



MDOT RC-1618A

**Research on Evaluation and
Standardization of Accelerated Bridge
Construction Techniques**

Appendices

SEPTEMBER 2015

Part-II



Department of Civil & Construction Engineering
College of Engineering and Applied Sciences
Western Michigan University

RESEARCH

Research on Evaluation and Standardization of Accelerated Bridge Construction Techniques

Appendices (Report 2013-2015)

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Submitted to:



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APPENDIX F

**SLIDE PROJECTS' FIELD VISITS
DOCUMENTATION**

US-131 over 3 Mile Rd

Slide bridge field visit documentation (US-131 over 3 Mile Rd) [05/30/2014]

- Permanent substructure components
[Met Mike Roberts from MDOT at the site]
 - (i) As-built details is different from the plans. When sliding a bridge over to an existing abutment, make sure to survey the existing abutment before starting the design to minimize design revisions.

- Temporary substructure components
[Met Mike Roberts from MDOT at the site]
 - (i) Temporary substructure for the northbound bridge slide has two lines of H-piles at each support. Angled piles are driven about 30 ft into the ground. Vertical piles are driven about 70 ft into the ground. Each H-pile is 40 ft long. Hence, splicing is required to make 70 ft. Temporary piles located 25 ft from foundation will be removed after sliding.

- Sliding operation related equipments and mechanisms
[Met Mike Roberts from MDOT at the site]
 - (i) In this project, only the superstructure is replaced. Further, the existing abutments have spread footings. Sliding rail columns are supported on the existing spread footing.
 - (ii) Widening of the existing footing is required to support sliding railing columns. Widening is also required to prevent abutment movement/rotation (tipping) once the existing superstructure is removed as well as during bridge slide since the slide path is supported on the existing foundation.

- Changes at the Job Site compared to planned

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Abdul Wahed Mohammed, and Lizmert

Date: 06/24/2014

- Permanent substructure components

Abutment wall, wing walls, footing (images: NBbr_AbutB_&SliderBeam01 to 11)

- Temporary substructure components

8 H-piles, 4 angled piles (NB br Abut-A & NB br Abut-B)

Slider rail, temporary I-beams that support slider rail and are installed on top of the footing (images: Temp-I-bm_suprt_SldrBm01 to 04)

During this visit the SB br Abut-A and SB br Abut-B temporary structure piles were being welded with the sliding bearing pad. Installation of the temporary structure piles for other abutments were completed.

- Sliding operation related equipments and mechanisms

Equipments on site (images: Equip-on-Site01 to 29)

- Changes at the Job Site compared to planned
Is it on schedule? (Ask for updated schedule)

Yes, on schedule

Any changes to the details? Reason?

Yes, the temporary I beams that support slider rail were now decided to be rotated 90deg and installed. This change was made to allow the workers reach over and install bolts for connecting the temporary I beams to the footing.

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Abdul Wahed Mohammed, Tim, and Lizmert

Date: 07/11/2014

MDOT personnel: Mike Roberts

What is the updated schedule?

NB Br Sliding will be performed during second week of August. August 8 is planned full bridge closure.

What are the dates of Demolition?

The demolition is planned during the second week of August (same week as the slide).

Demolition of 3-4 girders of the bridge will be performed before the allowed 5-day full closure, to reduce number of activities during the full closure.

Temporary substructure components (changes)

- The change proposed about changing the orientation of support columns was rejected because of weak axis bending. Thus, the contractor got few workers (thin) who can access the bolts behind the support columns.
- A small spread footing is planned to be added at the SB Br_AbutA and SB Br_AbutB. This is to support the temporary structure beam when the slider rails are not in place at the SB Br.
- The temporary structure piles are moved 1/8 feet inside (i.e., towards the center line of 3-Mile Rd) on both sides, because the final survey identified the abutments' faces to be uneven (wavy) instead of flat.
- The slider rails underneath the bridge are planned to be reused from NB Br to SB Br. This was not in the plan. On the SB Br the slider rails may have difficulty to be placed because the support columns will be already in place; whereas, on the NB Br, the slider rails and support columns were assembled first and then placed on the footing.
- On the temporary structure (NB Br), there will be no factor of safety for the bearing capacity when the new bridge is constructed on them. It is expected that the temporary piles may exceed their bearing capacity because of moment induced halfway in the slide operation. The following 3 options are proposed to prevent this:
 1. Drive the piles more deep to get more capacity
 2. Construct the barrier wall after the slide (but may raise traffic safety concern)
 3. Place a temporary barrier wall on the new bridge and move it during the slide to spread the load.

Sliding operation related equipments and mechanisms

- Equipments on site (images: Equip-Added-01 to 11)
- The sliding pads made of Neoprene/Teflon had a concern that they may be sliding along with the bridge during the sliding operation. Thus, Stopper Pads were installed on the slider rail every 18 in.

