Wadhams Road over the Black River

Constructing a big bridge with unique features

OHM
Advancing Communities℠

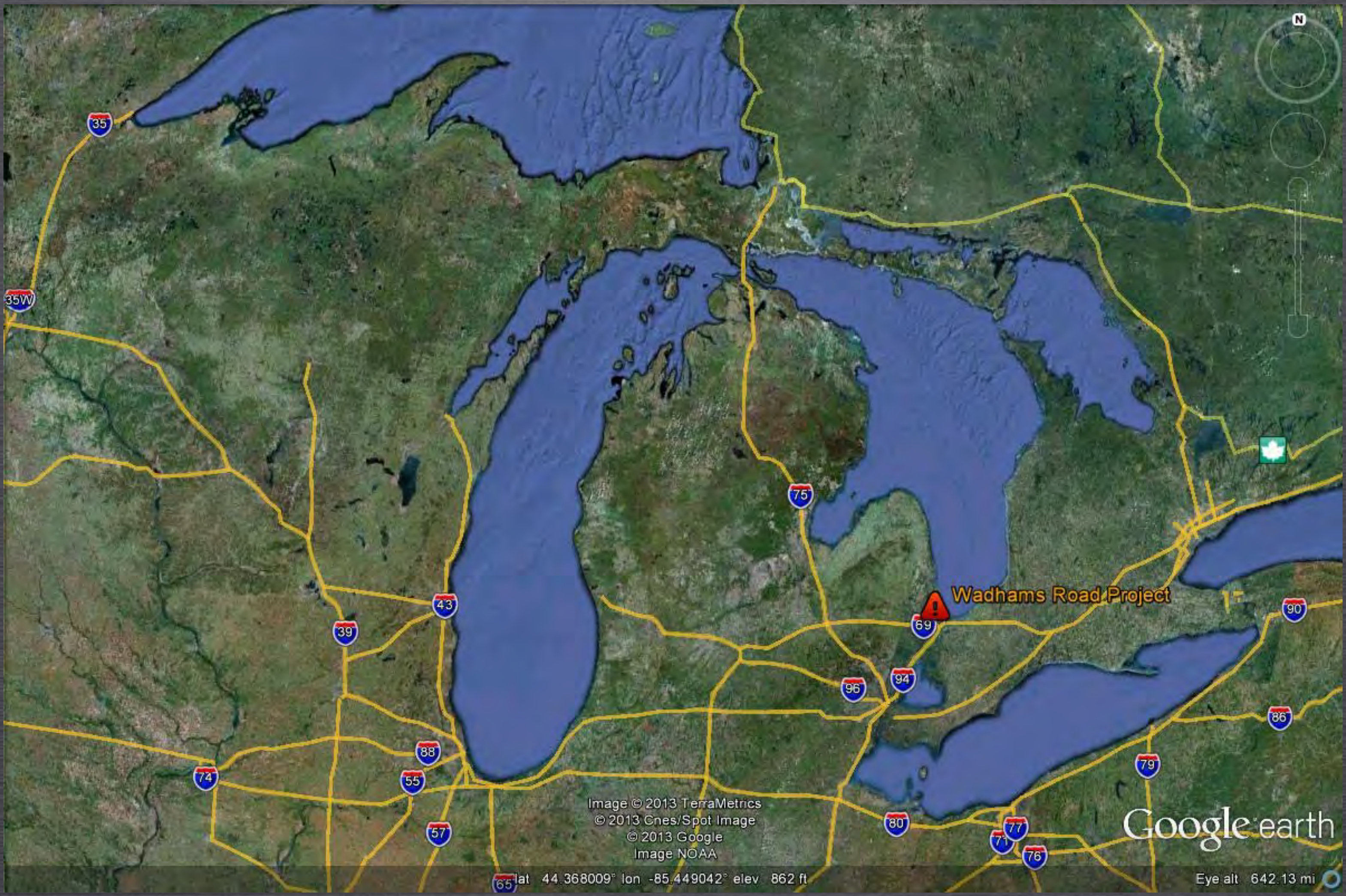
Craig Dashner, PE

Craig.dashner@ohm-advisors.com

734-522-6711

Wadhams Road over the Black River – Unique Features

- Drilled Shafts and Box Piles
- Pier footing mass pour
- Drilled earth anchors
- Structural steel testing/investigation



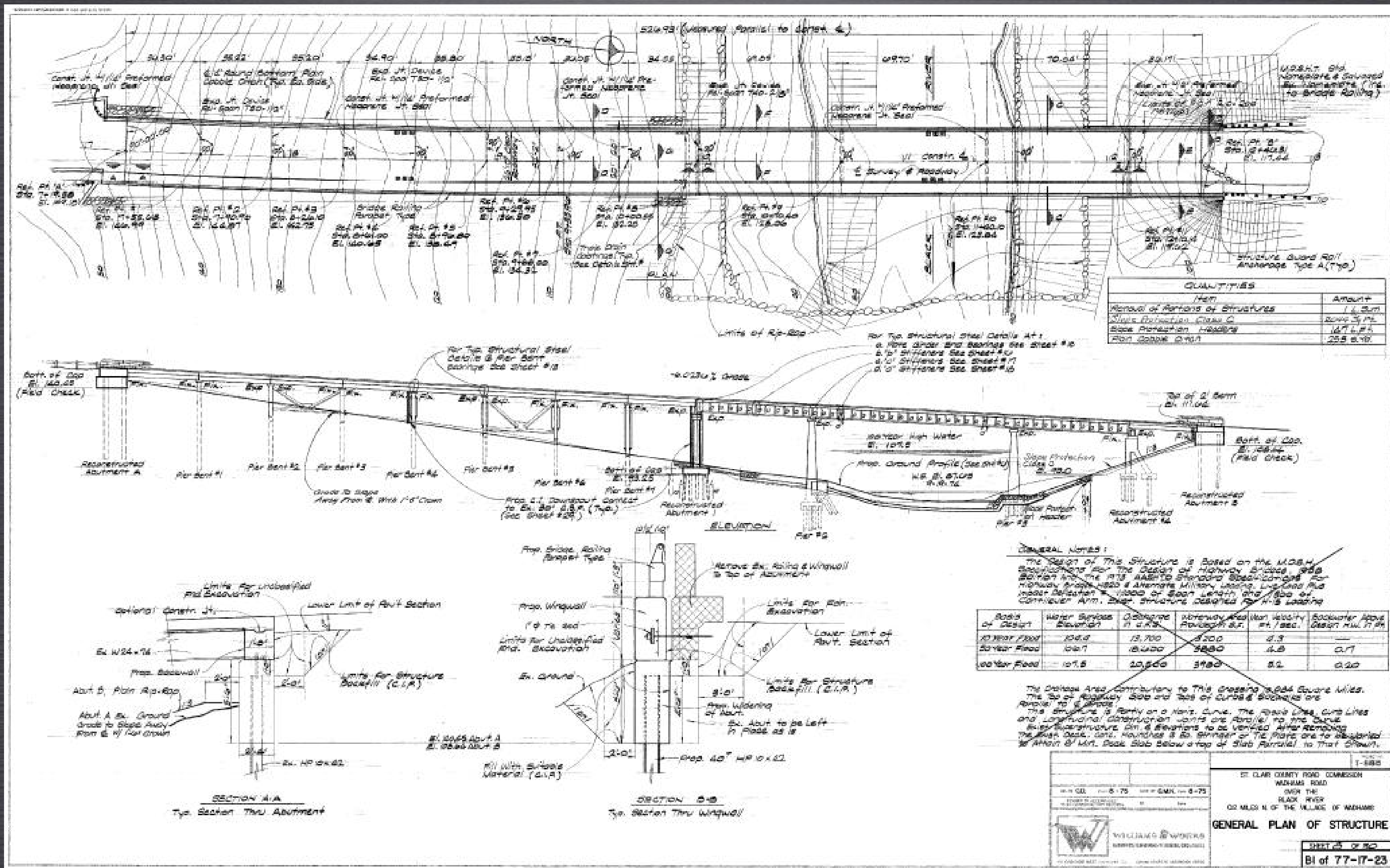
Wadhams Road over the Black River, Kimball Township, MI

