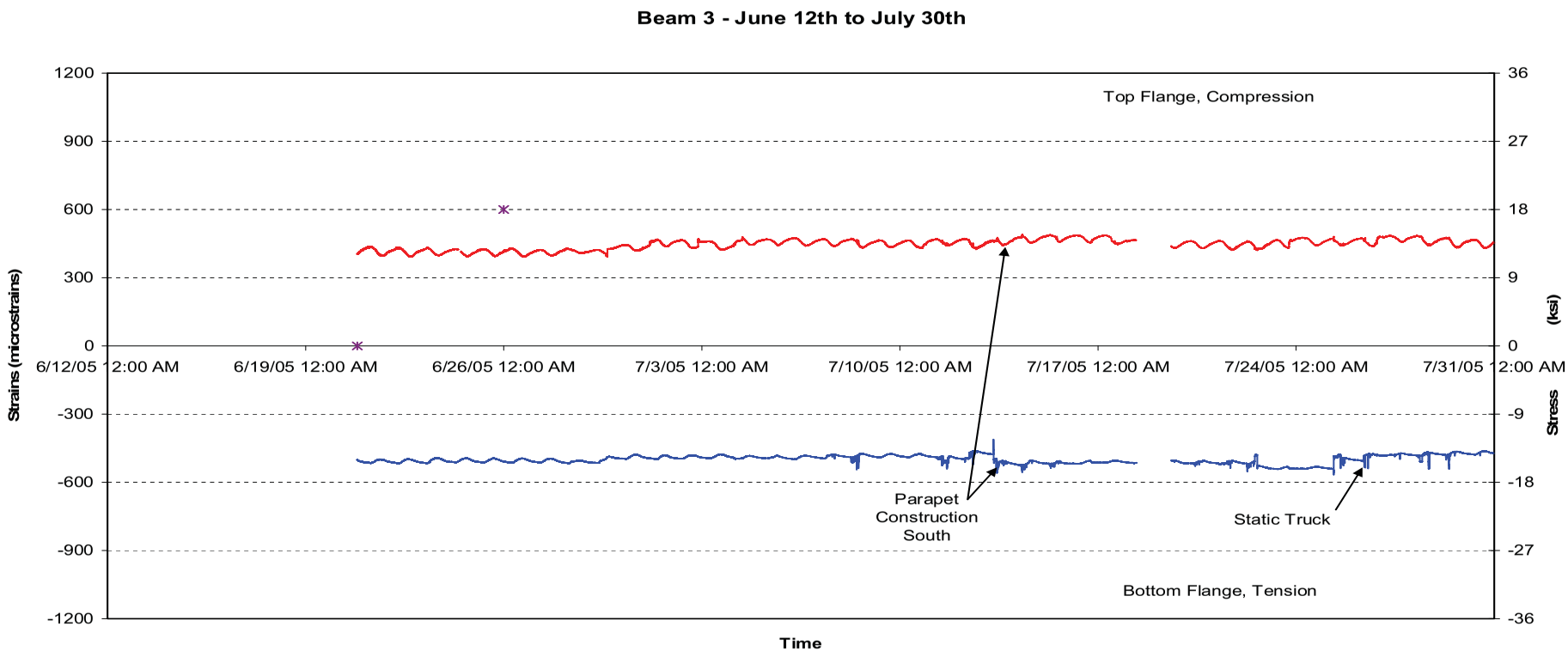
The stress-versus-time plots are as follows.

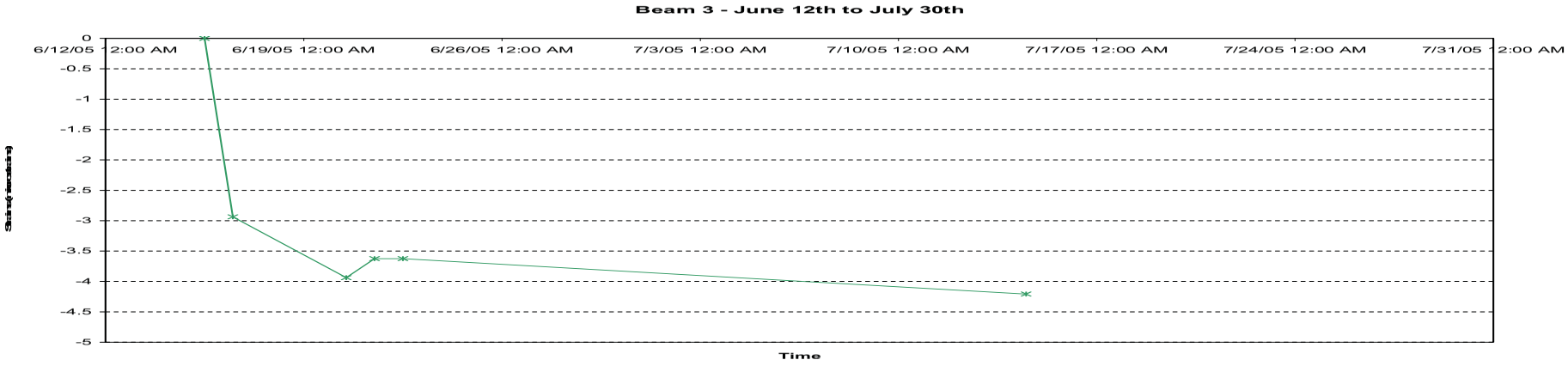

Beam 1 (North) June 12th to July 30th
Strains (microstrains)
Stress (ksi)
Time
1200
900
600
300
0
-300
-600
-900
-1200
36
27
18
9
0
-9
-18
-27
-36
6/12/05 2:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 12:00 AM
Top Flange, Compression
Parapet Construction North
Bottom Flange, Tension
Static Truck