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Abdul Wahed Mohammed

Date: 08/01/2014

MDOT personnel: Tom Fox

What is the updated schedule?

August 03: 8 in. thick cast-in-place deck casting

August 08: Bridge closure and demolition of NB Bridge.

August 10 night or August 11 morning: Bridge Slide-In of NB Bridge. It is estimated to be 4 to 6 hour slide operation at the rate of 10 ft/hr.

Temporary Substructure Components:

Temporary structure pin connection [Dr. Upul Images]

Sliding pads and stoppers [Dr. Upul Images]

Four jacks are used at each bridge. Two of the jacks are reserve jacks for backing-off. All jacks are for pulling only.

Changes at the Job Site compared to planned

[Refer images: SB Br Abut-B_UnderBr&Temp_1 to SB Br Abut-B_UnderBr&Temp_7]

During the previous field visit, the site personnel provided information about the SB Bridge that the slider rail was planned to be built on temporary support piles and the slider rail underneath the bridge would be reused from the NB Bridge. However, during this visit it was identified that the plan is changed; the slider rail is now decided to be built underneath the bridge and the slider rail on temporary support piles would be reused from the NB Bridge. This change has caused delay in constructing the new SB Bridge on the temporary supports.

[Refer images: SB Br Abut-B_PINconn-Loc_1 to SB Br Abut-B_PINconn-Loc_3]

Previously it was decided that two temporary footings would be built under the pin-connection location of slider rail. This was to support the slider rail on temporary piles while the pin connection is incomplete and new bridge being built. However, they changed the plan because the slider rail is neither being built on temporary piles, nor it is supporting the new bridge. The new plan is to connect the slider rails under the bridge and on the temporary support using the pin-connection, then construct the new bridge. The pin-connection slider rail portion is planned to be supported by two temporary supports while sliding the bridge.

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Dr. Upul Attanayake

Date: 08/01/2014

MDOT personnel: Tom Fox (616-813-9176) Grand Rapids TSC, Lead Transportation Tech.

What is the updated schedule?

Expecting to move northbound bridge on August 10 or 11

Expected to finish sliding within 4 to 6 hours.

Expected speed is 10 ft/hr.

Going to add two temporary columns underneath the connecting beam *between* temporary structures.

Temporary Substructure:

The images in "US-131_over_3MileRd" folder show the following:

- Slide beam connect * - During superstructure construction on temporary supports, the sliding beam is connected to the temporary support columns. For that, a threaded sleeve was welded to the slide beam first and, then, a threaded rod and nuts were used.
- Slide Rail Pin Connection * - Slide rails on the temporary piles and existing abutment footings are connected using a H-section with a pin connection at each end. Expectation is to eliminate movement transfer during bridge move (due to bridge superstructure self-weight). However, due to some considerations on potential differential settlement, it was decided to add two temporary columns.
- Extended pile as temp support * - Two lines of piles were driven to build the temporary structure to support new bridge superstructure. Two sets of holes are drilled at top to connect slide rail and slide beam.
- Column-abutment footing connection * - Show temporary column and abutment spread footing connection.
- Neoprene -PTFE-Stainless Steel Slide shoe * - show the sliding stainless steel shoe sitting on a neoprene pad with a Teflon layer. At the each end of the neoprene pad a steel tube is welded to prevent the bearing pad movement during sliding. The space between two bearings will be filled with additional neoprene bearings with Teflon surfaces. See the pictures "Neoprene with Teflon."

Note: "General View" picture folder in "US-131_over_3MileRd" folder contains pictures showing the general site condition.

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Abdul Wahed Mohammed

Date: 08/08/2014

MDOT personnel: Mike Roberts

What is the updated schedule?

August 09: At 7 AM demolish half bridge (US-131 traffic open);

At 3 PM demolish remaining bridge (US-131 traffic closed)

August 10: Full Slide at 12 PM (noon)

Test Slide:

Documented separately.

Jacking Operation and Monitoring:

Documented separately.

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Abdul Wahed Mohammed

Date: 08/09/2014

MDOT personnel: Mike Roberts

What is the updated schedule?