Wadhams Road over the Black River, Kimball Township, MI

Existing Bridge

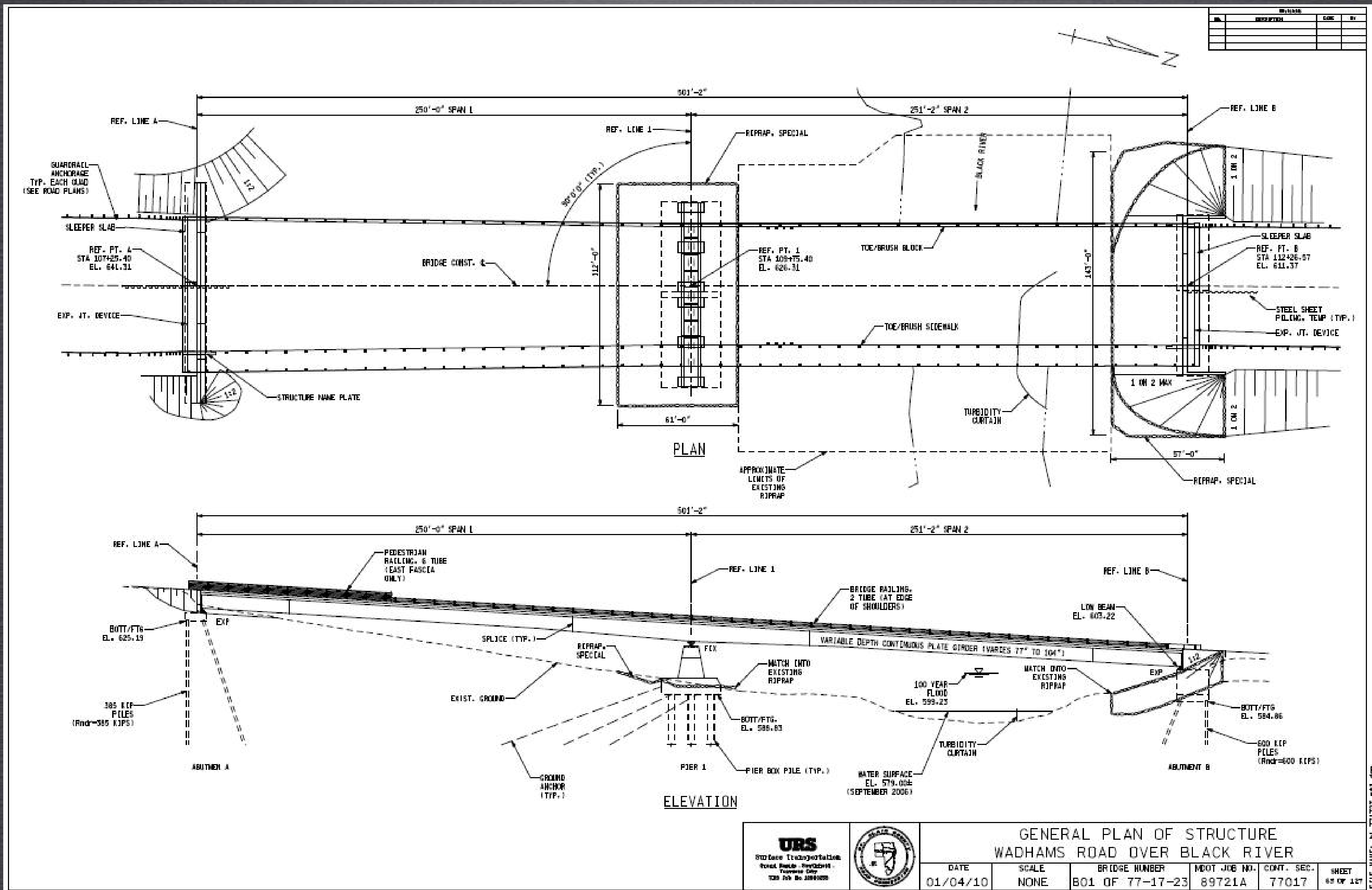
Existing Bridge

Existing Bridge

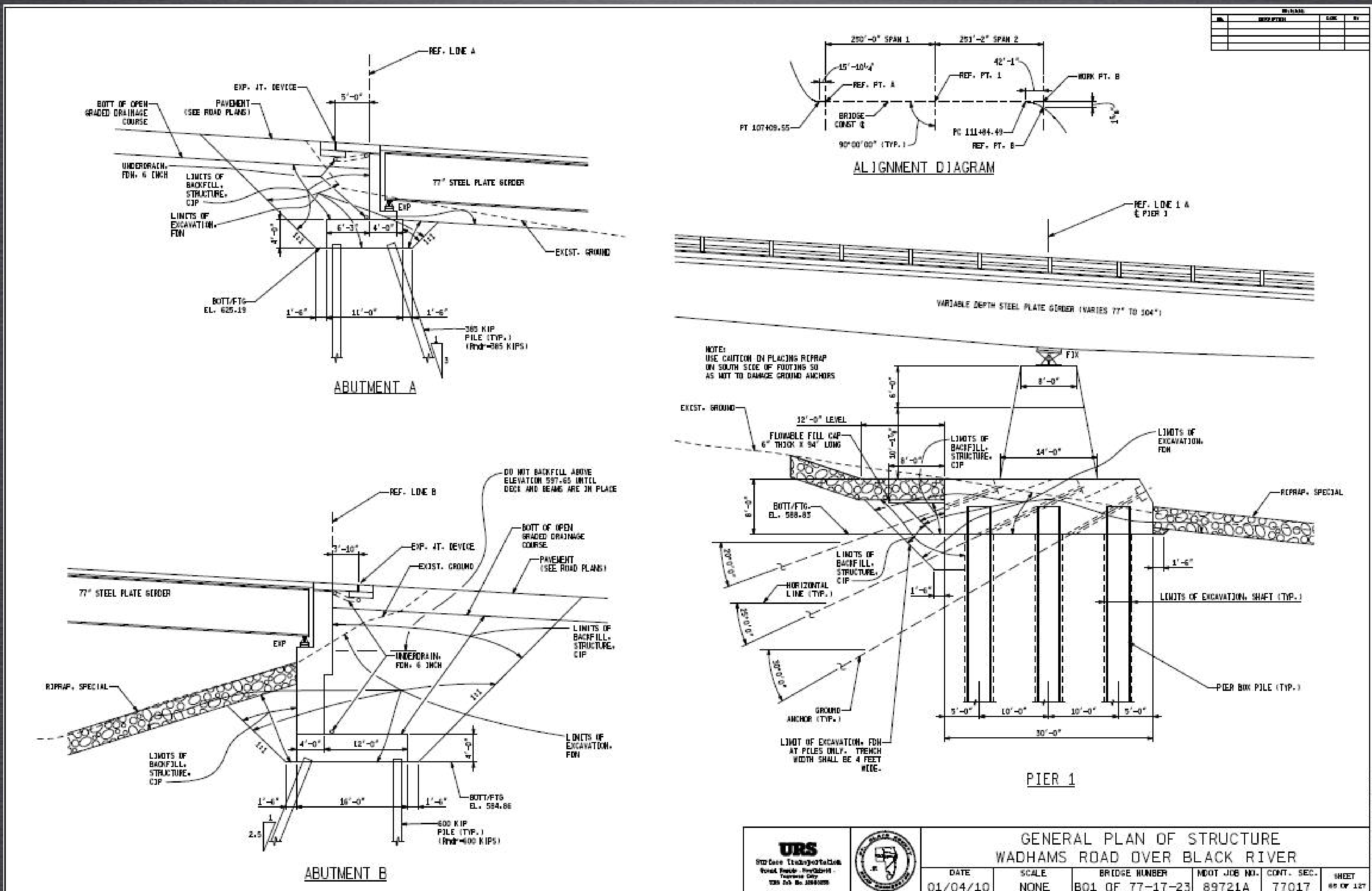


Existing Bridge

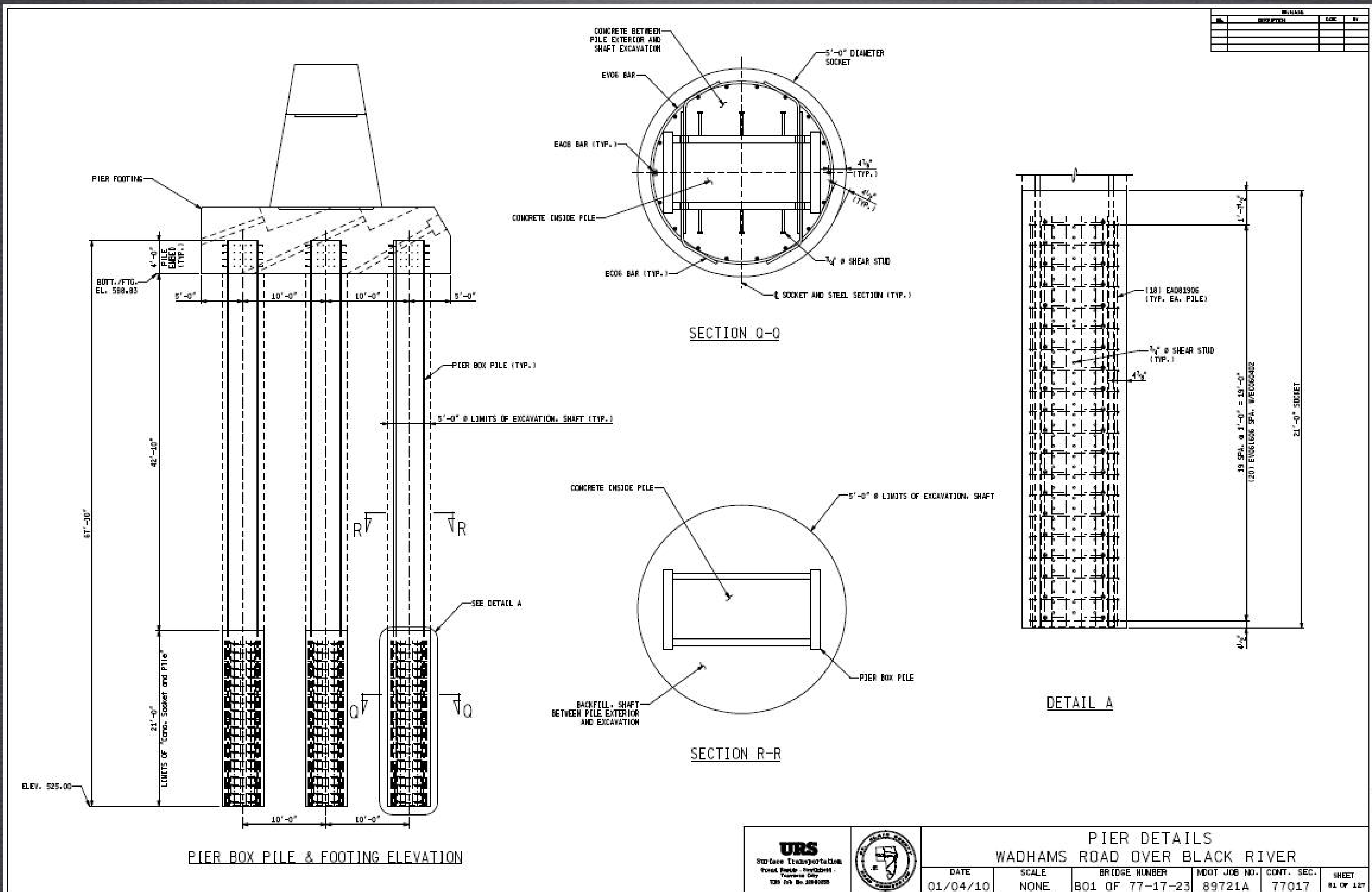
Existing Bridge



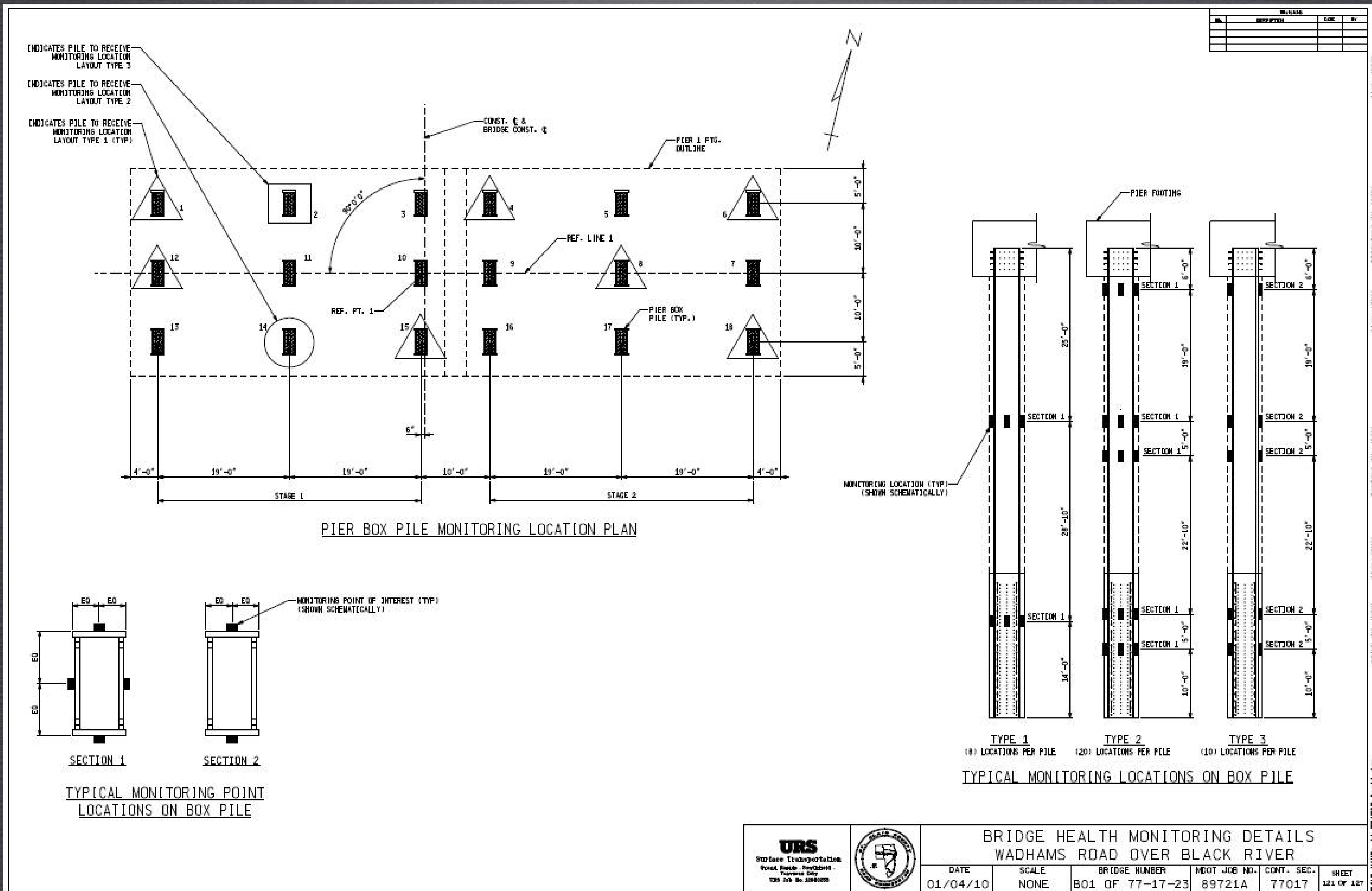
Proposed Bridge



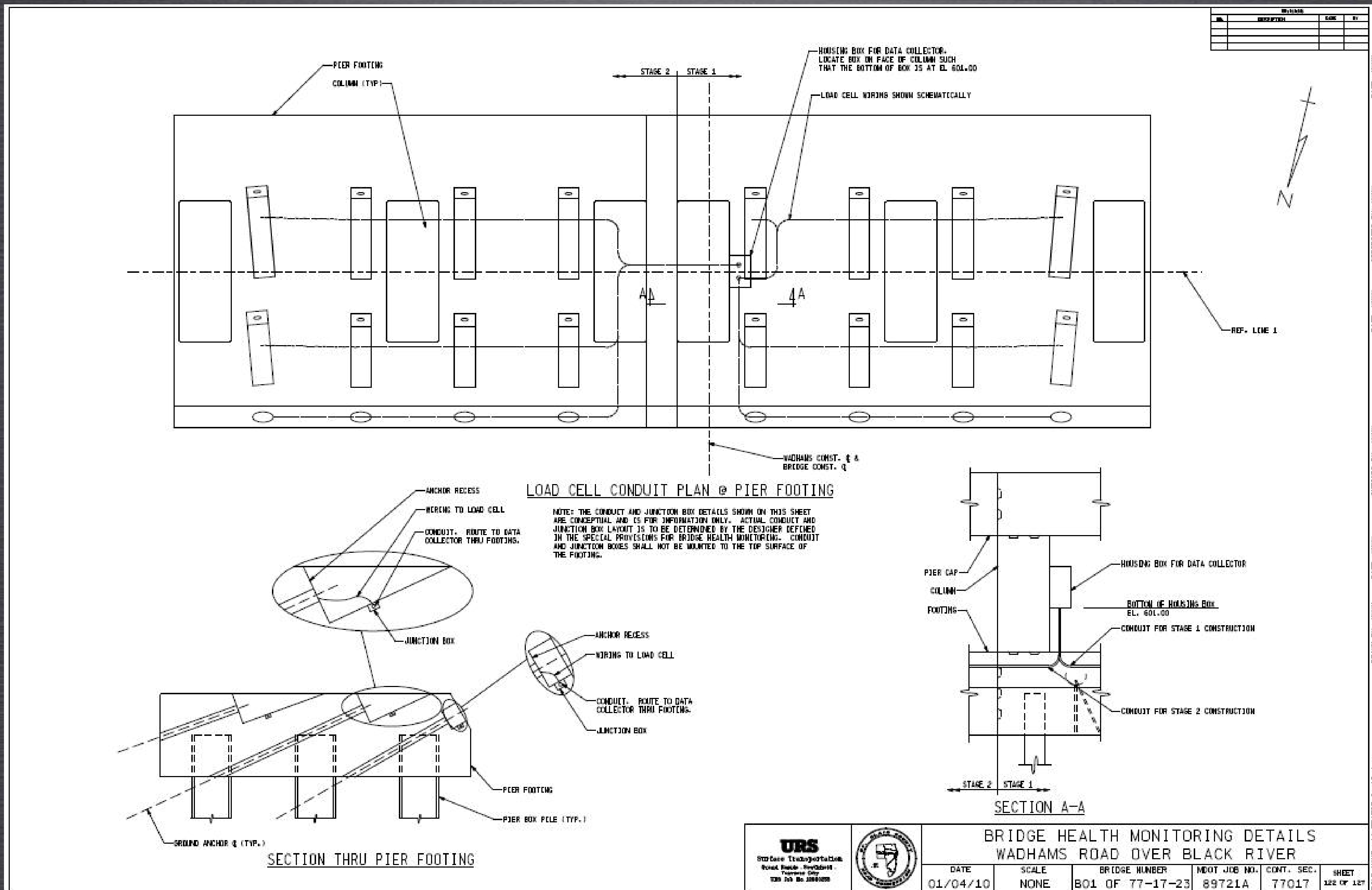
Proposed Substructure



Proposed Pier



Proposed Pier



Proposed Pier

Drilled Shafts

Drilled Shafts

Drilled Shafts

Drilled Shafts

Drilled Shafts

Drilled Shafts

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Pier footing

Pier Footing

Pier Footing

Pier Footing

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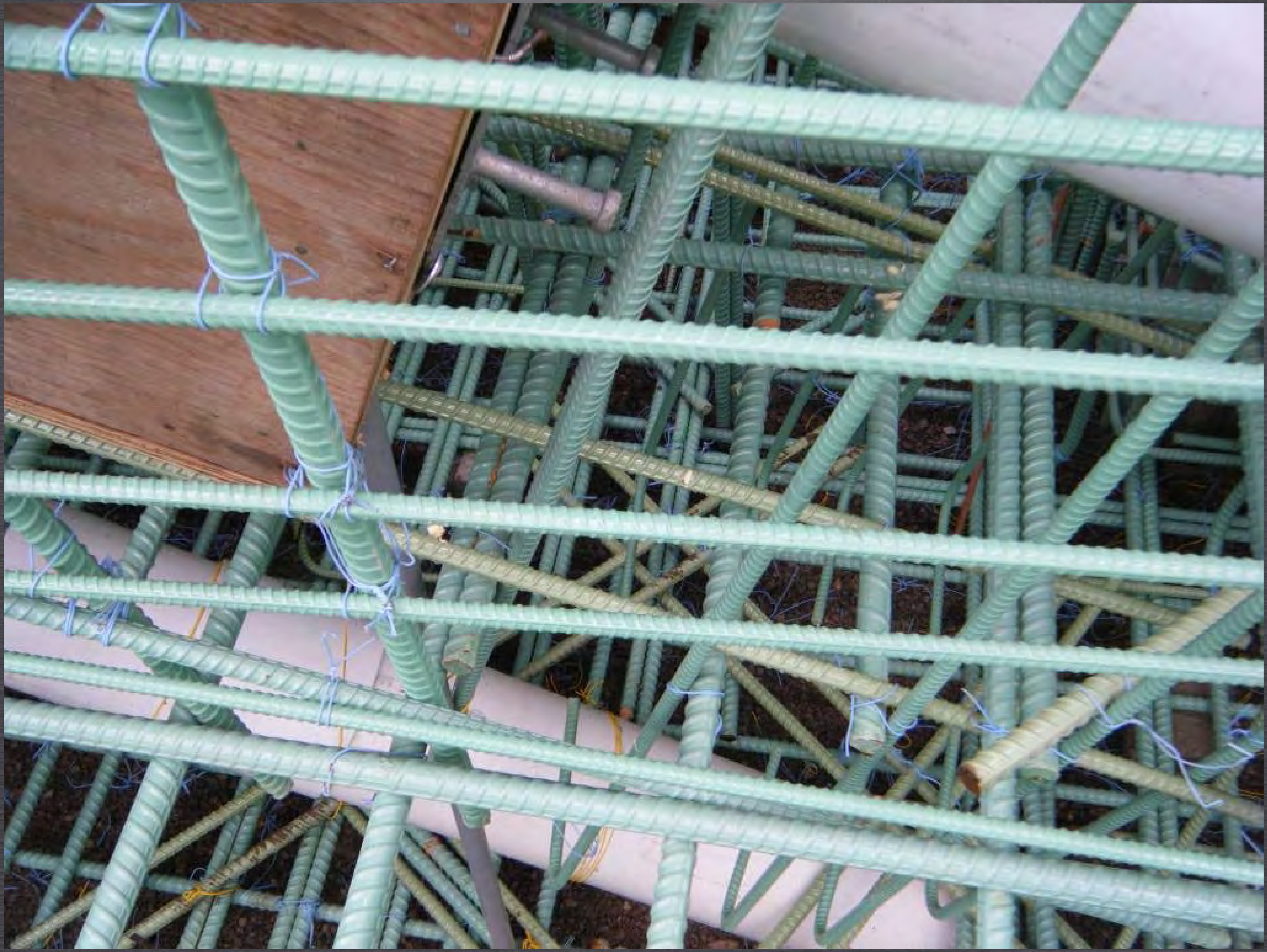
Pier Footing