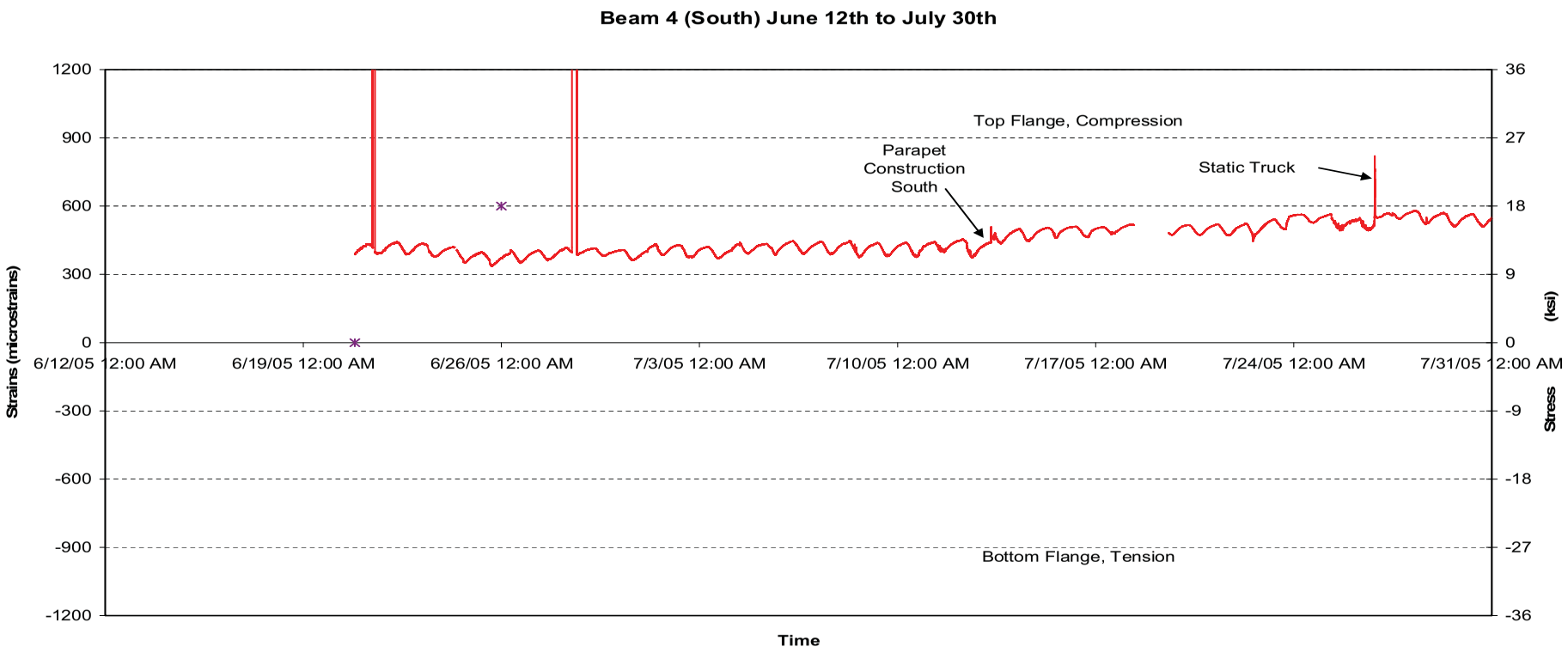

Beam 1 (North) June 12th to July 30th
Time
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
6/12/05 2:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 2:00 AM

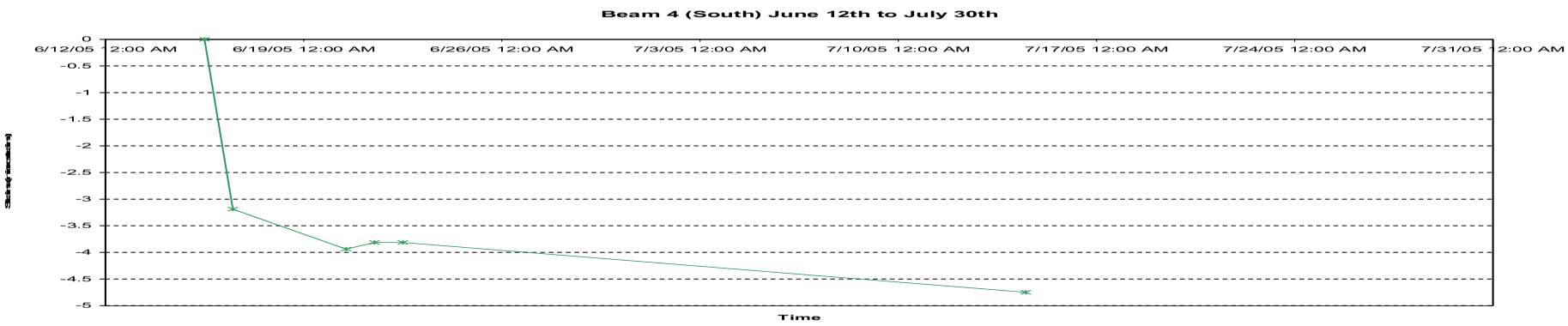

Beam 2 - June 12th to July 30th
Top Flange, Compression
Static Truck
Parapet
Construction
North
Bottom Flange, Tension
Strains (microstrains)
Stress (ksi)
Time
1200
900
600
300
0
-300
-600
-900
-1200
36
27
18
9
0
-9
-18
-27
-36
6/12/05 2:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 2:00 AM


Beam 2 - June 12th to July 30th
Time
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
6/12/05 2:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 2:00 AM


Beam 3 - June 12th to July 30th
Top Flange, Compression
Bottom Flange, Tension
Parapet Construction South
Static Truck
Strains (microstrains)
Stress (ksi)
Time
1200
900
600
300
0
-300
-600
-900
-1200
36
27
18
9
0
-9
-18
-27
-36
6/12/05 12:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 12:00 AM


Beam 3 - June 12th to July 30th
Time
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
6/12/05 12:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 12:00 AM


Beam 4 (South) June 12th to July 30th
Top Flange, Compression
Parapet Construction South
Static Truck
Bottom Flange, Tension
Strains (microstrains)
Stress (ksi)
Time
1200
900
600
300
0
-300
-600
-900
-1200
36
27
18
9
0
-9
-18
-27
-36
6/12/05 12:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 12:00 AM


Beam 4 (South) June 12th to July 30th
Time
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
6/12/05 12:00 AM
6/19/05 12:00 AM
6/26/05 12:00 AM
7/3/05 12:00 AM
7/10/05 12:00 AM
7/17/05 12:00 AM
7/24/05 12:00 AM
7/31/05 12:00 AM