August 09: At 7 AM closed 1-lane of US-131 NB to demolish only the wing walls
At 3:10 PM closed US-131 NB completely (2-lanes) to start demolition

Slide bridge field visit documentation

Site: US-131 over 3 Mile Rd

Name: Abdul Wahed Mohammed

Date: 08/10/2014

MDOT personnel: Mike Roberts

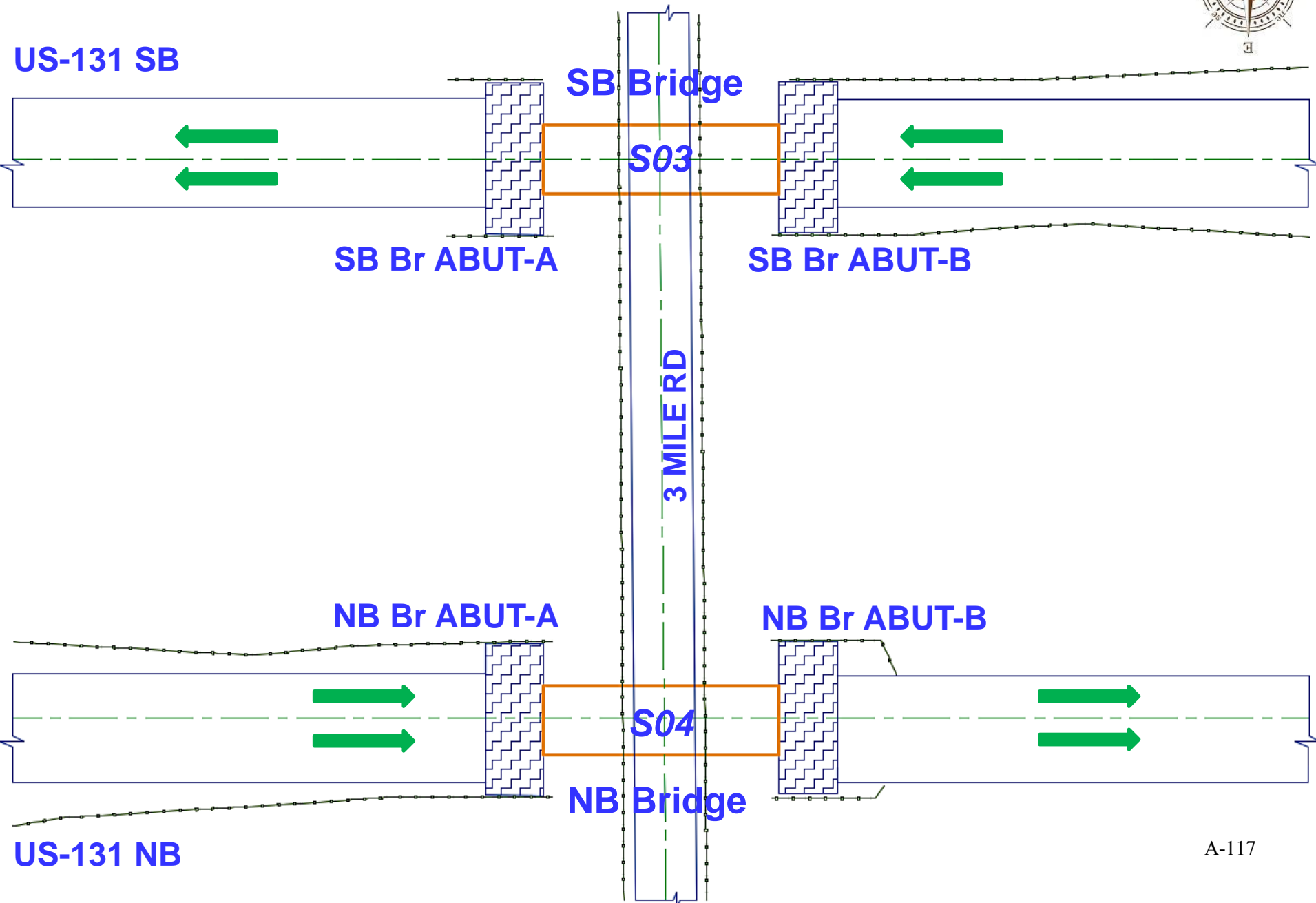
What is the updated schedule?