Pier Footing

Pier Footing



Pier Footing

Pier Footing

Pier Footing

Pier Footing

Pier Footing

Pier Footing

Pier Footing – Pour started 7:40 am

Pier Footing

Pier Footing

Pier Footing

Pier Footing

Pier Footing

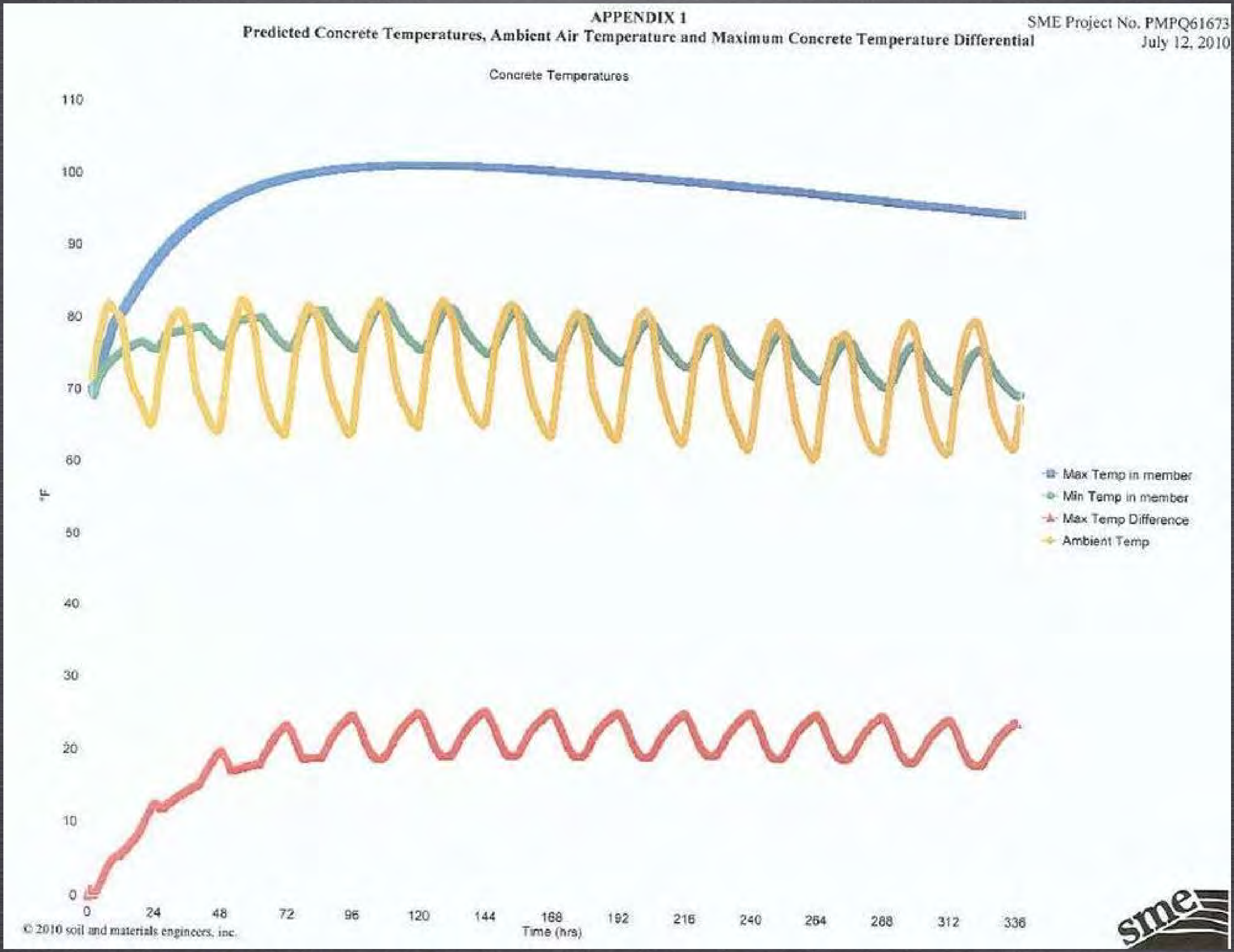
Pier Footing

Pier Footing – Pour completed 12:30 pm

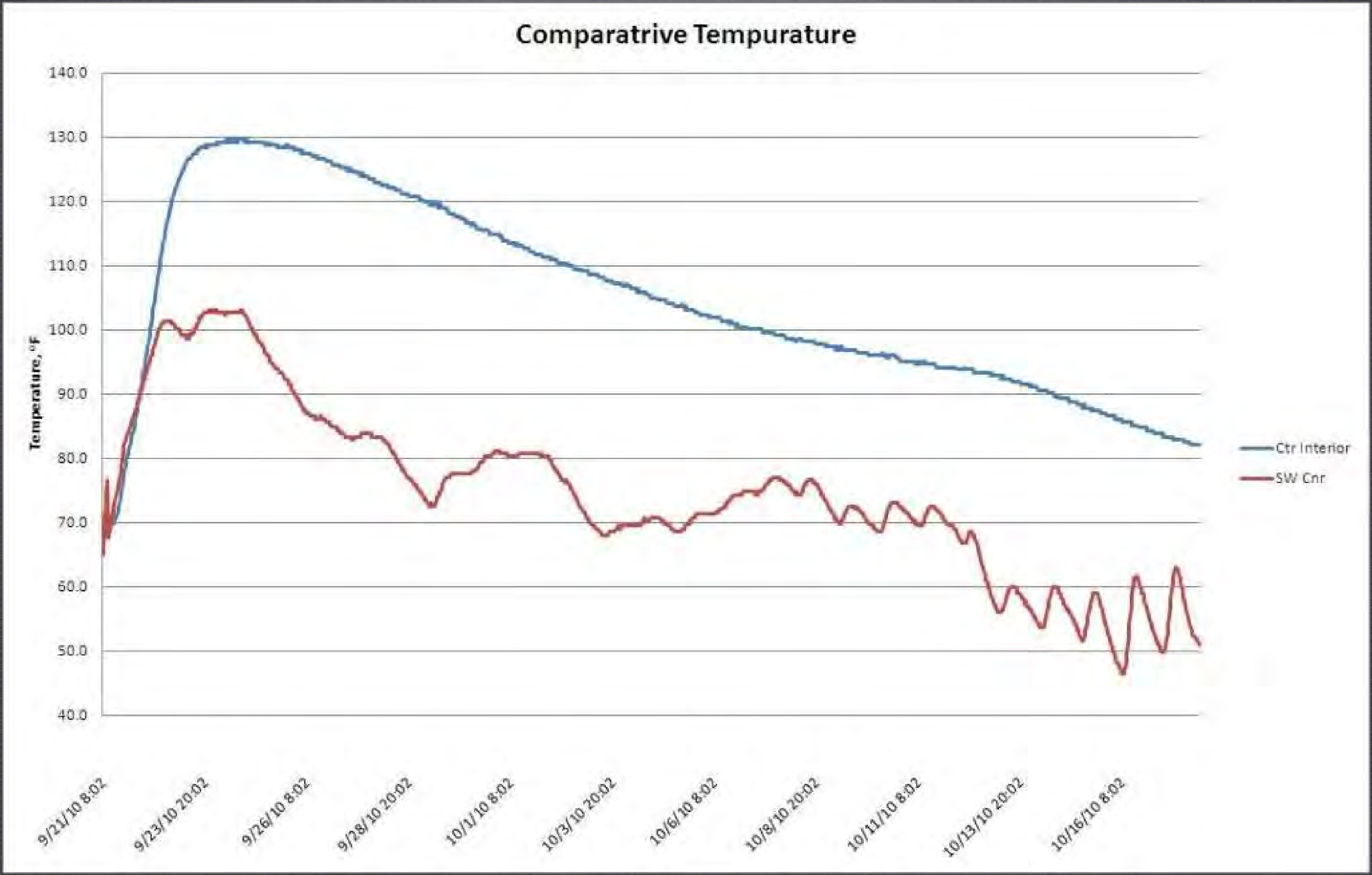
Pier Footing

Pier Footing

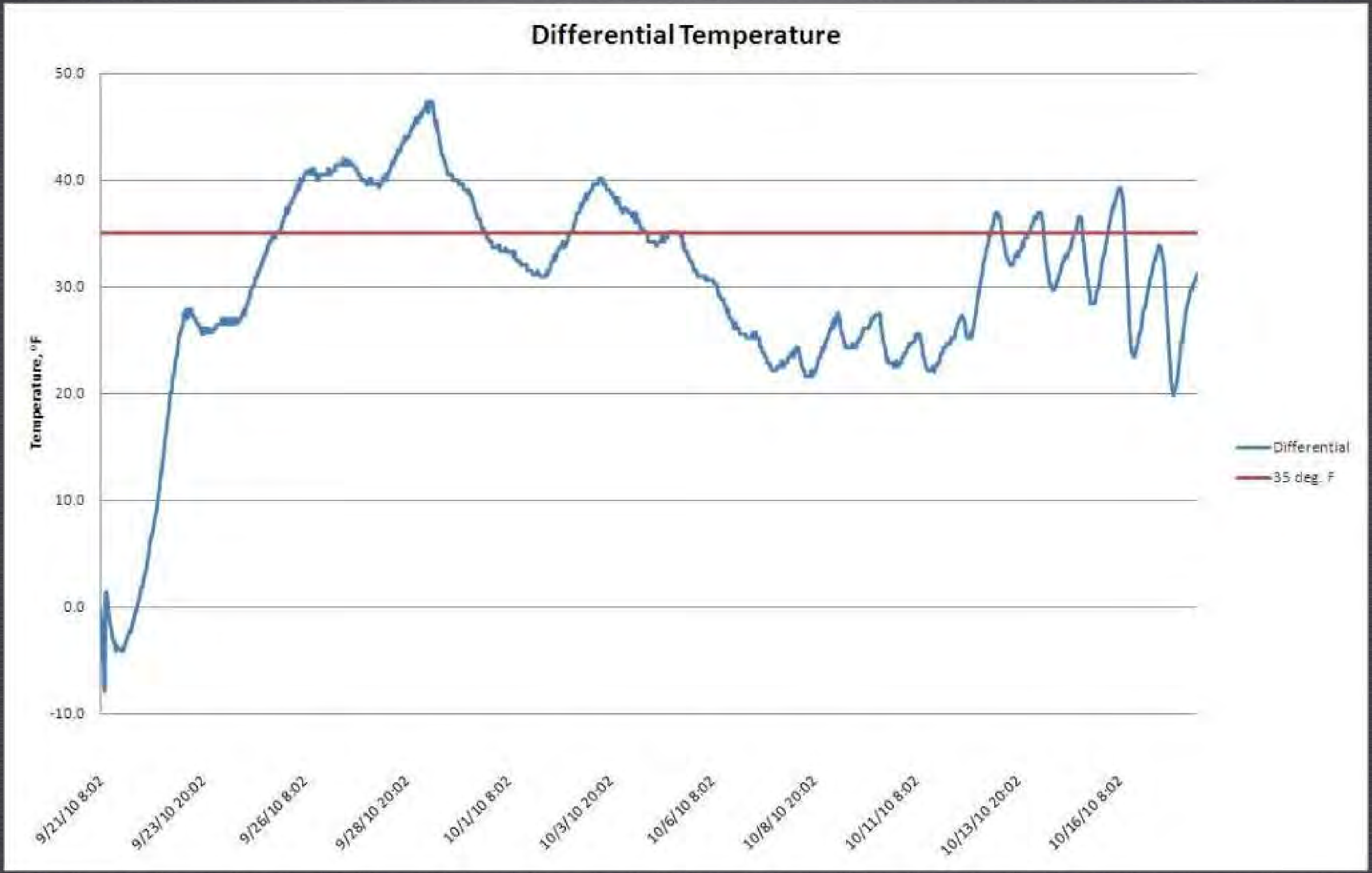
Pier Footing



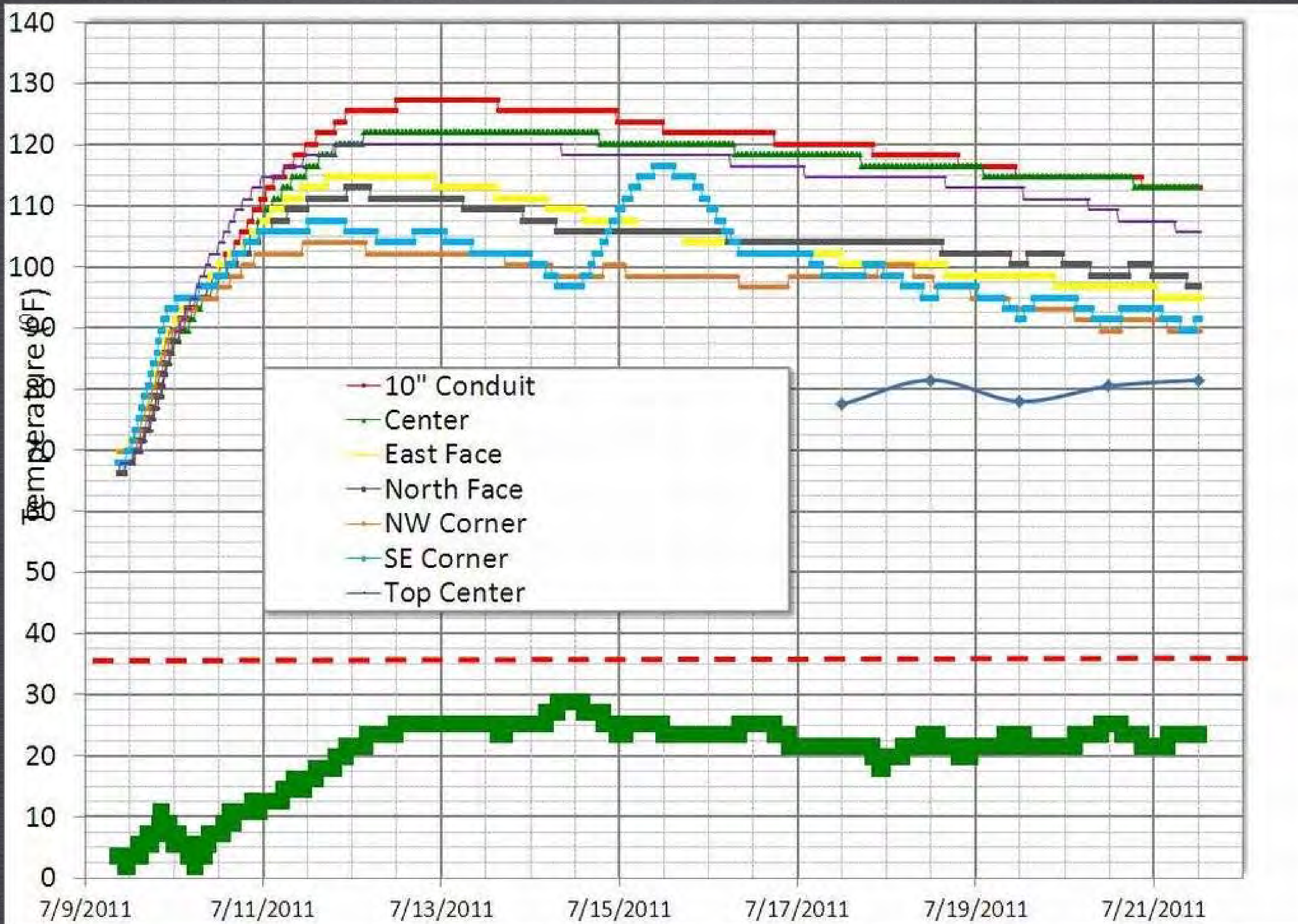
Pier Footing – Modeled Temperature Data



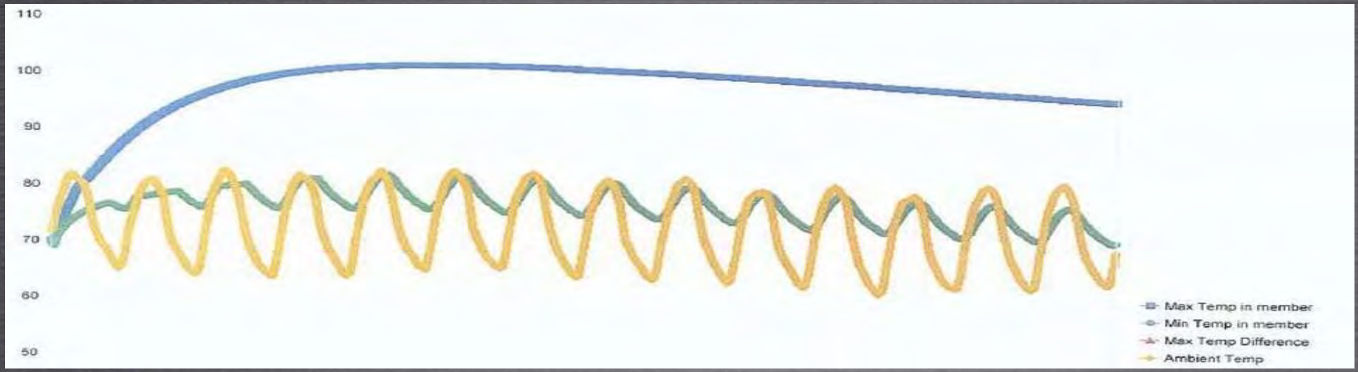
Pier Footing – Stage 1 Recorded Temperature Data