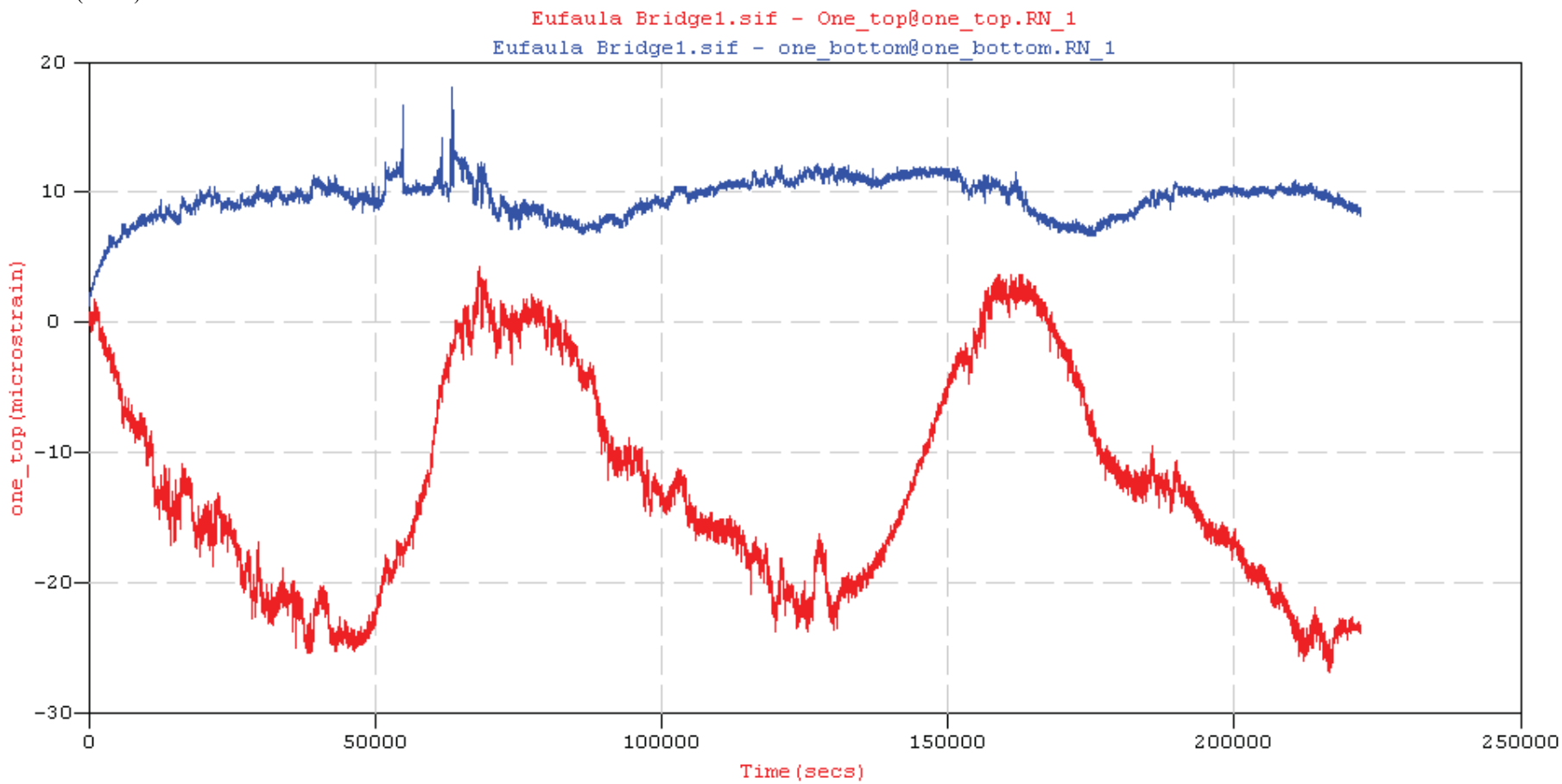
4. CONCLUSIONS AND RECOMMENDATIONS

The stress monitoring of this bridge leads us to the conclusion that the over deflection of the girders is not due to an obvious under strength condition. Loading with the test trucks lead to a stress level and deflection that was within the range expected. Further conclusions concerning the cause of the over deflection and on going deflection is not possible with this very limited investigation.

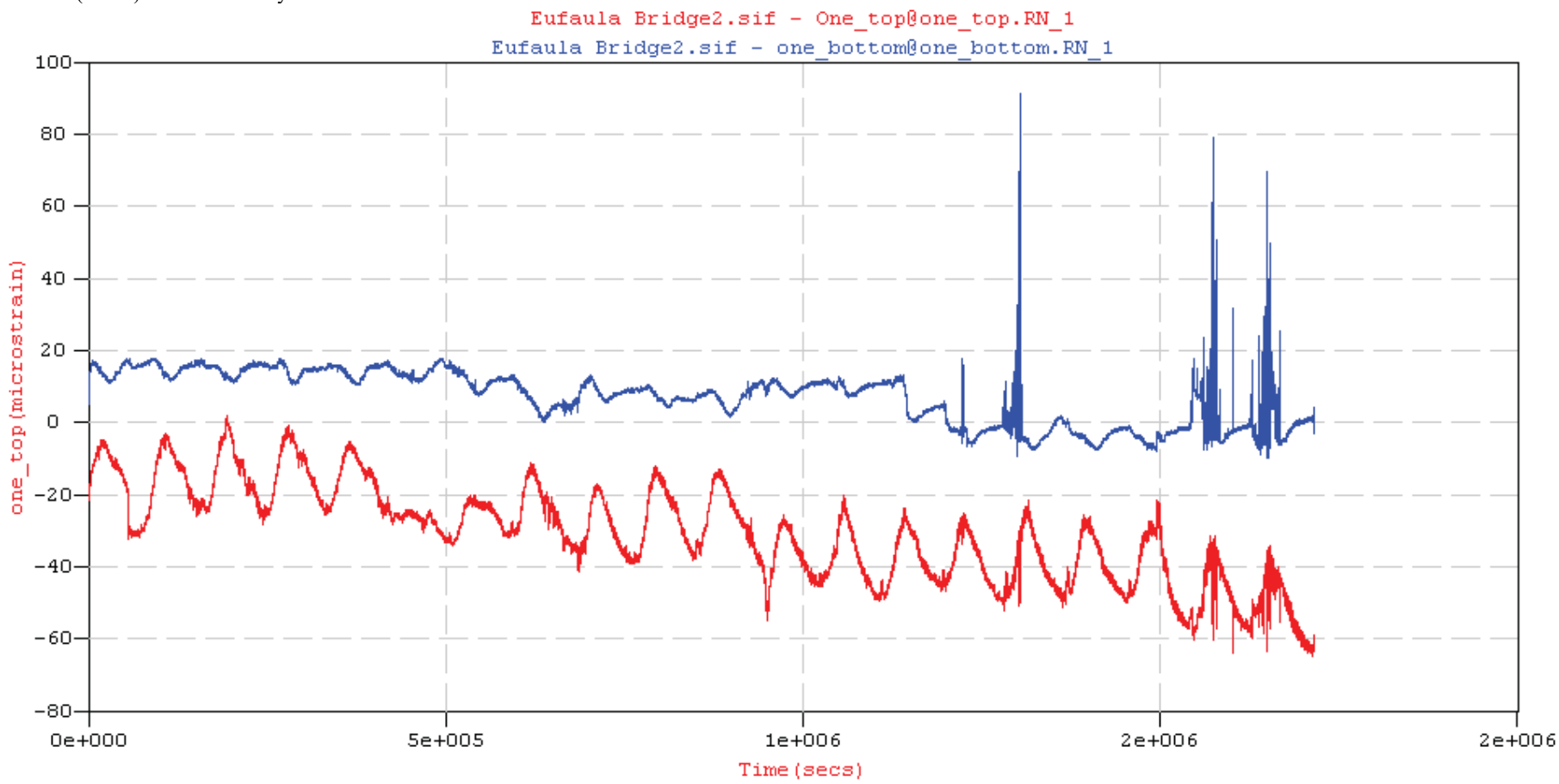
Our recommendation, to better understand the cause of this excessive deflection, is to research the stresses and deflections in this type of bridge from the initial stages and follow the material all the way through construction and early age. Since the Lake Eufaula Bridge is the first bridges designed using the AASHTO LRFD bridge specification it is our recommendation that this additional research include a study of the impact of specification on this deflection problem.