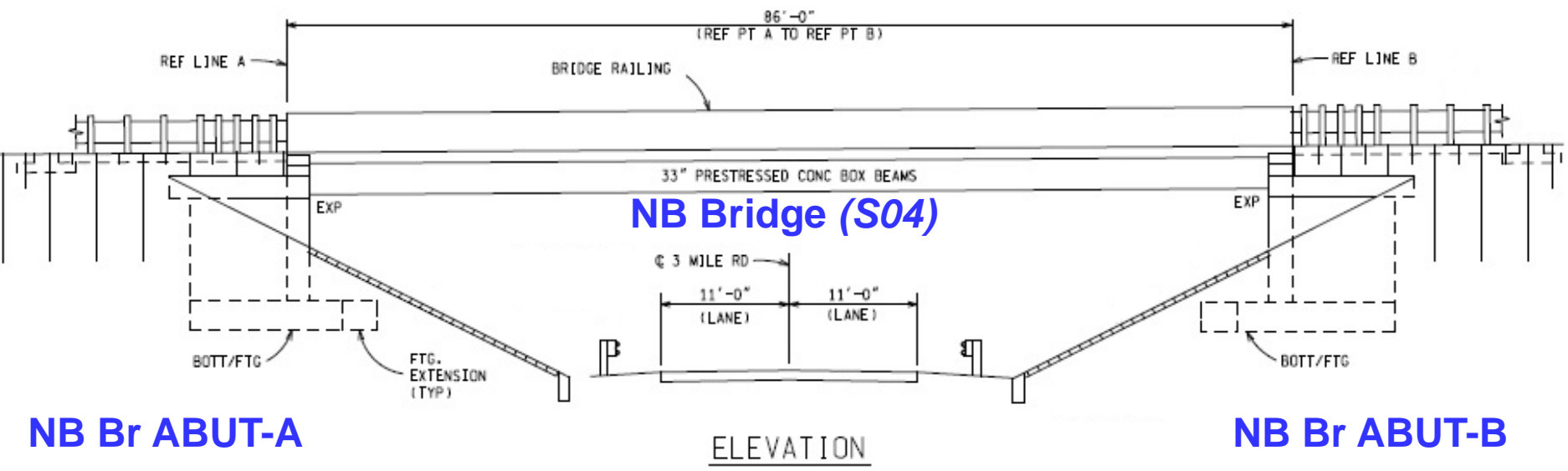
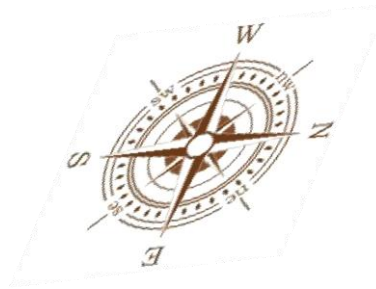
August 09: The demolition ended at 10 PM (Saturday) and the cleaning of debris was completed at 3:30 AM (Sunday, August 10).

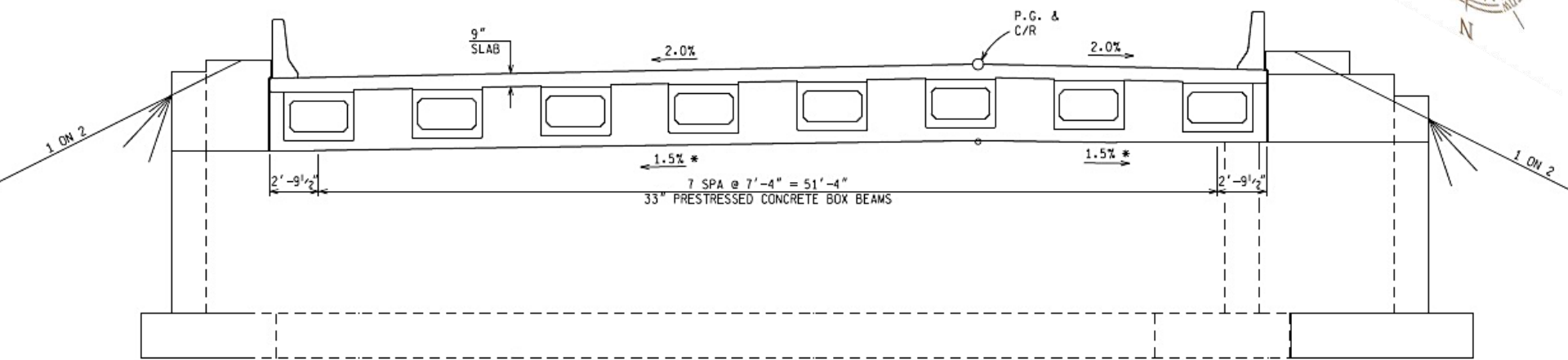
August 10: At 12:45 PM the slide operation started. The slide operation is planned to be stopped in the evening when the 2nd (from W) sliding shoe passes the transition zone.

August 11: The slide operation is planned to be resumed at 7 AM and be completed by evening.