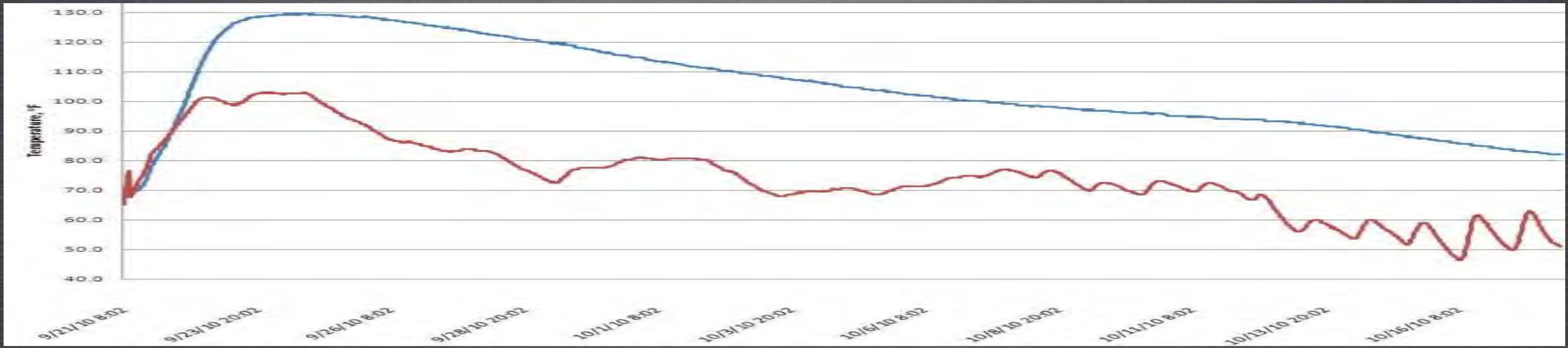


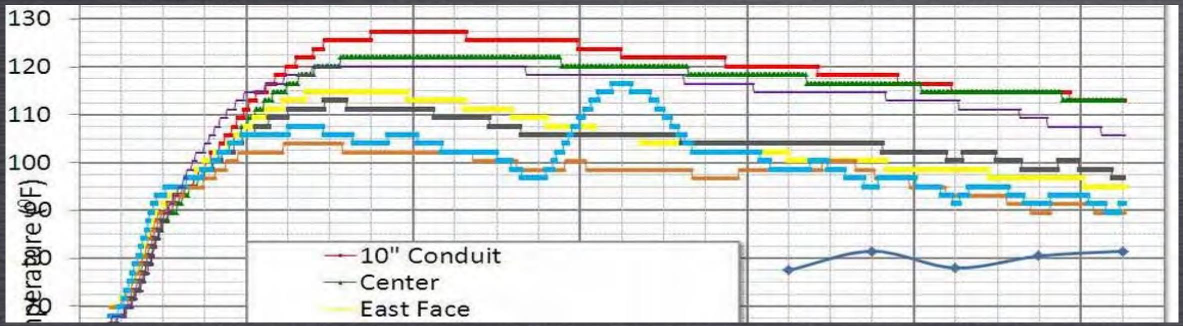
Pier Footing – Stage 1 Temperature Differential



Pier Footing – Stage 2 Temperature Data







Pier Footing – Stage 2 Temperature Data

Drilled Earth Anchors

Earth Anchors

Earth Anchors

Earth Anchors

Earth Anchors

Earth Anchors

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Earth Anchors

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Earth Anchors

Earth Anchors

Earth Anchors

Pier Footing – Closure Pour

Earth Anchors

Health Monitoring

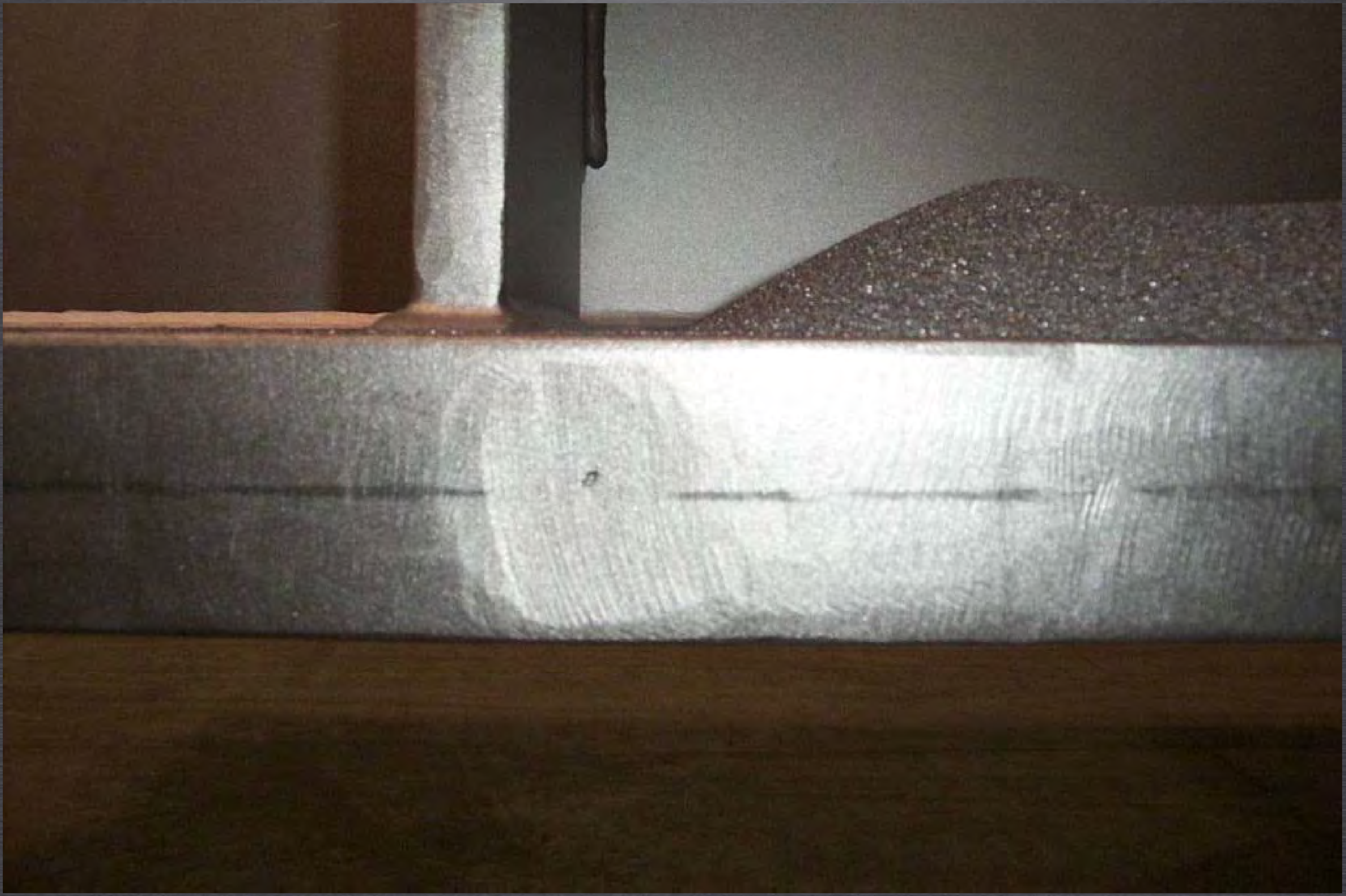
50 sensors on Earth Anchors – 47 operational
86 strain gauges on box piles – 86 operational
Design life of 20 years

To date, very little change in readings

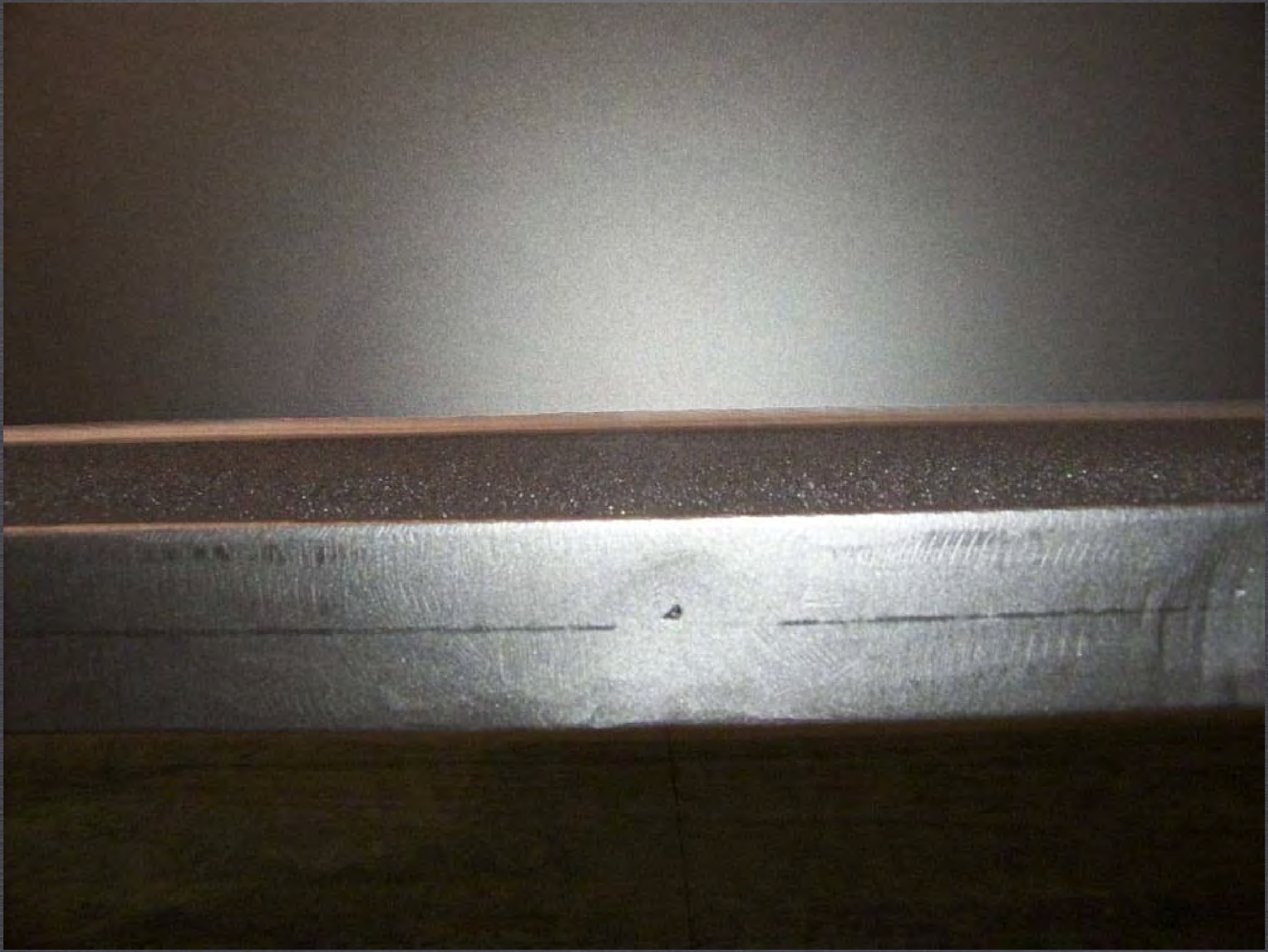
Structural Steel Testing/Investigation

Structural Steel Fabrication

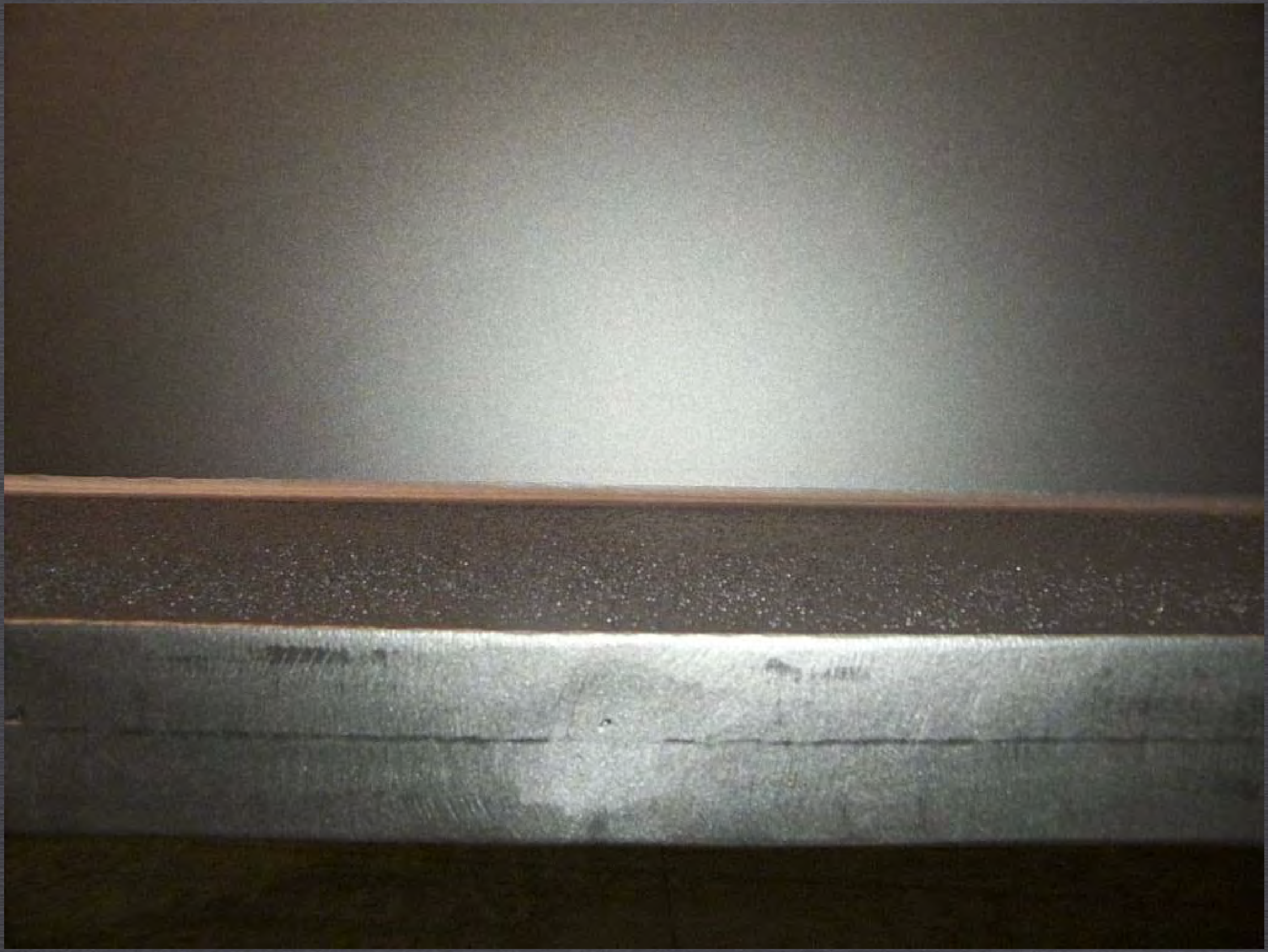
Structural Steel Fabrication



Structural Steel Fabrication



Structural Steel Fabrication



Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

Aliquippa, PA

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TÜVRheinland®
NDT NON-DESTRUCTIVE TESTING SERVICES