APPENDIX A – Data Logger Graphs

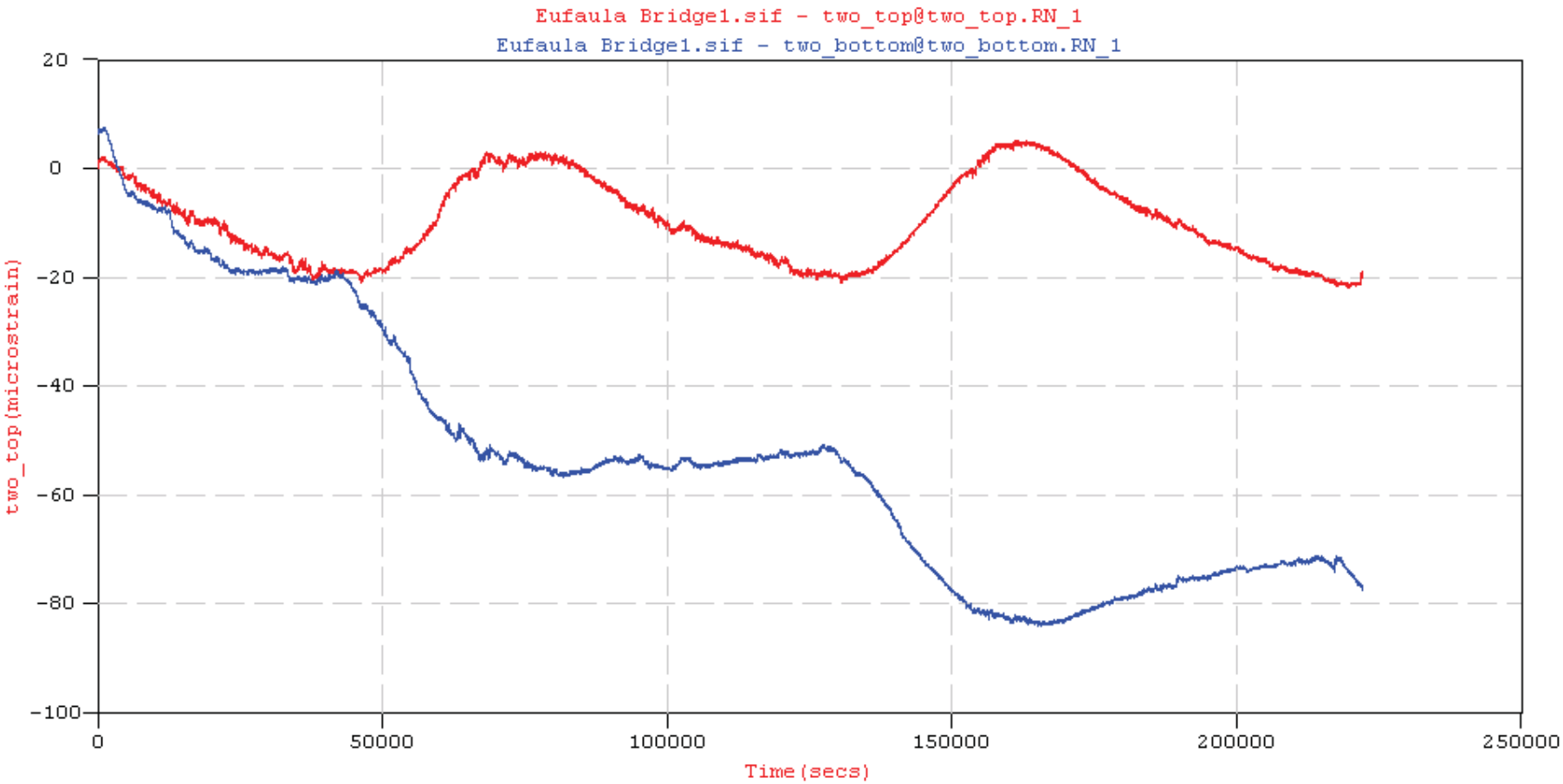
Beam 1 (North) June 20th to June 23rd



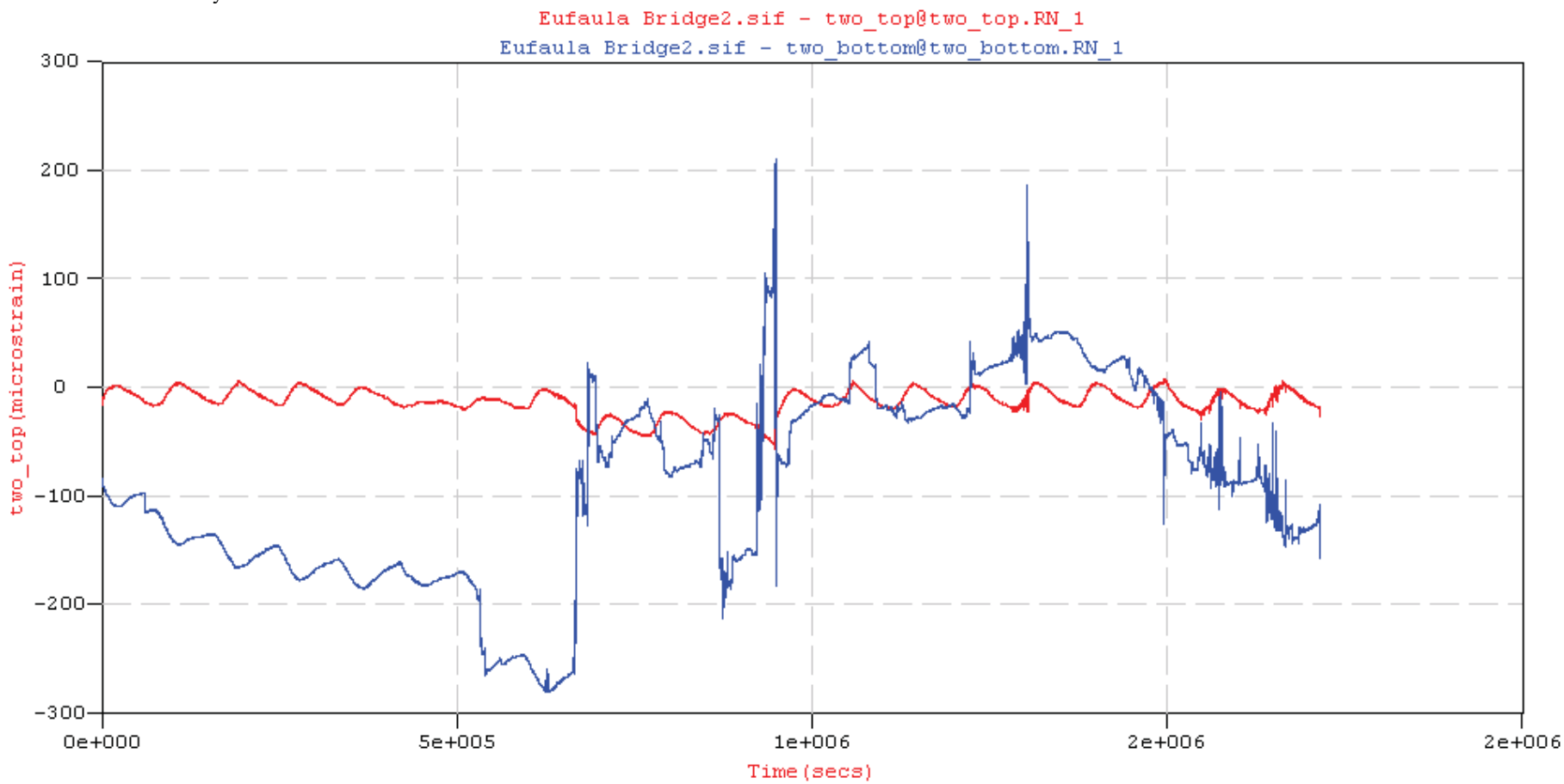
Beam 1 (North) June 23rd to July 13th