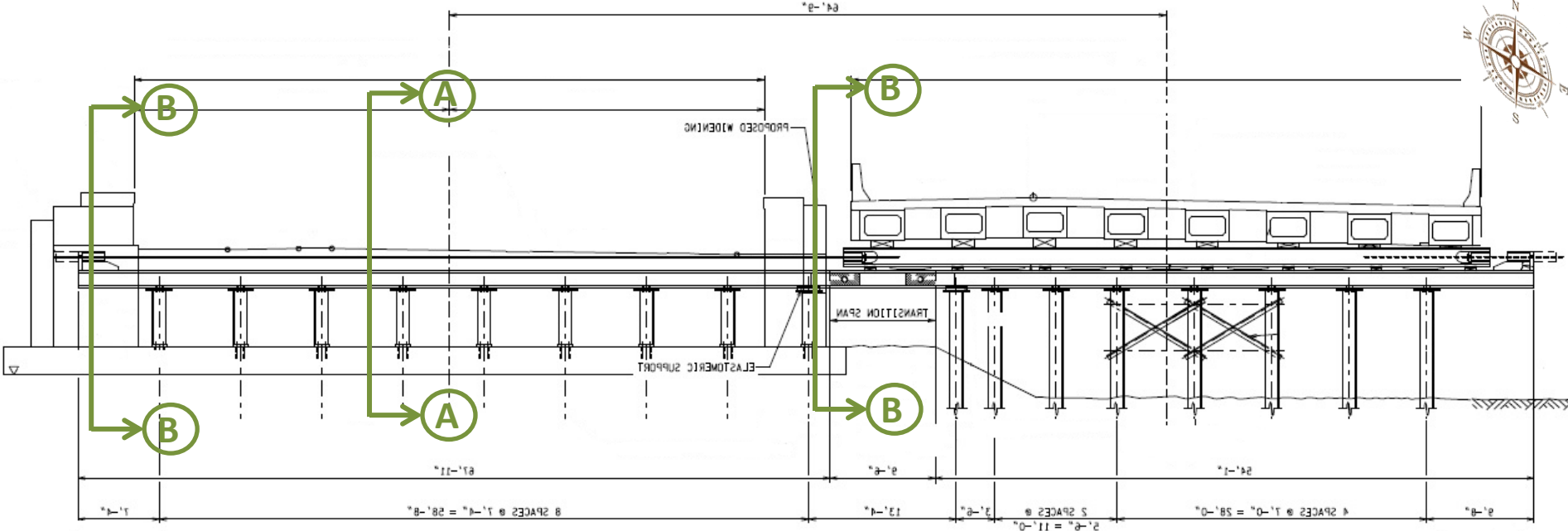
August 12: The permanent bearings will be installed and the NB bridge is planned to be jacked up around 12 PM to remove the temporary wooden blocks and rest the bridge on permanent bearings.







NB Br ABUT-A
(ELEVATION) (Looking South)

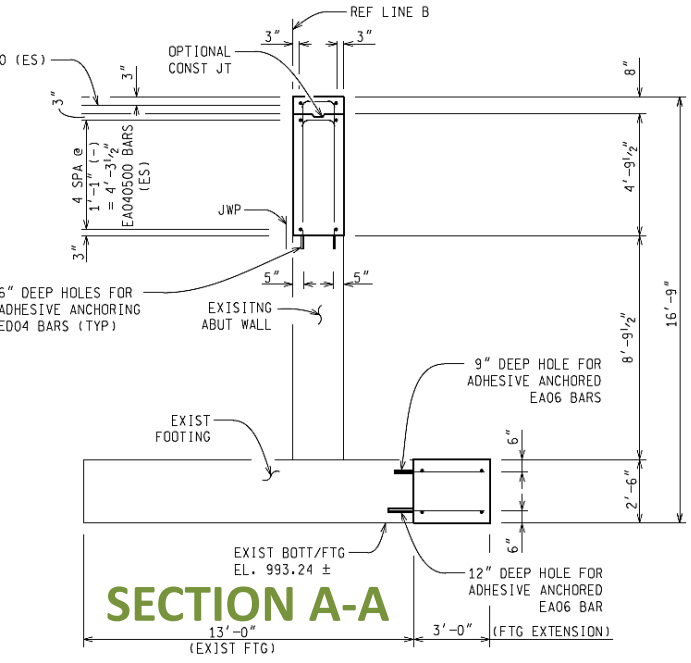


EXISTING ABUTMENT WITH PROPOSED WIDENING

NB Br ABUT-B

(ELEVATION) (Looking North)