TENSILE TEST REPORT

Report #: 1 *Rev. 1* Page 1 of 1

Orchard, Hiltz & McCliment
34000 Plymouth Road
Livonia, MI 48150

PO #: 10-5044/51
Lab #: 101348
Date Received: 8/23/10
Date Tested: 8/24/10

Date: August 24, 2010 ***Revised August 26, 2010*** Work Order #: 400001

Test Method: ASTM- A370-09 NDTG Procedure: MEC-04 Rev. 2

Material Specification: A709-Gr. 50 [ ] Conforming [X] Non-Conforming

Material Description: Plate: 2.5" x 2.5" ***Nuc Plate Mill He #0503885-02***

ID	Dim. Inch Diameter or width & thickness	Original Area, Square Inches	Yield Load, Pounds	Max Load, Pounds	0.2% offset Yield Strength, psi	Tensile Strength, psi	Elongation in 2 Inches, %	Red. Of Area, %	Red. Dia., in	Red. Area, Sq in
	.504	.1995	7,830	14,94	39,300	75,000	.49/25	43	.382	.1146

Yield Strength Determined (if not @ 0.2% offset): @ 0.2% offset

Comment: (Reason for not using 0.2% offset)

Tensile: 65 ksi min. Yield: 50 ksi min. Elongation: 21% min. R/A: N/A

Is Fracture Location in Center Half of Gage Length? [ ] Yes [X] No

Equipment Used:

Tensile Machine Control #:	409	Extensometer Control #:	511	Caliper and / or Micrometer Control #(s):	405/434

Test Witnessed By:

Test Technician:

Respectfully submitted,
Scott Robertson
Mechanical Laboratory Supervisor
Non-Destructive Testing Group

Structural Steel Fabrication

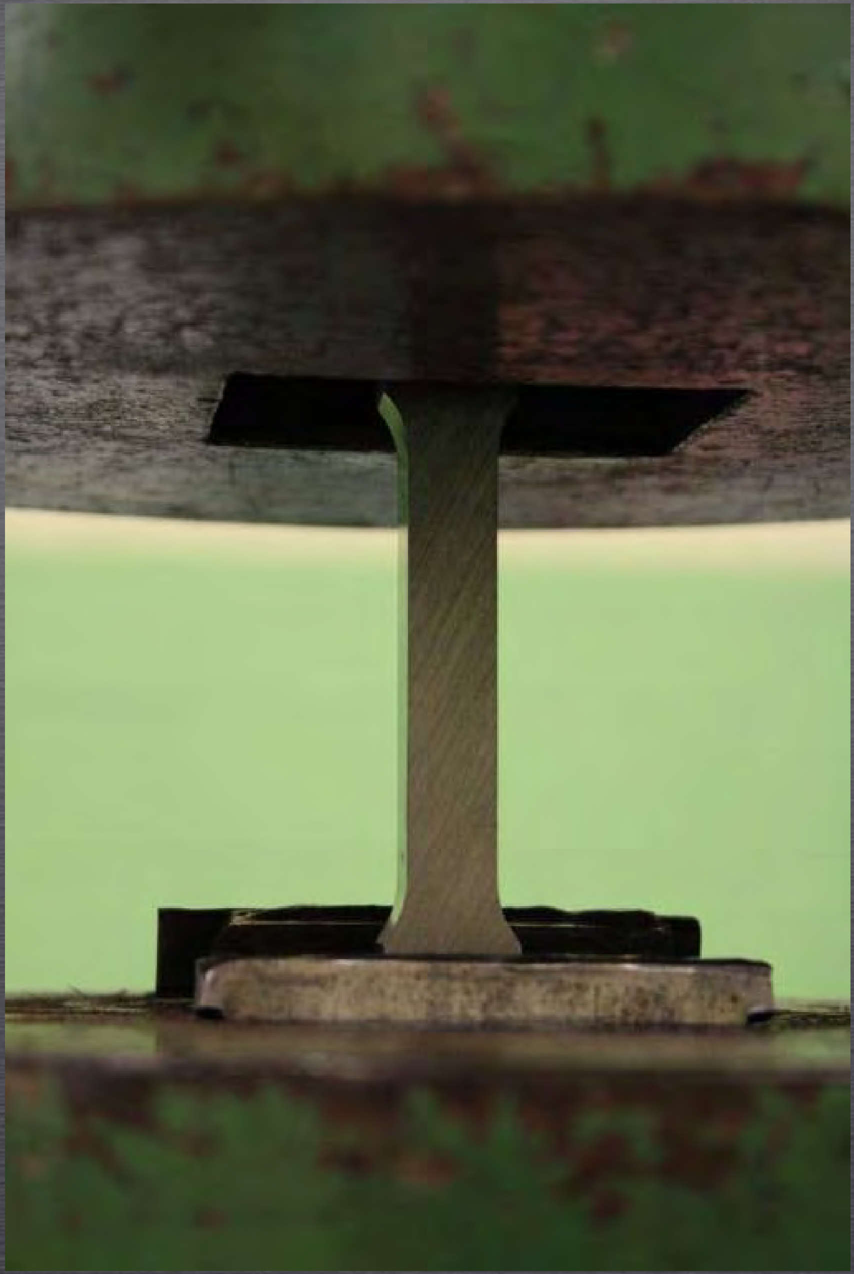
Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