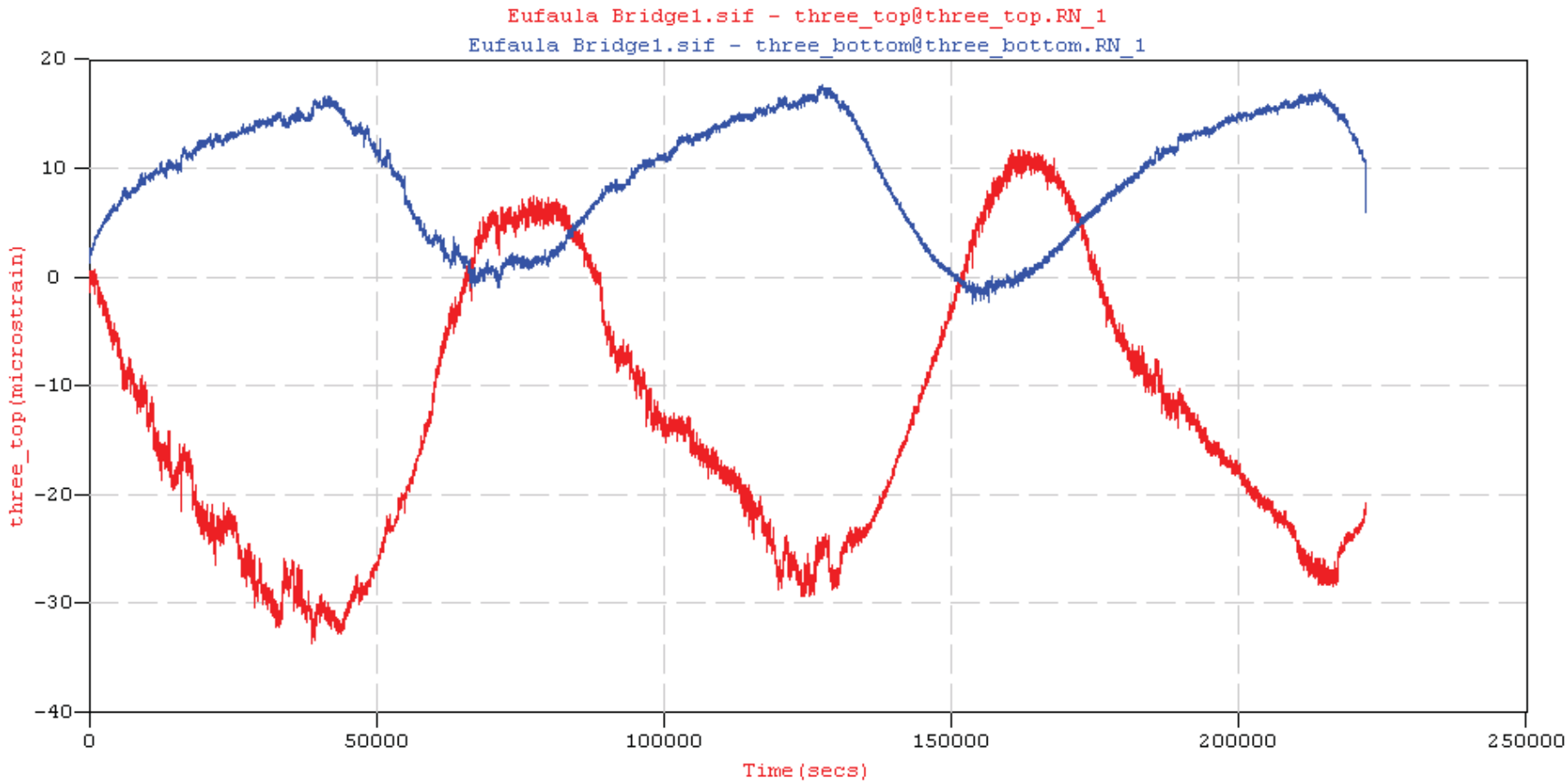
Beam 2 - June 20th to June 23rd



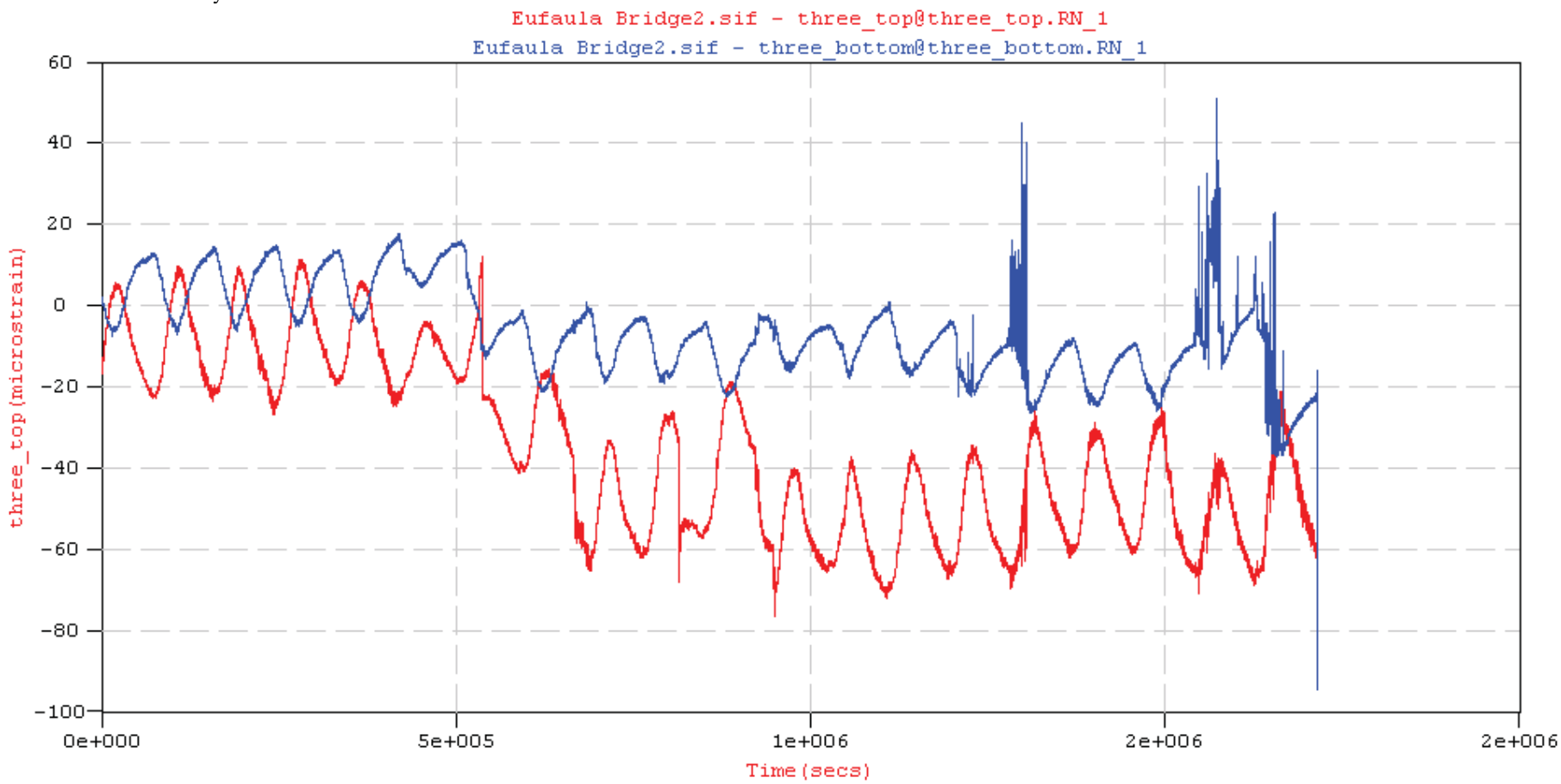
Beam 2 June 23rd to July 13th



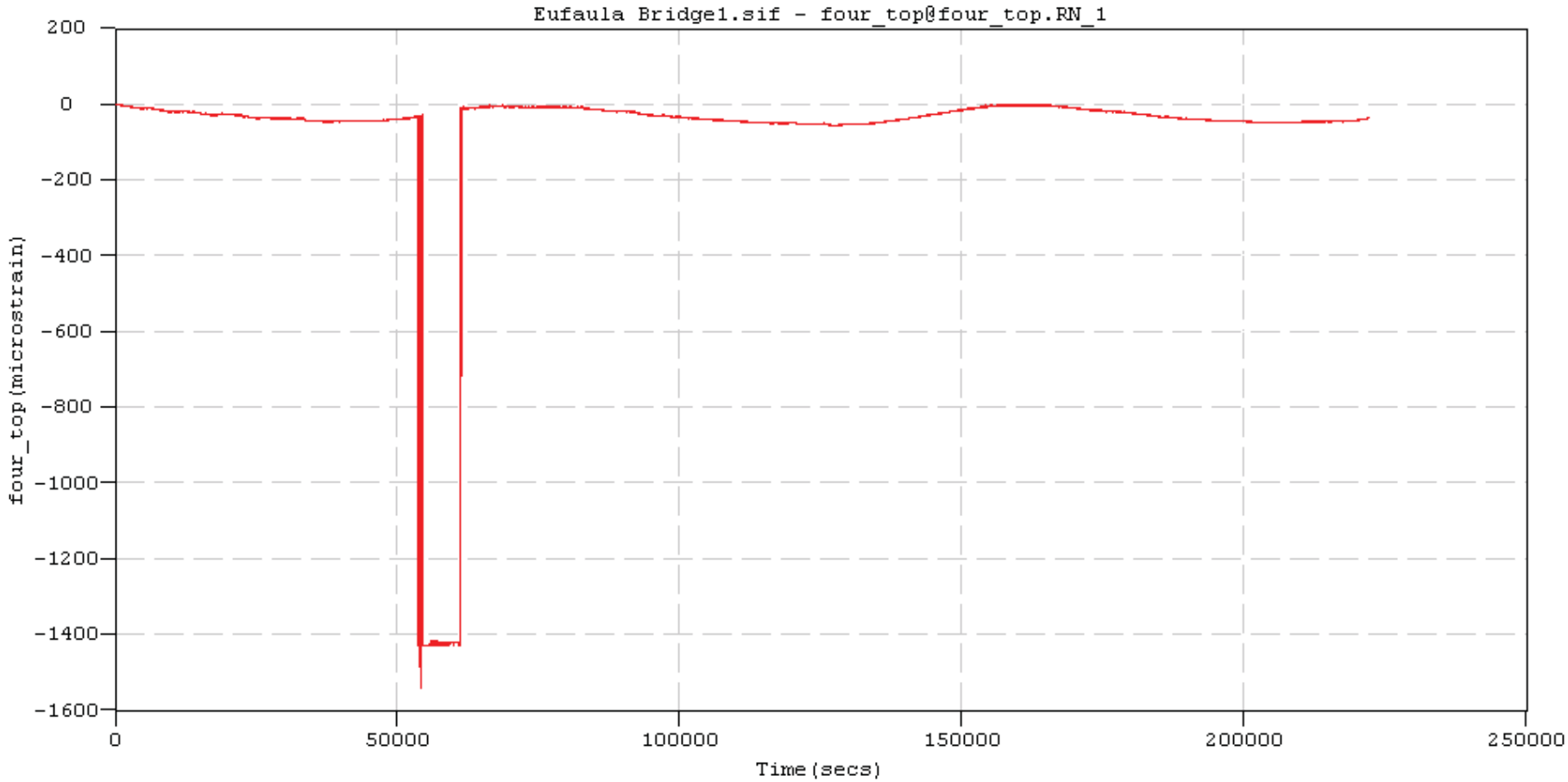
Beam 3 - June 20th[t] to June 23rd