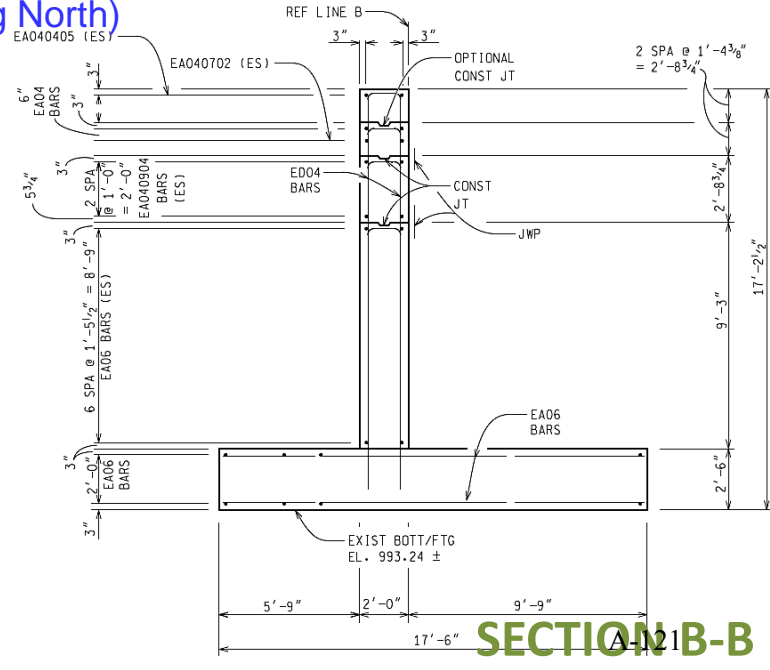
TEMPORARY ABUTMENT



SECTION A-A

SECTION THRU EXIST ABUTMENT B

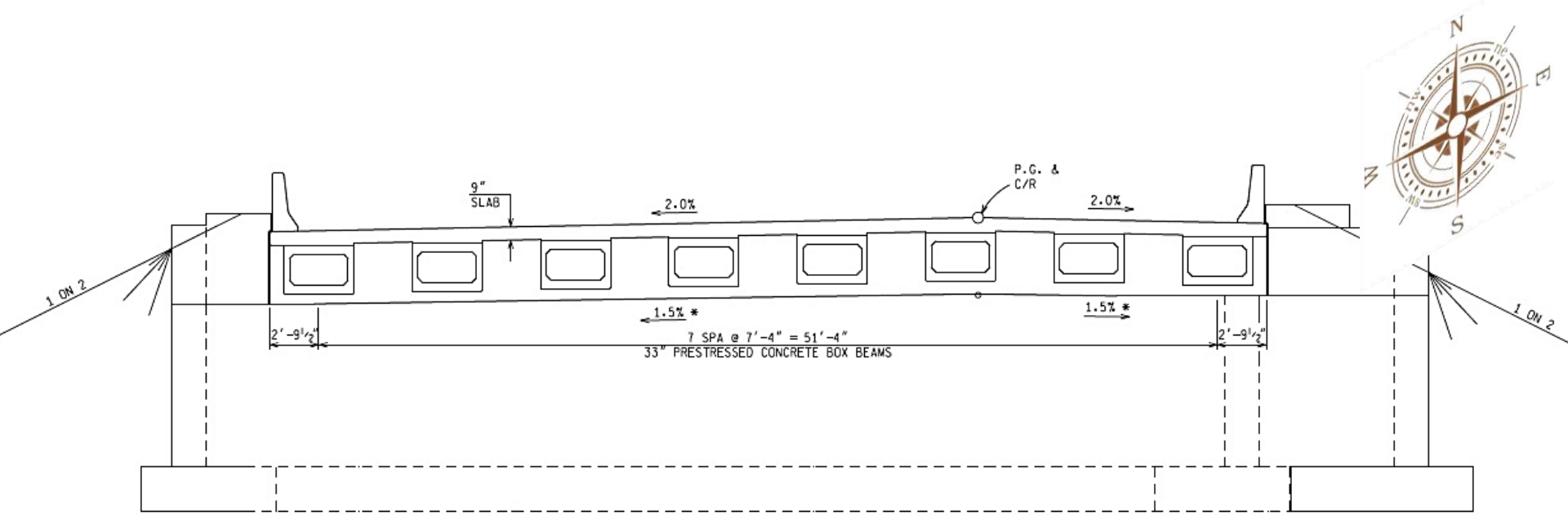
NORTHWEST QUAD



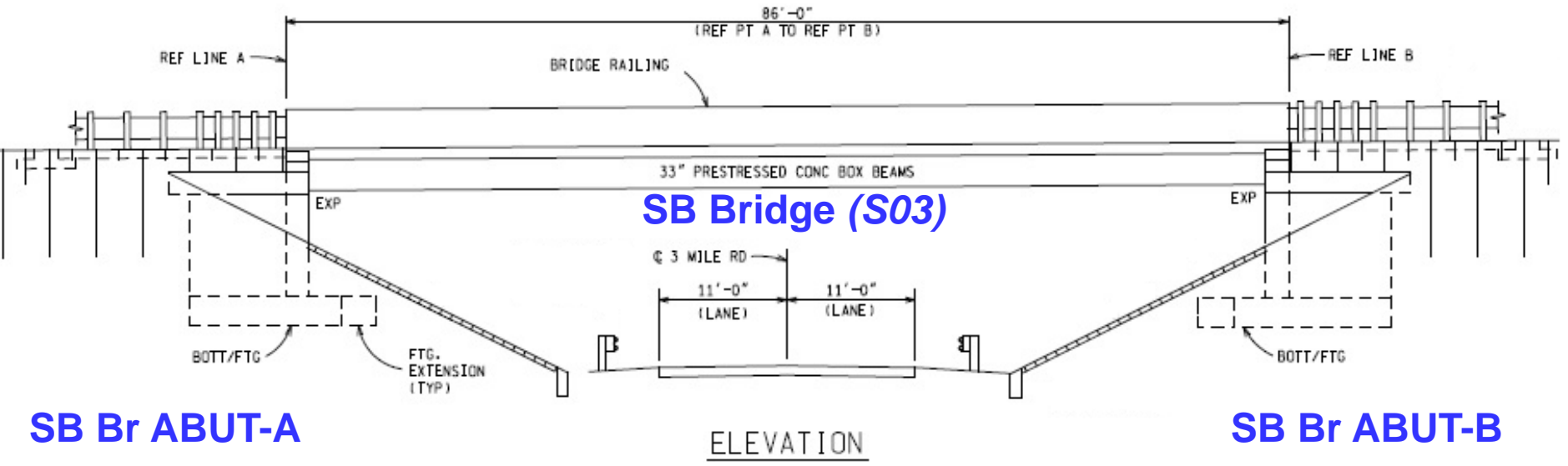
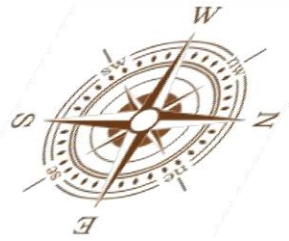
SECTION B-B