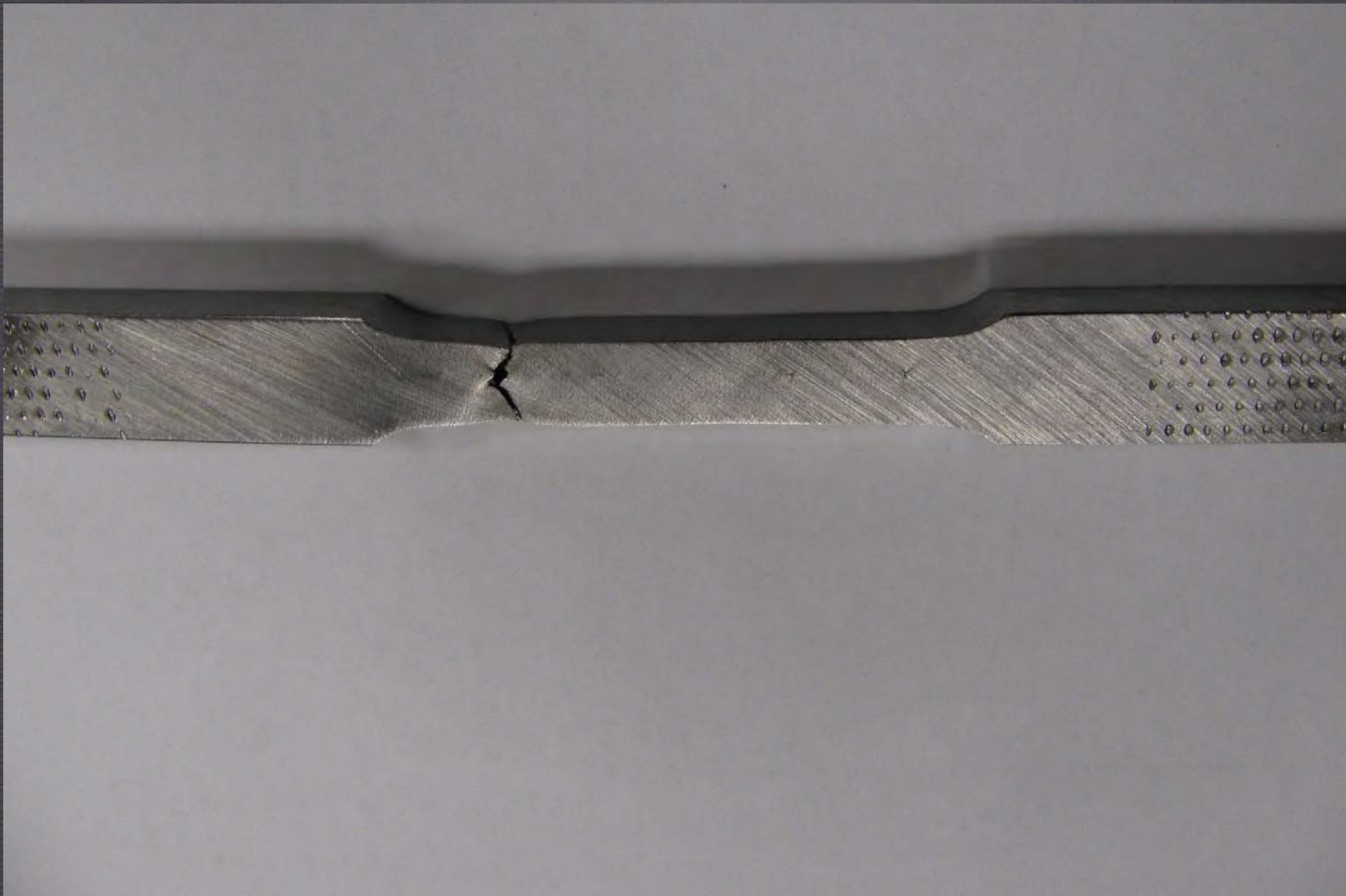


Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

Structural Steel Fabrication

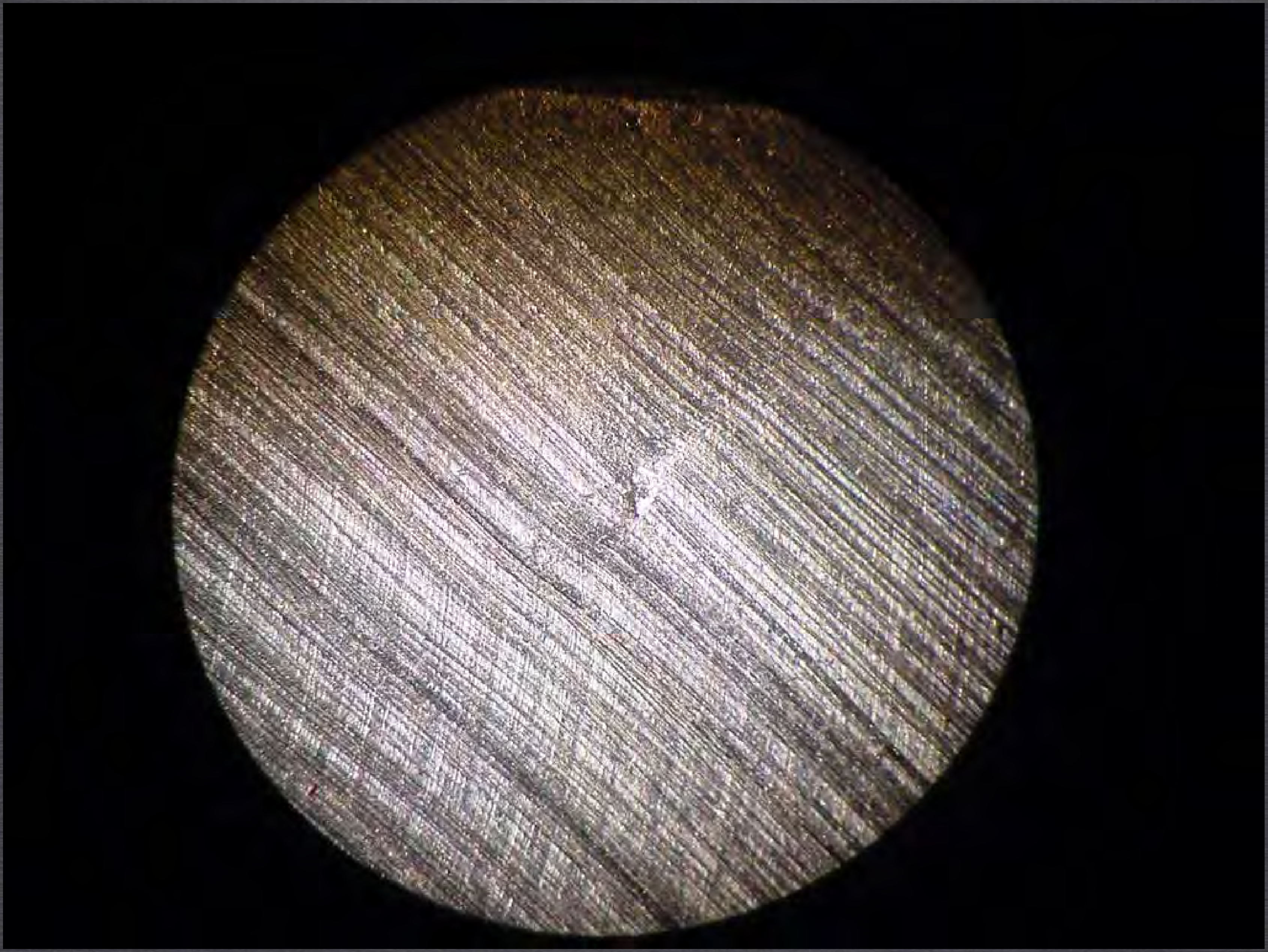


Structural Steel Testing – Sample A
Fy=47,460psi, 14.4% elongation

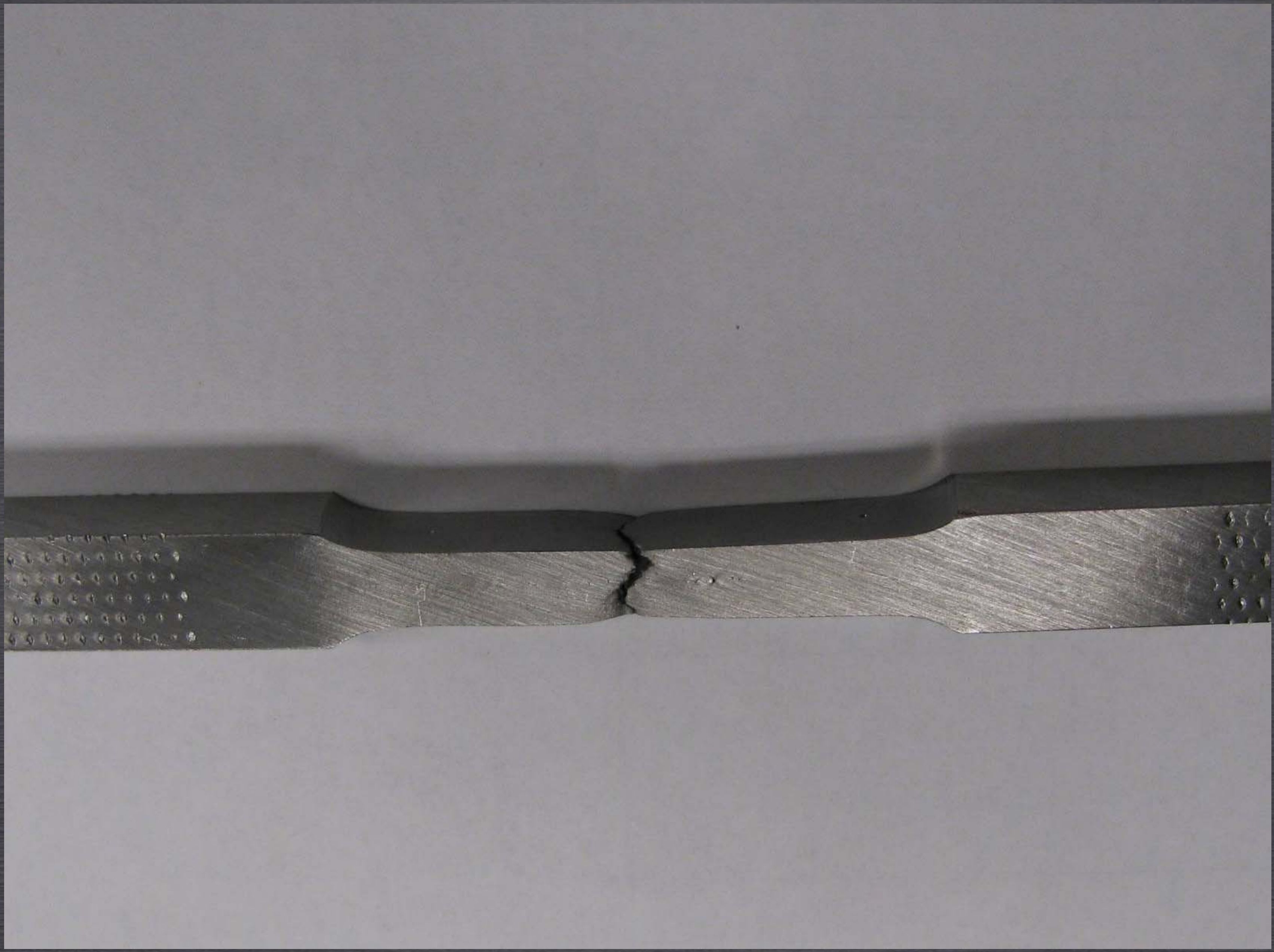
Structural Steel Fabrication

Structural Steel Fabrication

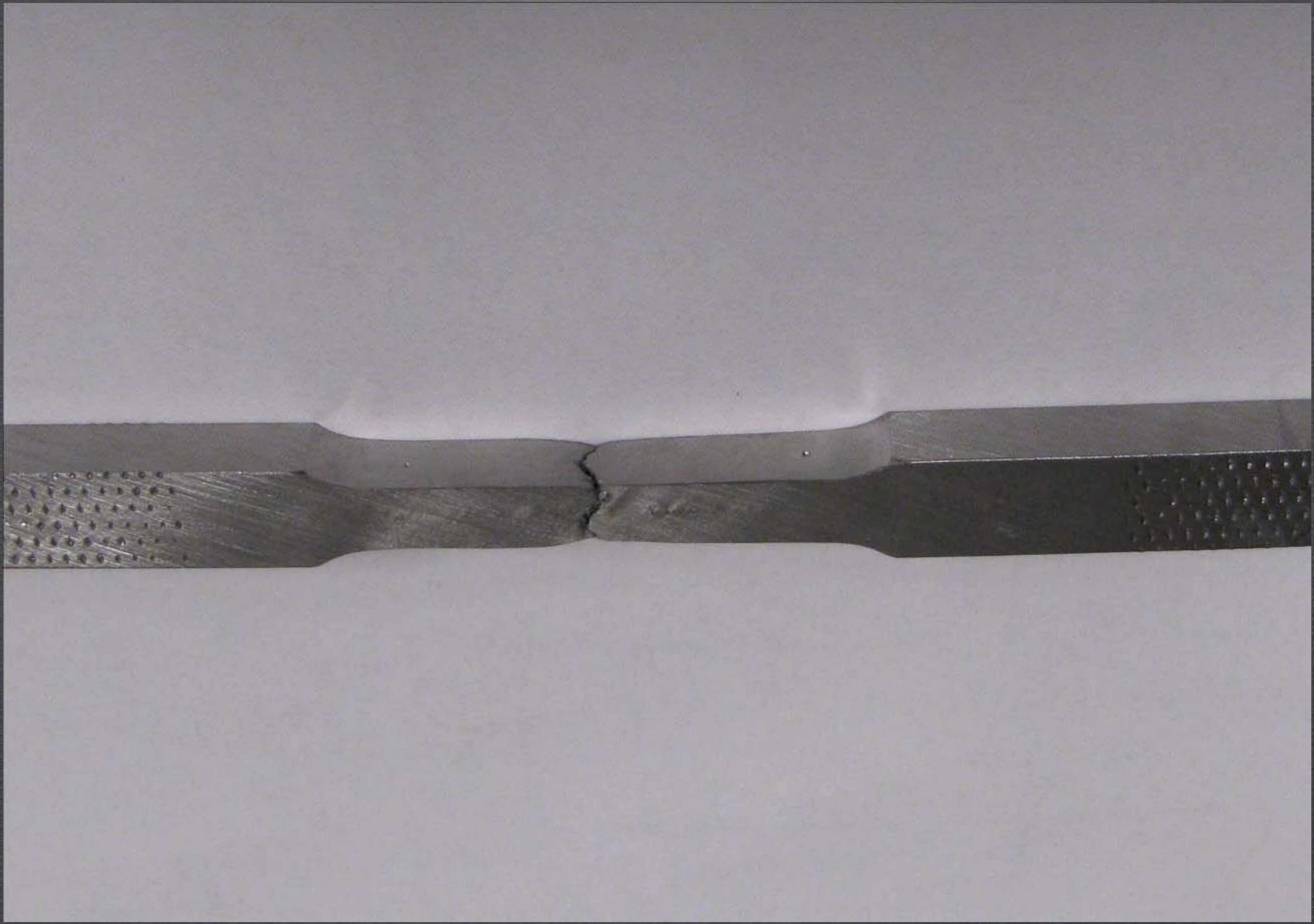
Structural Steel Fabrication – Sample A



Structural Steel Fabrication – Sample A

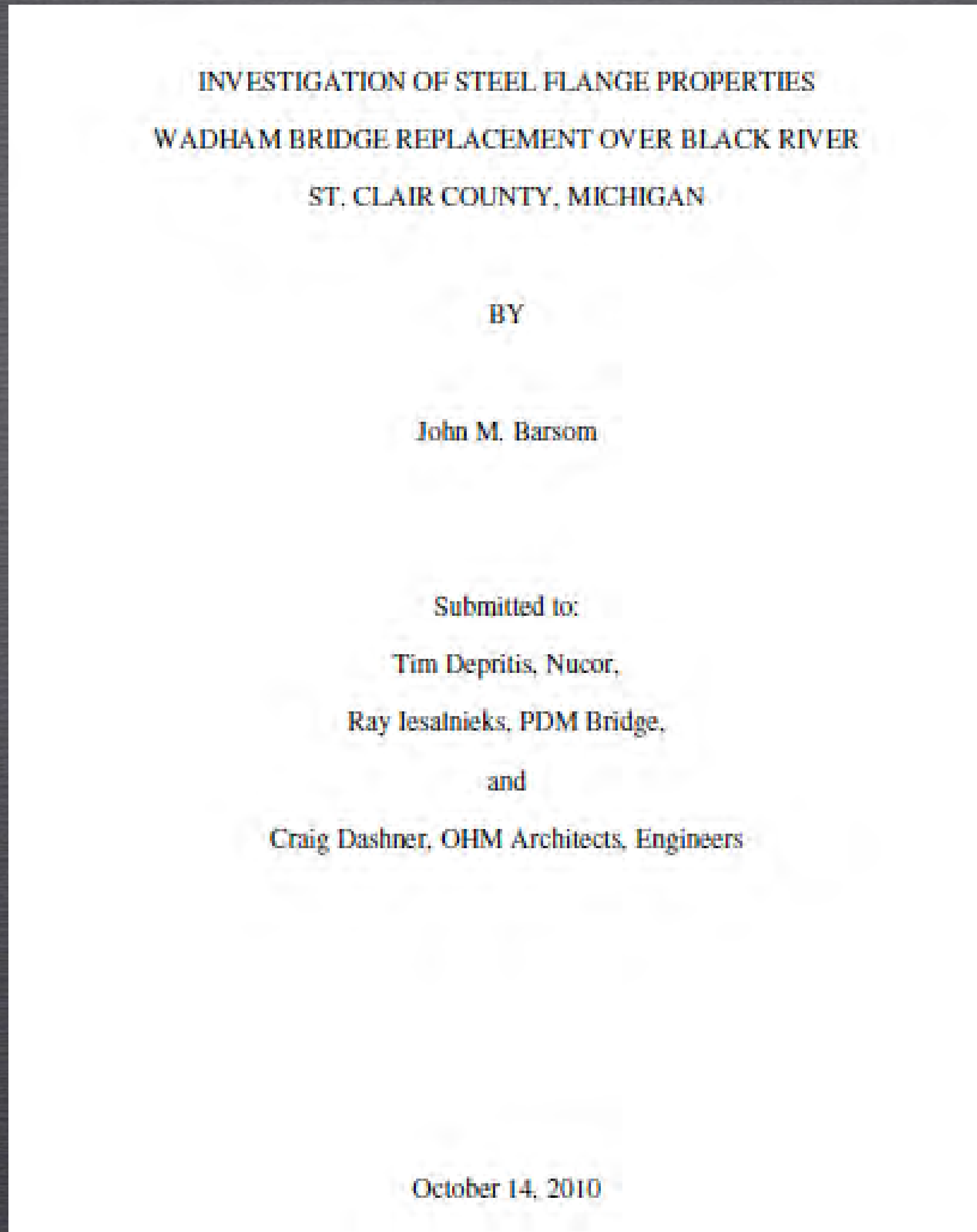


Structural Steel Fabrication – Sample B
Fy=44,780 psi, 17.3% elongation



Structural Steel Fabrication – Sample B

Structural Steel Fabrication – Sample B


INVESTIGATION OF STEEL FLANGE PROPERTIES

WADHAM BRIDGE REPLACEMENT OVER BLACK RIVER

ST. CLAIR COUNTY, MICHIGAN

BY

John M. Barsom

Submitted to:

Tim Depritis, Nucor,

Ray Iesalnieks, PDM Bridge,

and

Craig Dashner, OHM Architects, Engineers

October 14, 2010

Structural Steel Testing – Additional Testing

FRACTOGRAPHIC INVESTIGATION

The tension specimens that were tested on September 27, 2010 and [Table 1] were visually examined immediately after they were fractured. **Visual examination** of the fracture surfaces **revealed the presence of several dispersed, shiny spots similar to "fish eye" features**. These features were present on specimens from mid thickness and from quarter thickness. **"Fish eye" features are usually associated with the presence of hydrogen in the steel in sufficient amount to detrimentally affect the ductility and fracture toughness of the steel under slow and intermediate loading rates**. The detrimental effects of hydrogen on steel properties are not observed under fast loading rate. Consequently, "fish eye" features are found on fracture surfaces of tension specimens but not on fracture surfaces of CVN specimens.

Table 1.

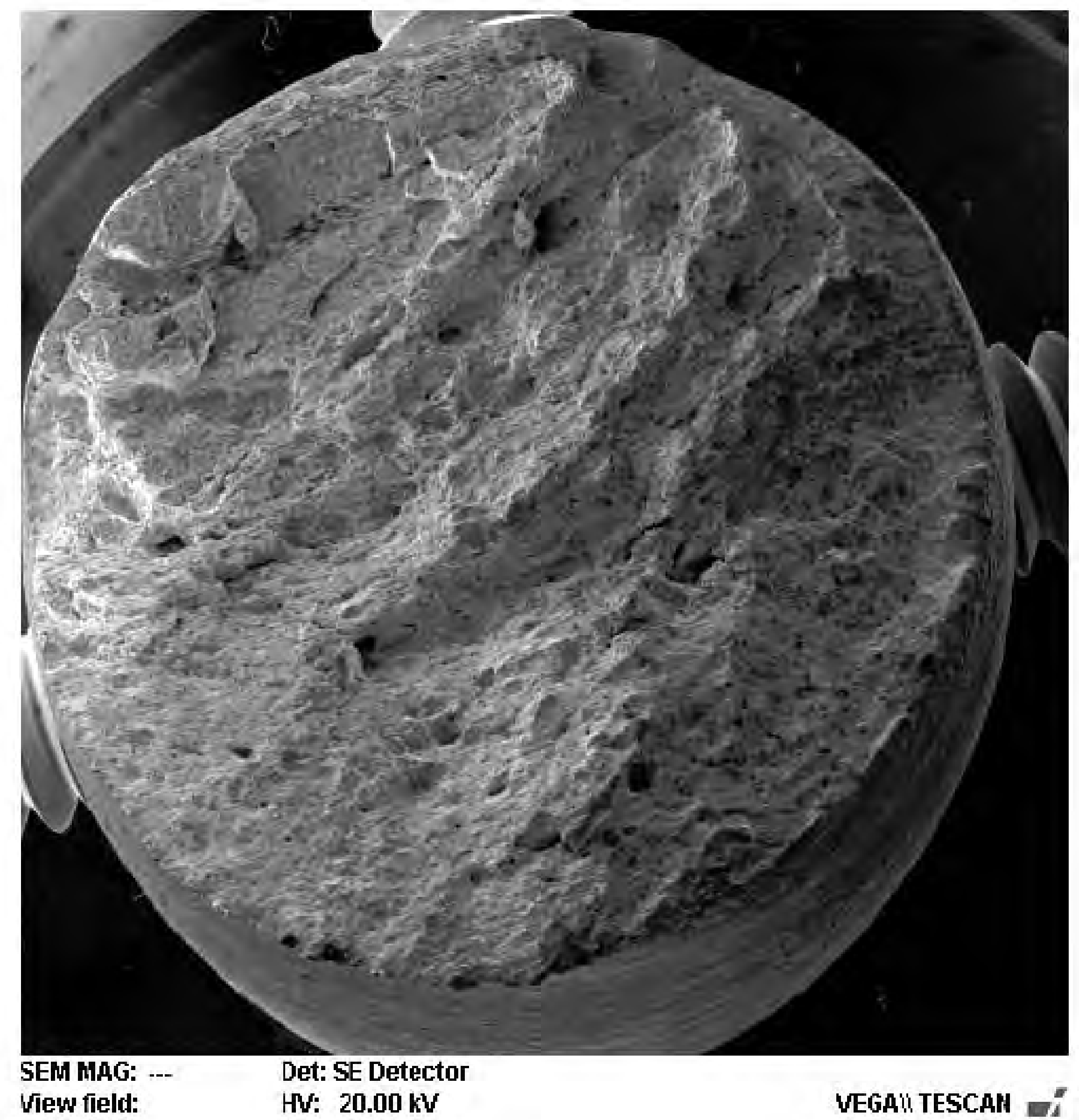
Tensile Properties of Slabs.