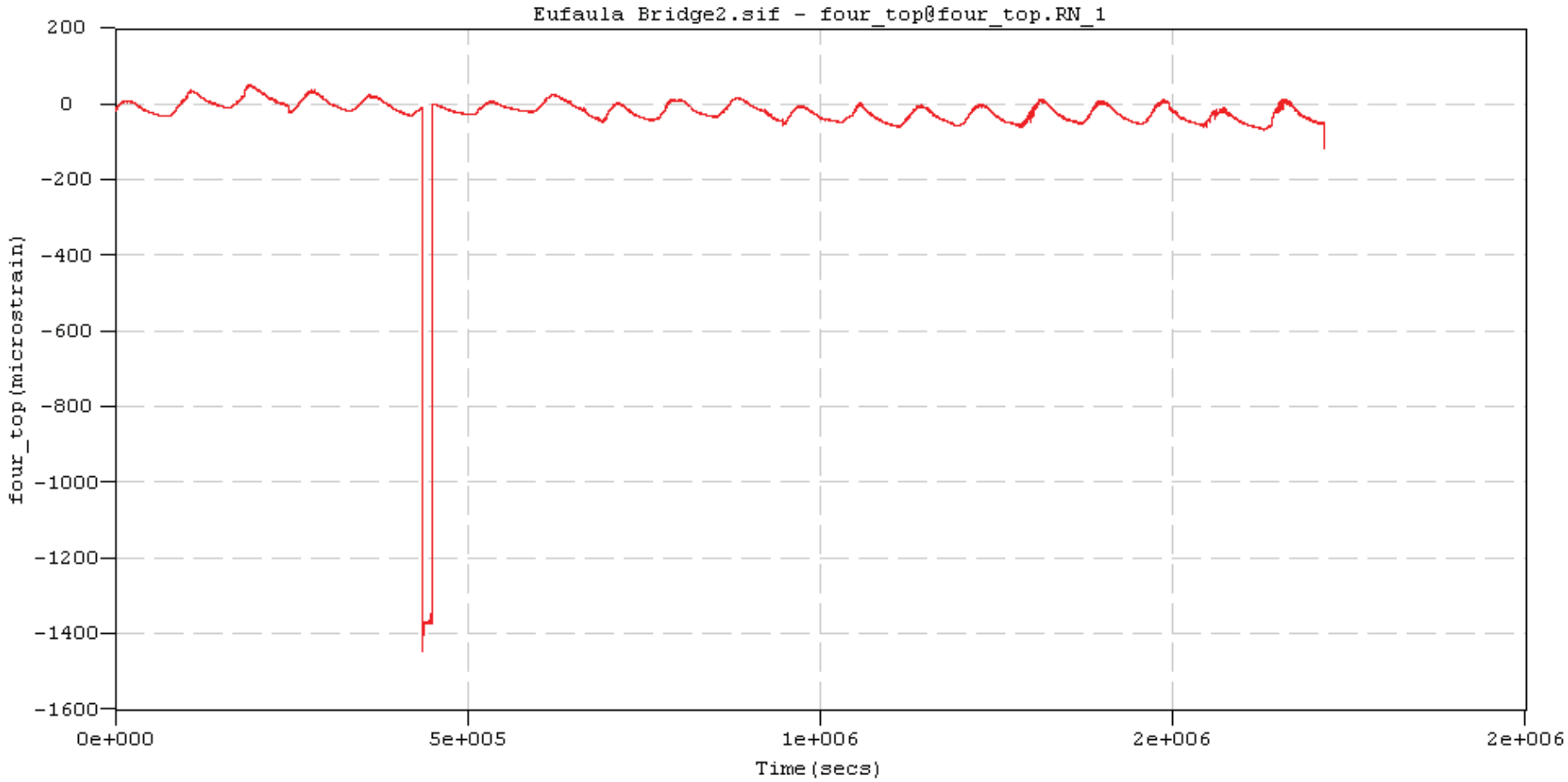
Beam 3 June 23rd to July 13th



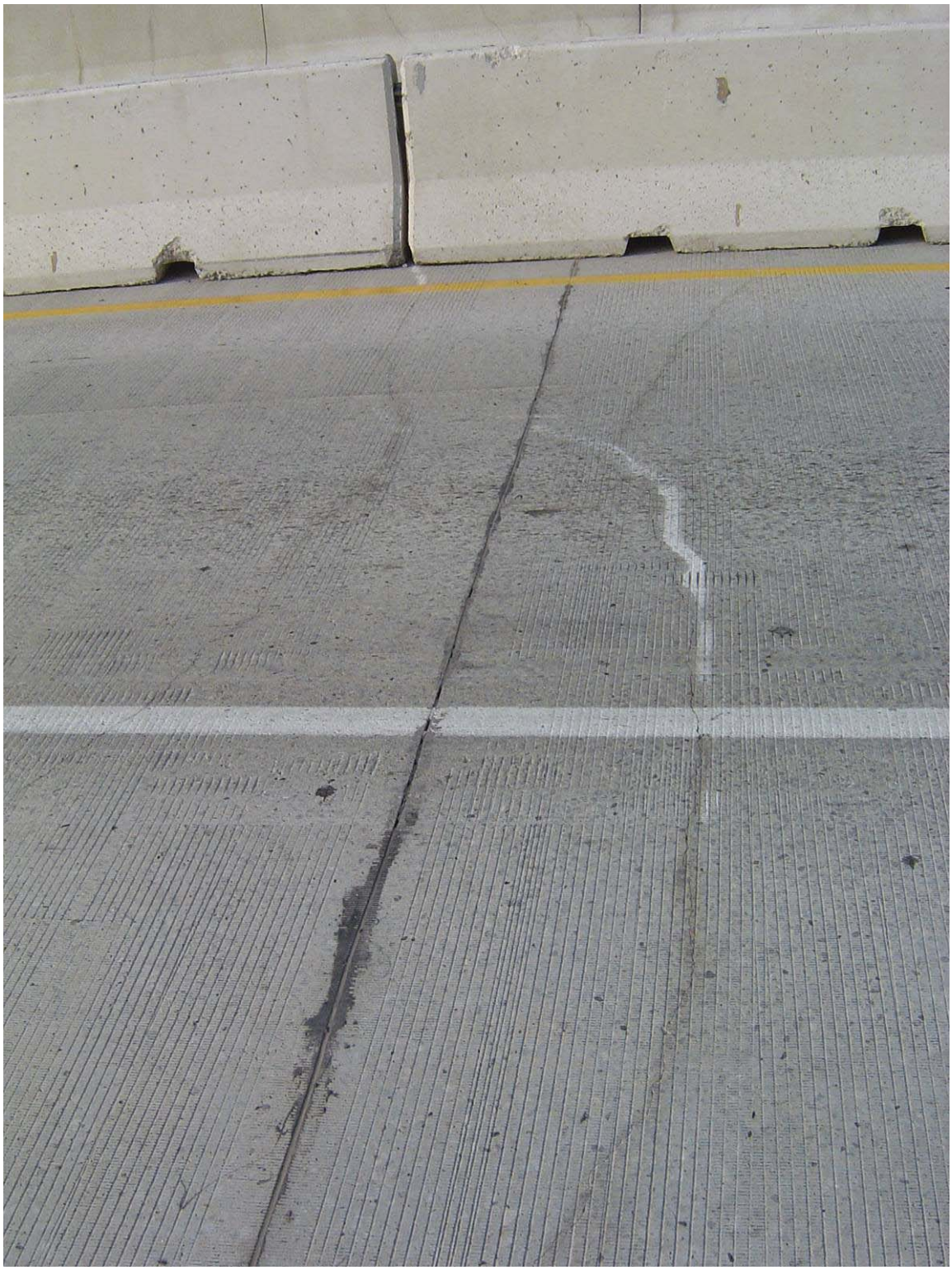
Beam 4 (South) June 20th to June 23rd



Beam 4 (South) June 23rd to July 13th