SECTION THRU ABUTMENT B WIDENING

NORTHEAST QUAD



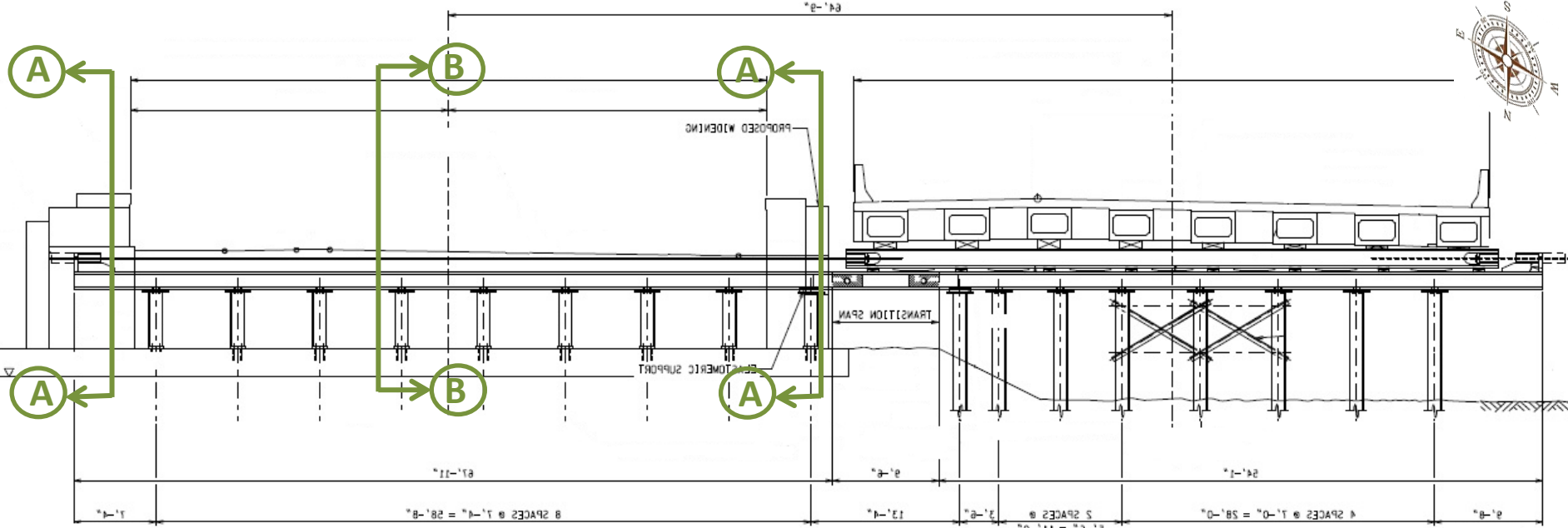
NB Br ABUT-B
 (ELEVATION) (Looking North)