Slab ID	Specimen Designation	Yield Strength, psi, (0.2 % offset)	Tensile Strength, psi	NDT, % Elong.	PES, % Elong.
0503860-02	3Q	52,500	85,500	20	19.2
	3C	65,000	85,000	15	15.8
0503860-05	5Q	54,000	86,000	15	14.4
	5C	54,000	85,000	13	14.4
0503885-XX	MQ	42,000	78,00	32	31.7
0503886-08	6Q	53,000	84,500	21	21.6
	6C	53,000	84,000	21	20.8
0503887-02	4Q	52,500	83,500	13	12.7
	4C	52,500	84,500	19	18.6

Structural Steel Testing – Additional Testing

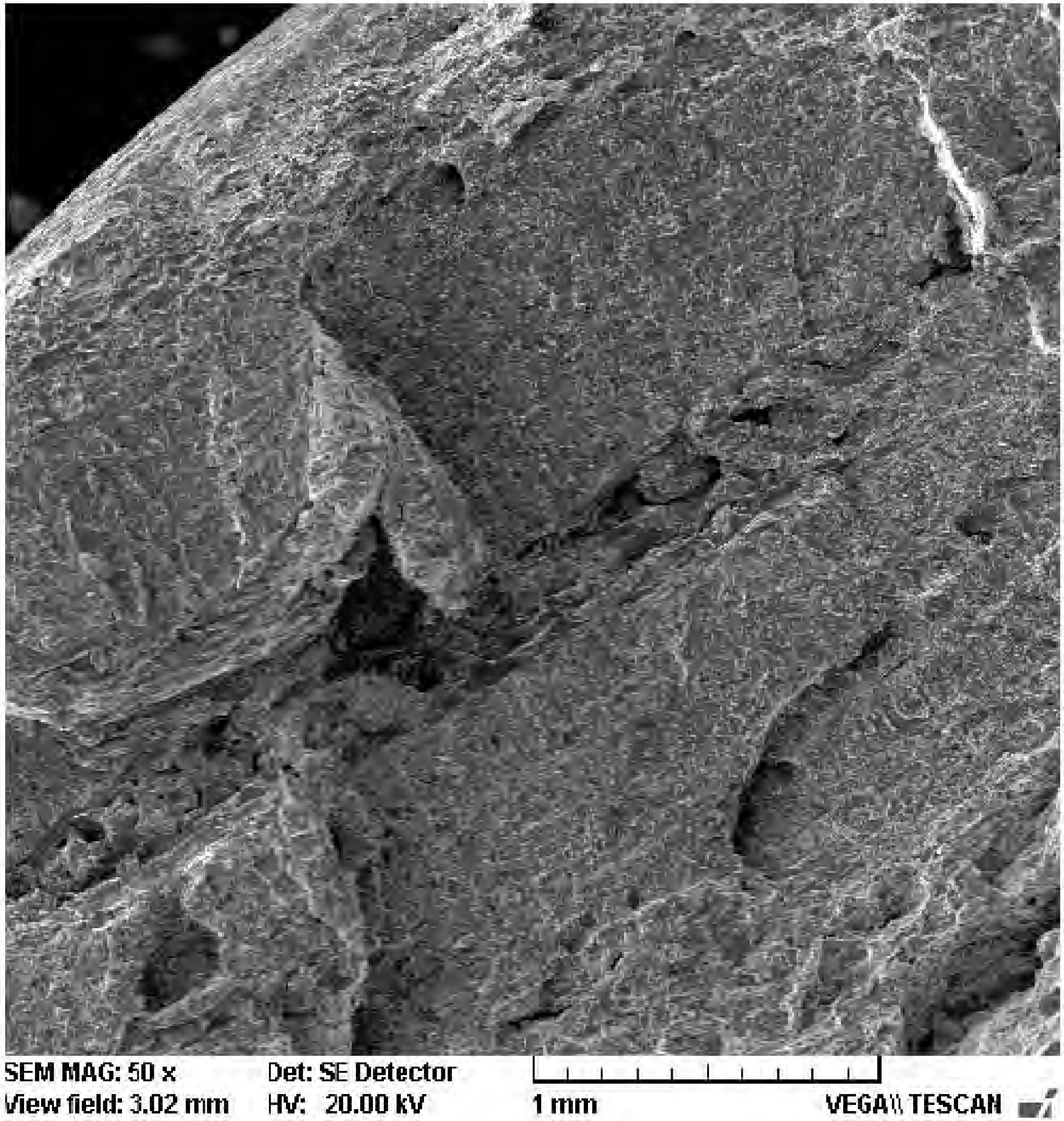
…..The sequence of SEM fractographs present the overall fracture surface, the selected “fish eye” feature, a close up of the origin that caused the initiation of the fish eye, the microstructure of the fish eye initiation site and the fracture mode of the fish eye surface. **The SEM analyses demonstrated that the fish eyes initiated and propagated from casting voids which exhibited typical interdendritic features.** These voids were not consolidated during hot rolling of the slabs into plates. **The voids were present at mid thickness and at quarter thickness**.

Structural Steel Testing – Additional Testing



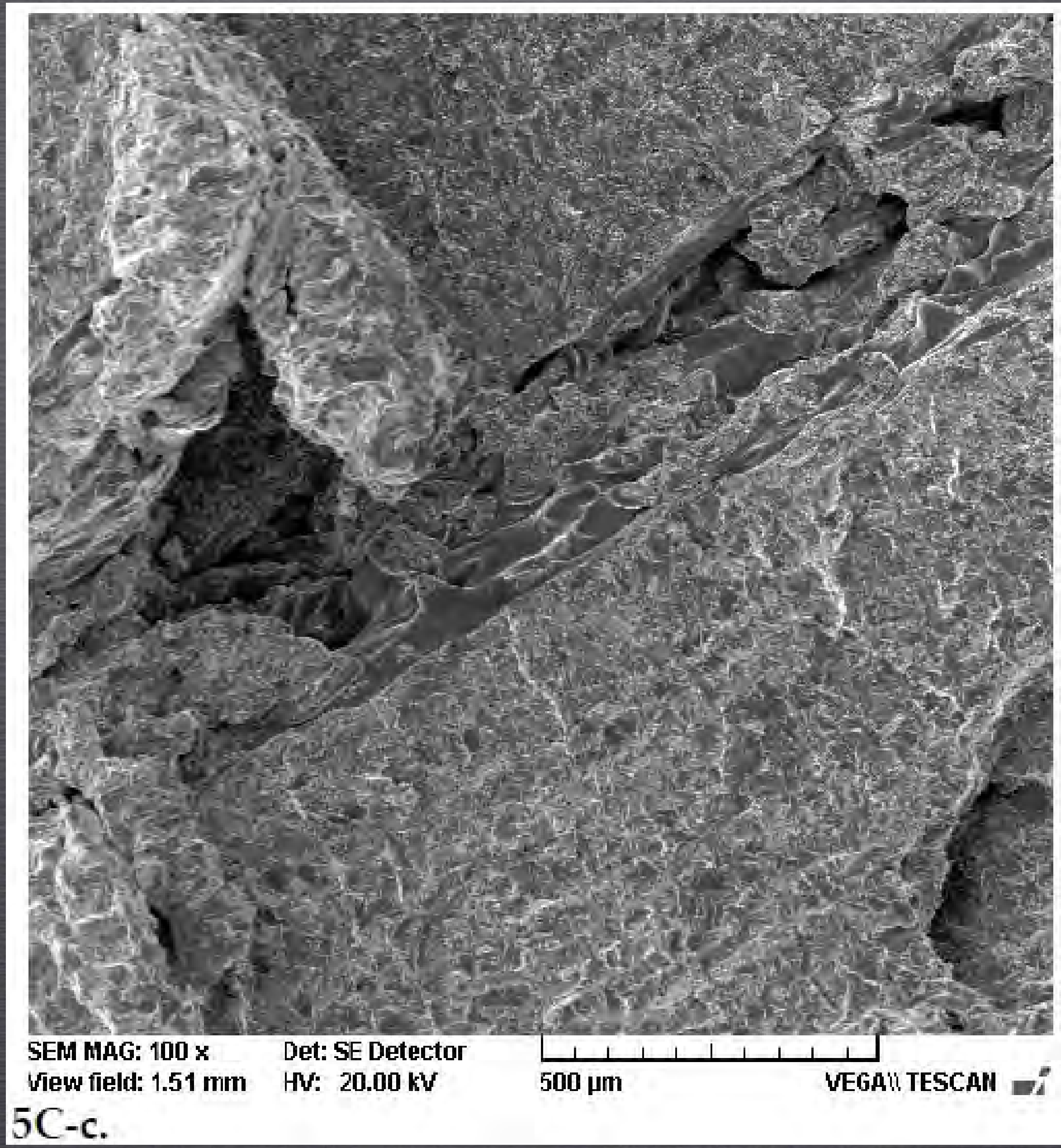
5C-a.

Structural Steel Testing – Additional Testing

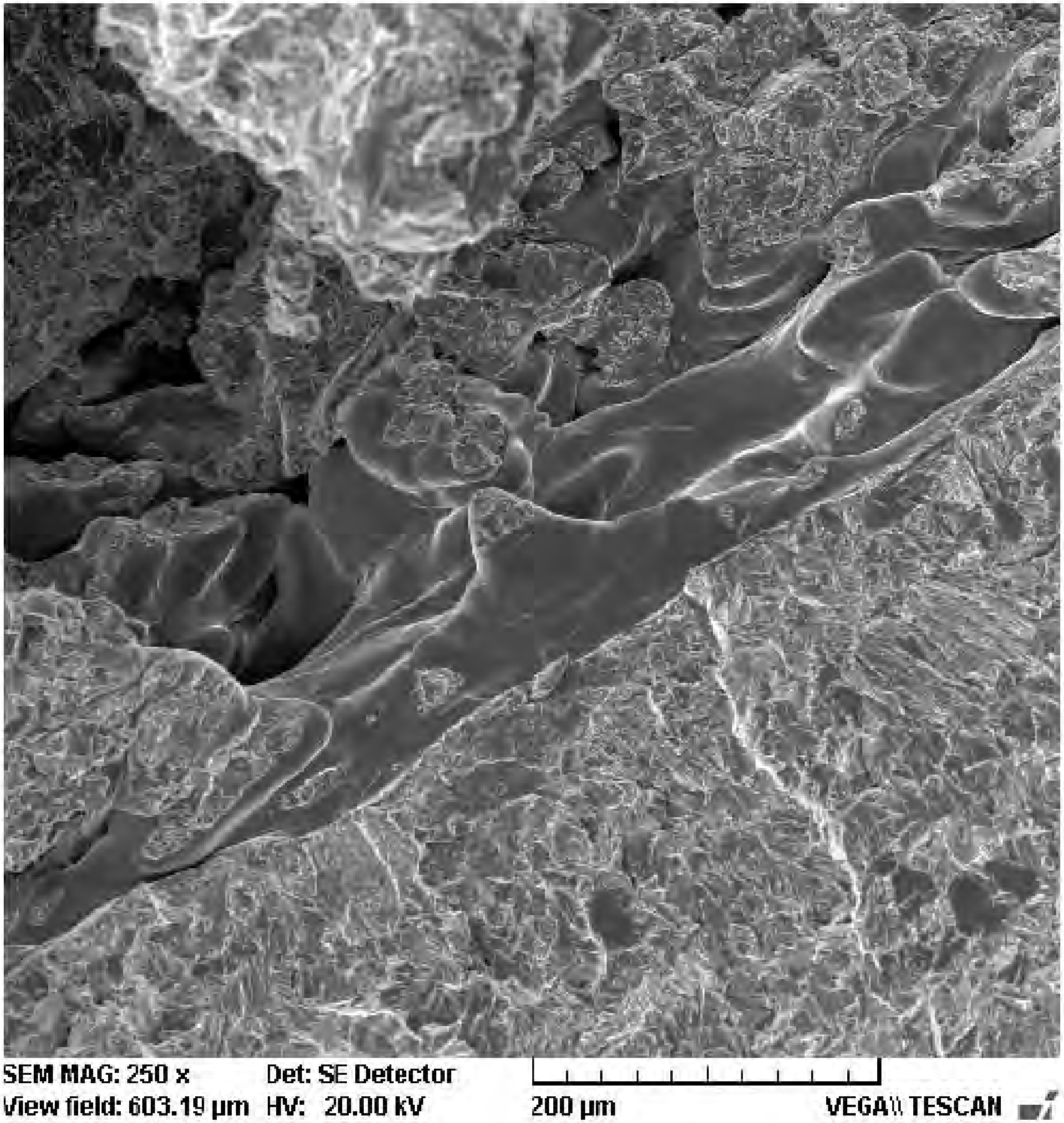


5C-b.

Structural Steel Testing – Additional Testing

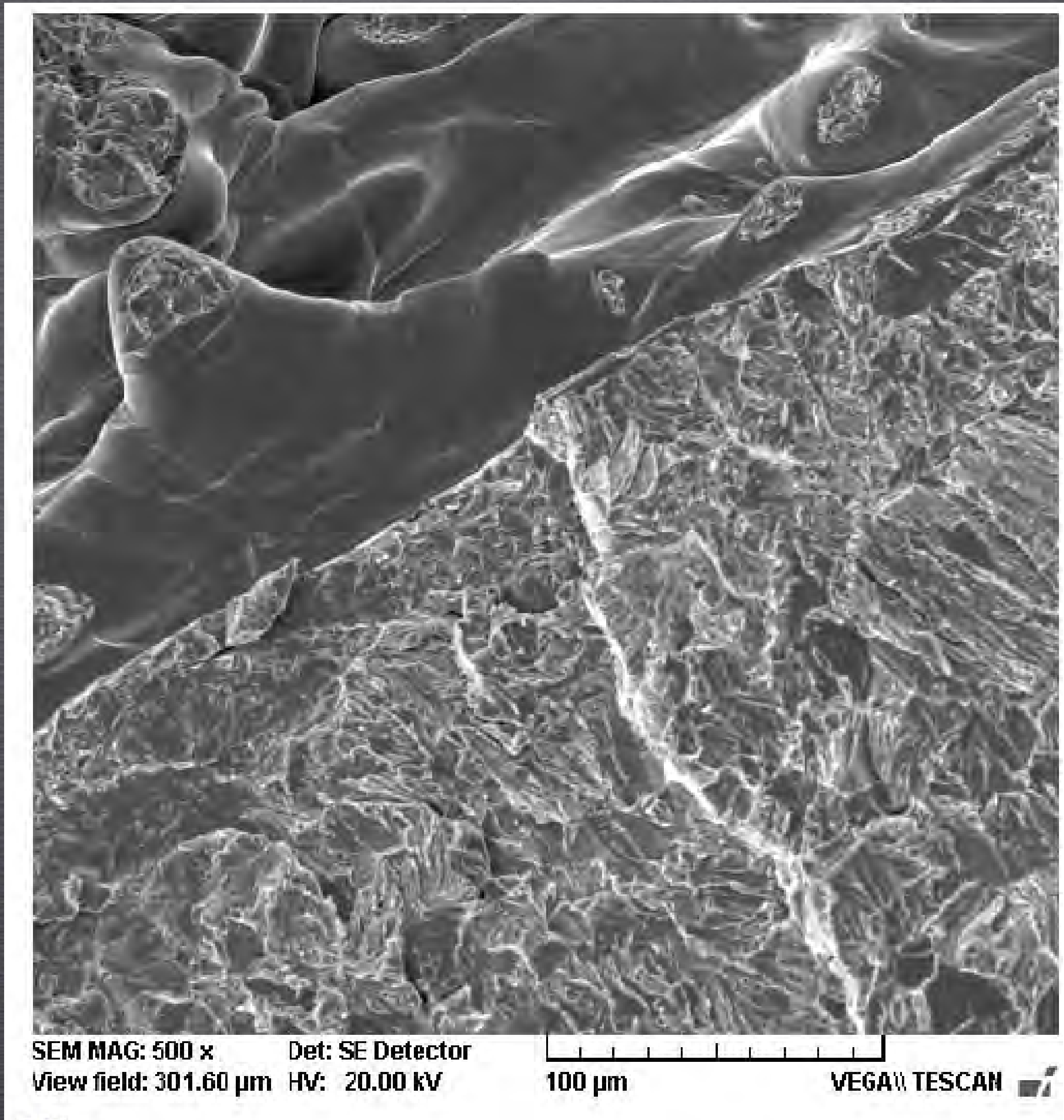


Structural Steel Testing – Additional Testing



5C-d.