APPENDIX B – Photographs of North Bridge Cracks



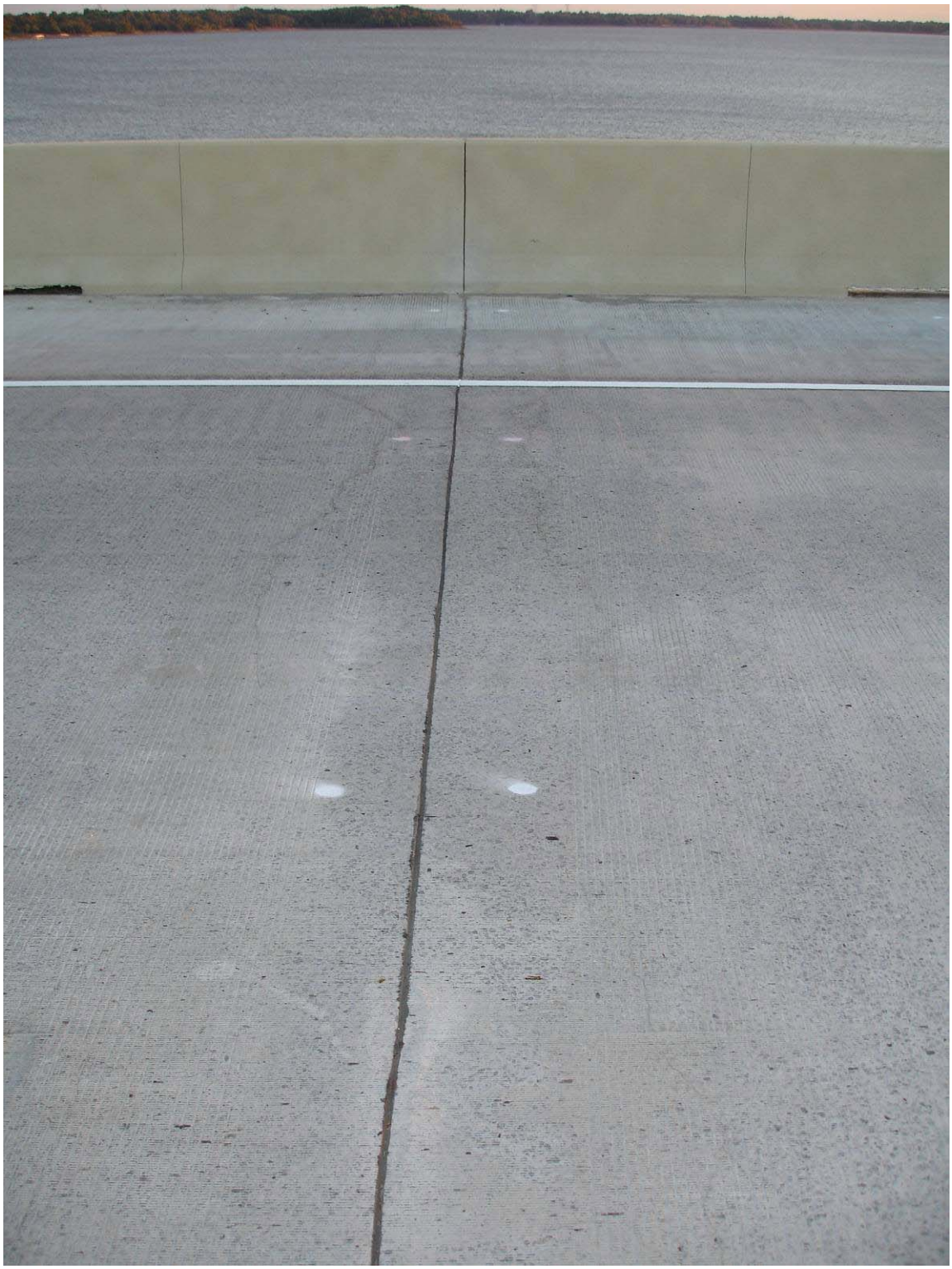
What the ODOT crews are calling "Smiley Face" cracks in deck of North Bridge at midspan North Lane - July 2005

Ditto

Parapet cracks in North Bridge – July 2005

Smiley face cracks, North Bridge, north lane – July 2005

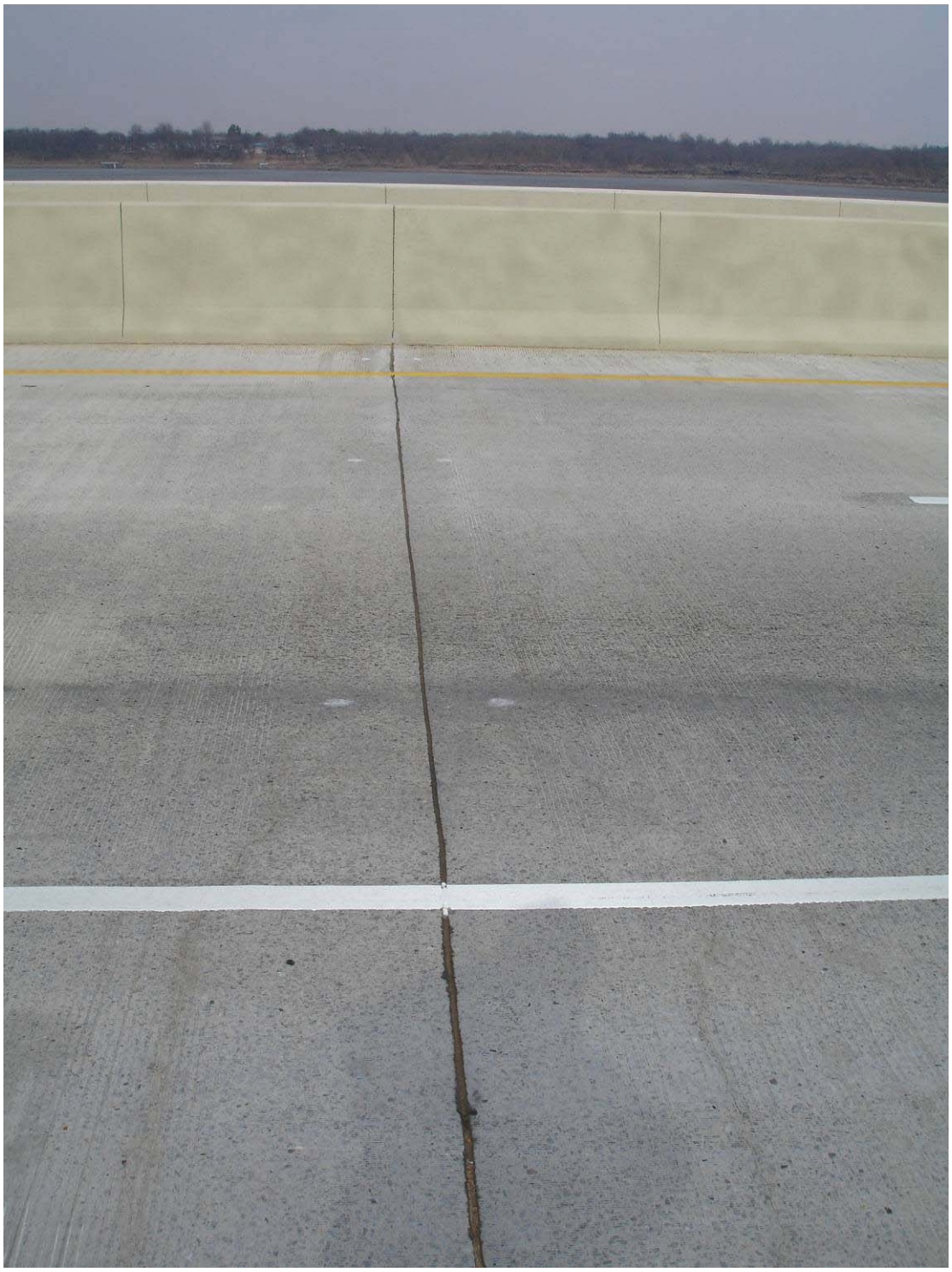
Parapet cracks in south parapet of North Bridge – July 2005



Smiley face cracks, South Bridge – Sept. 2006 (bridge is 90 days old)

Smiley face cracks, South Bridge – Sept. 2006 (bridge is 90 days old)

Solar collector powering data collection system – Jan. 2006



Transverse cracks on South Bridge – Jan. 2006

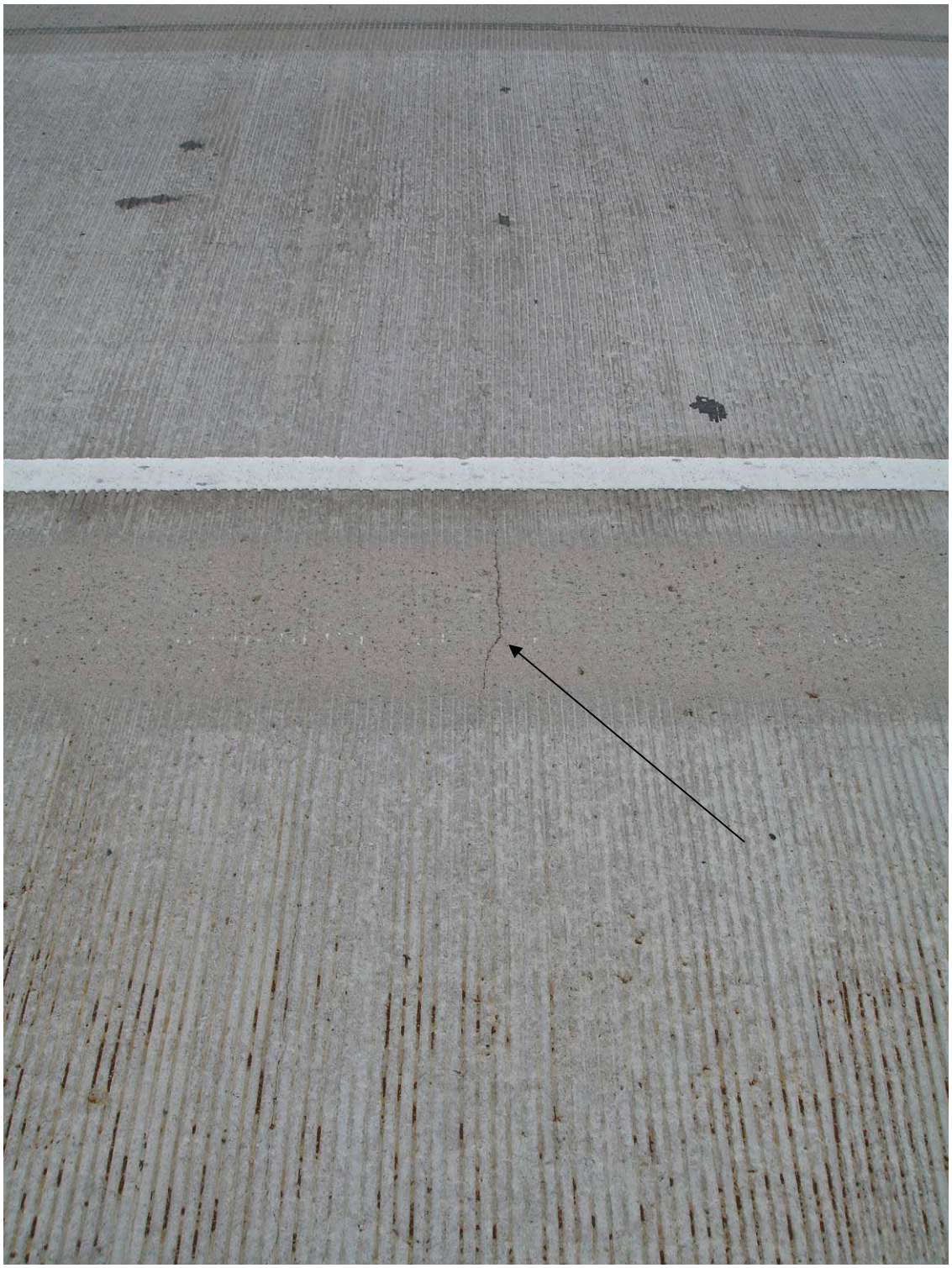
South Bridge showing water migration & cracks on bottom of deck – Jan. 2006

Longitudinal Cracks in North Bridge – Jan. 2006

Close up of Longitudinal crack in North Bridge – Jan. 2006

North Bridge Parapet wall showing vertical cracks – Jan. 2006

North Bridge mid-span deck "smiley face" cracks & flexure cracks in parapet – Jan. 2006



Close up of transverse crack, North bridge, span 2 from west end – Jan. 2006