Structural Steel Testing – Additional Testing



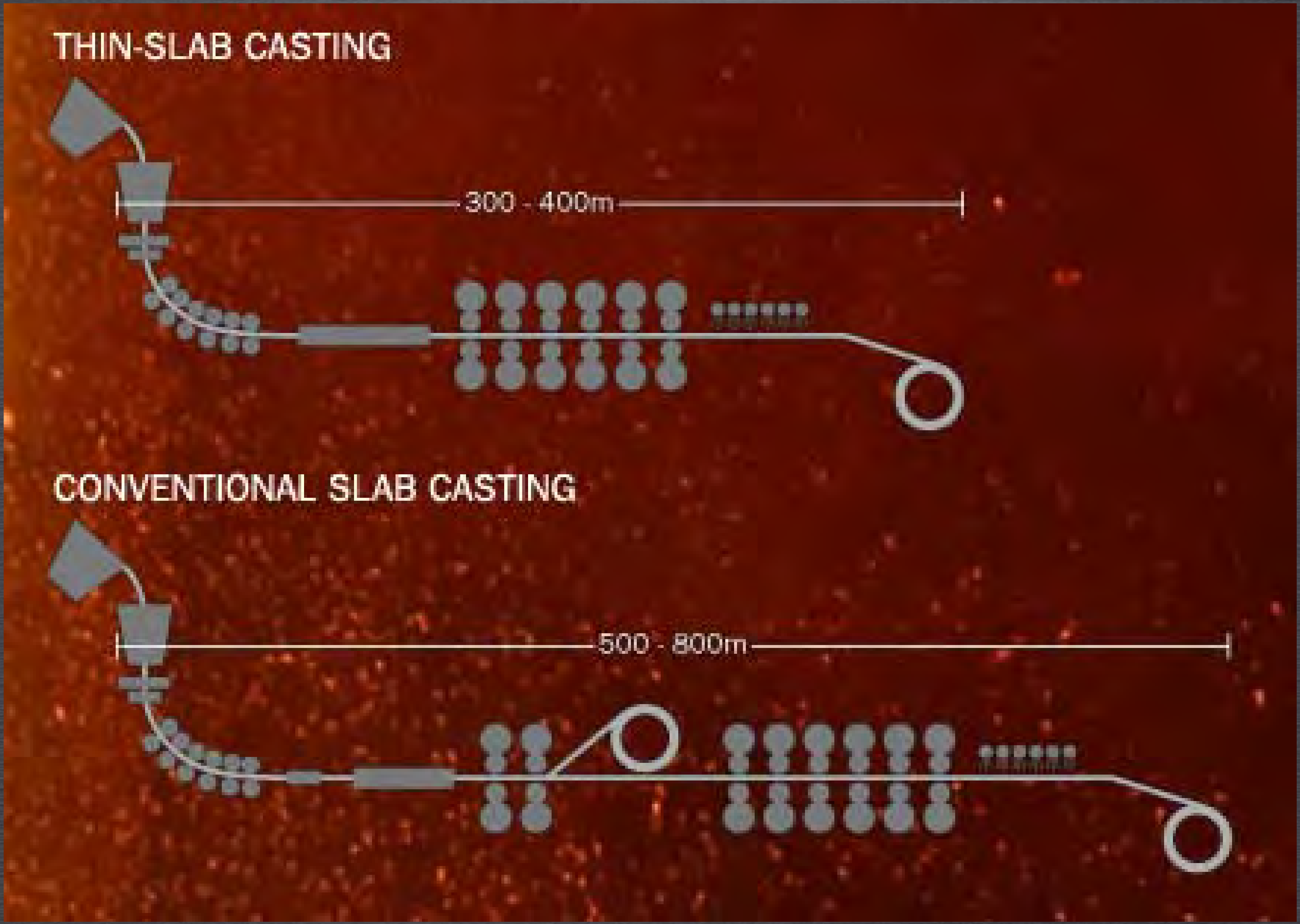
5C-e.

Structural Steel Testing – Additional Testing

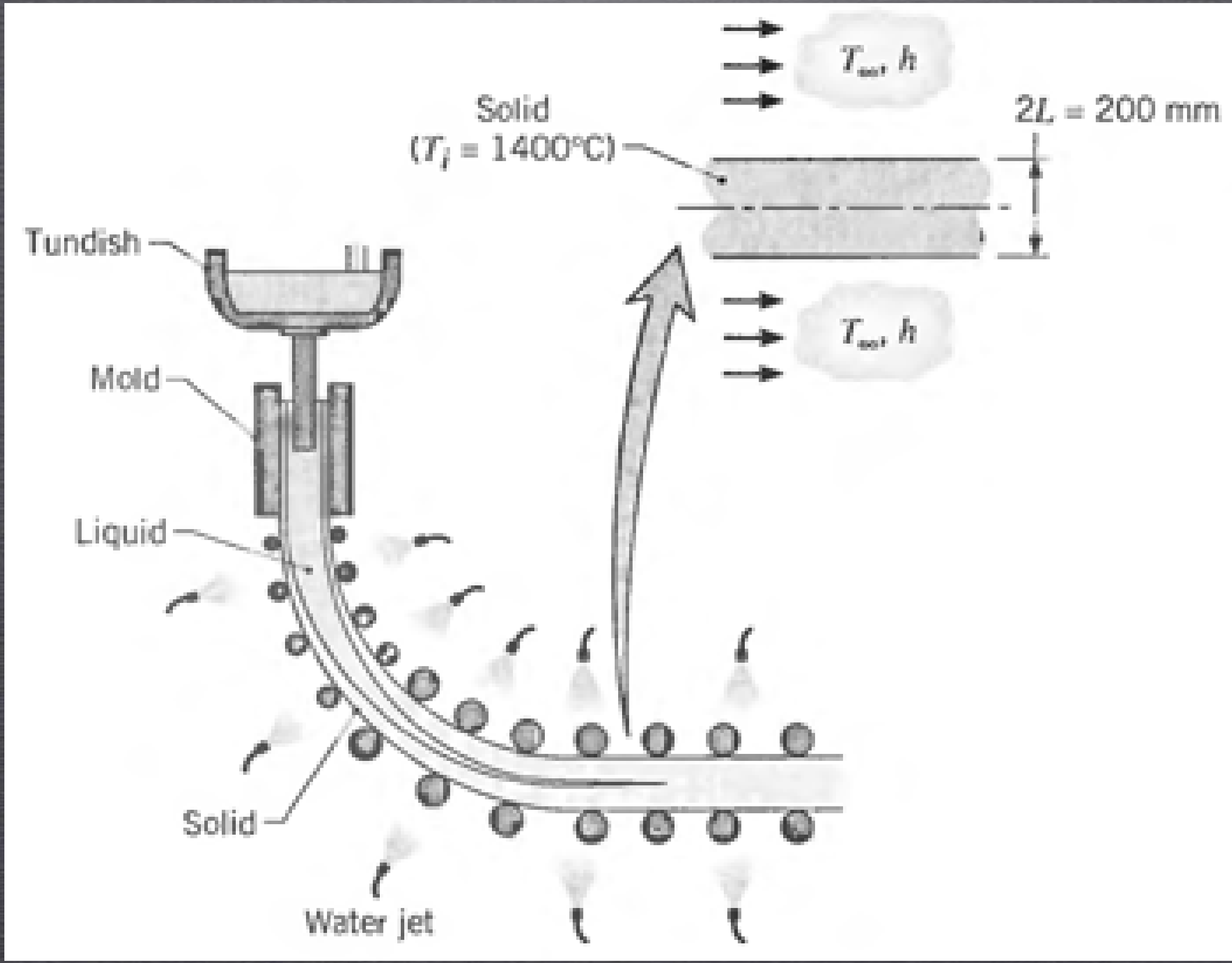
This investigation demonstrated the presence of hydrogen in the steel in sufficient quantity to detrimentally affect the ductility and fracture toughness of the steel under slow and intermediate loading rates typical of bridge service. Therefore, these plates cannot be recommended for use in the bridge.

Structural Steel Testing – Additional Testing

Structural Steel Testing



Structural Steel Testing



Structural Steel Testing

Structural Steel Testing

While there is some evidence that the **replacement plates contain minor hydrogen flaking** it is to a much lesser extent than what was observed on the original order. We can say with certainty that Phase Array UT testing, the most sophisticated method available, did not detect any indications that would have been "recordable" by ASTM A578 UT standard, let alone rejectable. Neither ASTM A709 nor AASHTO addresses the need for hydrogen control for Grade 50 NFCM plate, and control of hydrogen is specified only for the HPS grades. If hydrogen flaking is of concern to the end user, there are remedies above and beyond ASTM A709 that can be specified, such as vacuum degassing.

January 4, 2011

PDM Bridge
2800 Melby Street
Eau Claire, WI 54702

Nucor-Hertford County has reviewed Dr. Barsom's report of December 24, 2010 with a synopsis as follows:

1) No issues noted with the 5/8" and 3/4" web replacement plates.

2) All tensile and charpy test results for 2 1/2" material passed ASTM A709-10, Grade 50T2 NFCM, when tested at the ASTM specified location of quarter thickness.

3) Results of tensile tests from the centerline of the plate, a **non-standard test location**, indicated some elongation results below 19%. It appears that Dr. Barsom is assuming that the centerline tests should also be 19% minimum; however, ASTM does not address this.

There is a fundamental difference in the test results for the replacement plates in that all tensiles passed at the ASTM specified location, whereas some of the original order tensile tests were below minimum (See Table 1). Dr. Barsom previously identified that the low tensile results on the original order were the result of hydrogen flaking. Therefore, Nucor implemented additional practices for the replacement plates to be certain that hydrogen levels were sufficiently reduced to avoid low physical results. The steps outlined in our letter of November 2, 2010 have been successful in that respect. Briefly, the practice changes were as follows:

- Double De-oxidation
- Max casting speed, 50ipm (previously 54ipm)
- Hood cool slabs
- Stack cool plates
- Protect exposed ends of plates
- UT ends of plates for 24" with Phase Array in lieu of straight beam

While there is some evidence that the replacement plates contain minor hydrogen flaking it is to a much lesser extent than what was observed on the original order. We can say with certainty that Phase Array UT testing, the most sophisticated method available, did not detect any indications that would have been "recordable" by ASTM A578 UT standard, let alone rejectable. Neither ASTM A709 nor AASHTO addresses the need for hydrogen control for Grade 50 NFCM plate, and control of hydrogen is specified only for the HPS grades. If hydrogen flaking is of concern to the end user, there are remedies above and beyond ASTM A709 that can be specified, such as vacuum degassing.

Results of tensile tests from the centerline of the plate**, a non-standard test location**, indicated some elongation results below 19%. It appears that Dr. Barsom is assuming that the centerline tests should also be 19% minimum; however, ASTM does not address this.

Nucor implemented additional practices for the replacement plates to be certain that hydrogen levels were sufficiently reduced to avoid low physical results. The steps outlined in our letter of November 2, 2010 have been successful in that respect. Briefly, the practice changes were as follows:

- Double De-oxidation
- Max casting speed, 50ipm (previously 54ipm)
- Hood cool slabs
- Stack cool plates
- Protect exposed ends of plates
- UT ends of plates for 24" with Phase Array in lieu of straight beam

Structural Steel Testing

It is quite evident from the photographs, that the amount of hydrogen flaking was reduced to the extent that sufficient ductility was obtained to meet ASTM standards. In addition, no dendritic nodules are present at the quarter point. It is our firm belief **that we have provided the replacement plates in accordance with the requirements of ASTM A507-10** Grade 50 T2 NFCM as ordered.

The vast number of SEM photographs in this current report and Mr. Barsom's previous report of October 14, 2010 are from the non-standard mid-thickness region. However, there are several photographs of quarter-point locations of various magnifications that indicate the improvements made in the replacement plates. Table 2 comprises SEM photographs from both reports, retaining the original identification with similar or identical magnification. The first series of photographs are from replacement heat/slab 0507796-02 (Figures 8.a.1 through 8.a.3) and the second from rejected heat/slab 0503860-05 (Figures 5Q-1 through 5Q-c).

Figure 8.a.1 is the SEM photograph of the fractured face of the tensile at 15X and shows a small fish-eye just below a ductile dimple, which is the dark indentation on Figure 8.a.2. Figure 8.a.3 exhibits a small amount of quasi-cleavage at 500X.

The second series of photographs are from rejected plate 0503860-05 with Figure 5Q-a showing a rather large fish-eye at the 10 o'clock position. Figure 5Q-b at 100X reveals a large amount of quasi-cleavage and Figure 5Q-c indicates the presence of dendritic nodules.

It is quite evident from the photographs, that the amount of hydrogen flaking was reduced to the extent that sufficient ductility was obtained to meet ASTM standards. In addition, no dendritic nodules are present at the quarter point. It is our firm belief that we have provided the replacement plates in accordance with the requirements of ASTM A507-10 Grade 50 T2 NFCM as ordered.

Sincerely,

T. A. Depretis
Product Metallurgist

Structural Steel Testing

Table 1-Tensile Test Results at Quarter Point

Replacement Plates

Heat/Slab	Test Location	Yield strength, ksi	Tensile strength, ksi	Elongation %
0507787-04	ASTM	60.5	79.9	30
0507787-03	ASTM	55.0	86.0	25
0507804-04	ASTM	57.4	86.6	23
0507804-03	ASTM	57.7	86.8	23
0507803-04	ASTM	53.3	84.0	26
0507803-03	ASTM	51.6	81.7	27
0507786-02	ASTM	53.0	83.4	24
ASTM Requirement, Minimum		50.0	65.0	19

Initial Order

Heat/Slab	Test Location	Yield strength, ksi	Tensile strength, ksi	Elongation %
0503860-02	ASTM	52.5	85.5	20
0503860-05	ASTM	54.0	86.0	15
0503885-XX	ASTM	42.0	78.0	32
0503886-08	ASTM	53.0	84.5	21
0503887-02	ASTM	52.5	83.5	13
ASTM Requirement, Minimum		50.0	65.0	19

Structural Steel Testing

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Steel Erection

Deck Forms, Reinforcement and Shear Studs

Deck Pour

Before

After

Bridge Health Monitoring System

Completed Bridge

Completed Bridge

Weights

Box Piles – 70,000 lbs each 1, 300,000 lbs total

Box Pile fill – 3,900,000 lbs(-2.7M lbs earth)

Pier Footing – 3,100,000 lbs

Caps & Columns – 1,400,000 lbs

Structural Steel – 3,500,000 lbs (2.2M lbs pier)

Deck Concrete – 4,600,000 lbs (2.9M lbs pier)

Total of 14.8M lbs on pier

Cost

Engineers Estimate = $15,575,335

Winning Bid Price = $11,606,520

Final cost = $11,675,636 (0.6% over bid price)

OHM CE contract 7% under budget with no amendments

Thank you!!

OHM
Advancing Communities℠

Craig Dashner, PE

Craig.dashner@ohm-advisors.com

734-522-6711