SB Br ABUT-A

SB Br ABUT-B

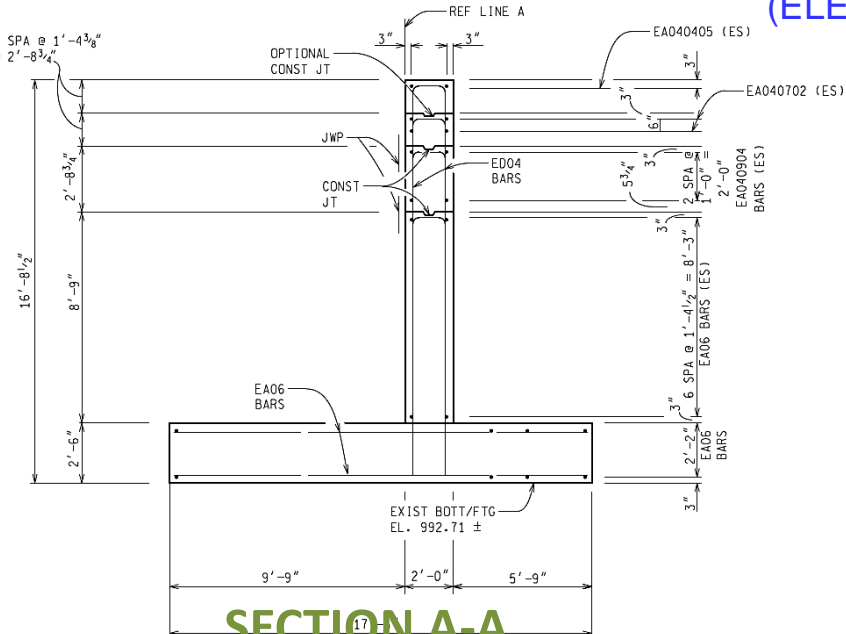
ELEVATION



EXISTING ABUTMENT WITH PROPOSED WIDENING

SB Br ABUT-A (ELEVATION) (Looking South)

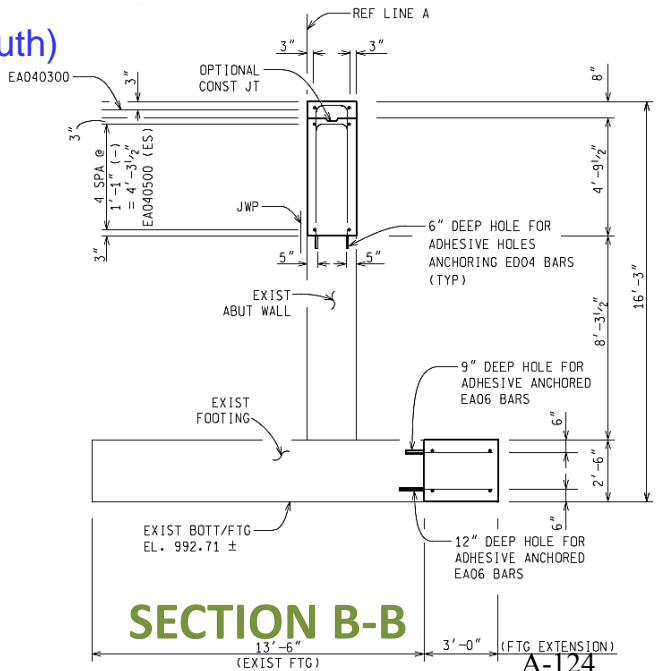
TEMPORARY ABUTMENT



SECTION A-A

SECTION THRU ABUTMENT A WIDENING

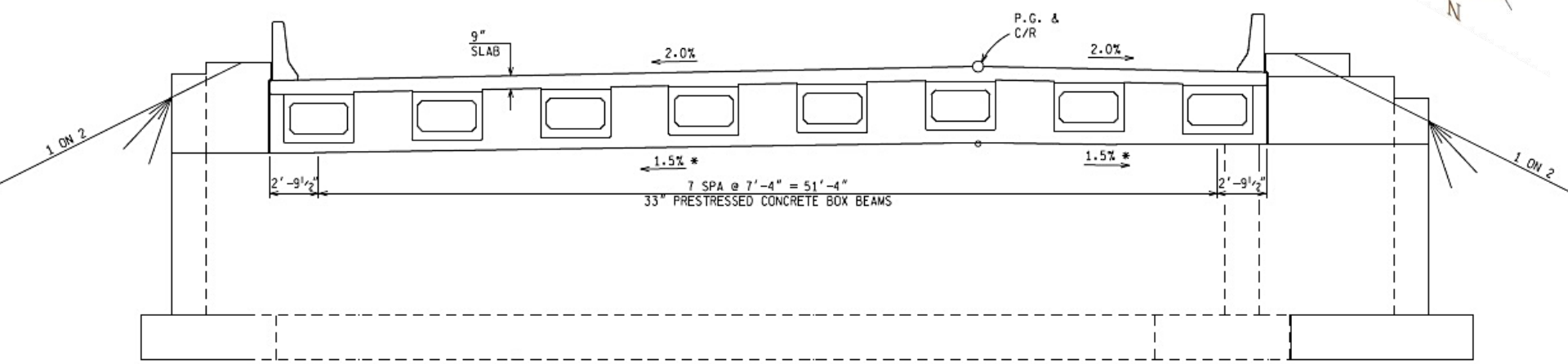
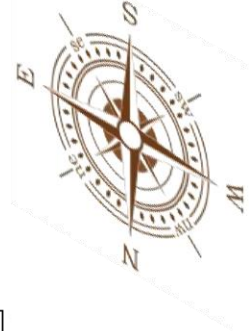
SOUTHEAST QUAD



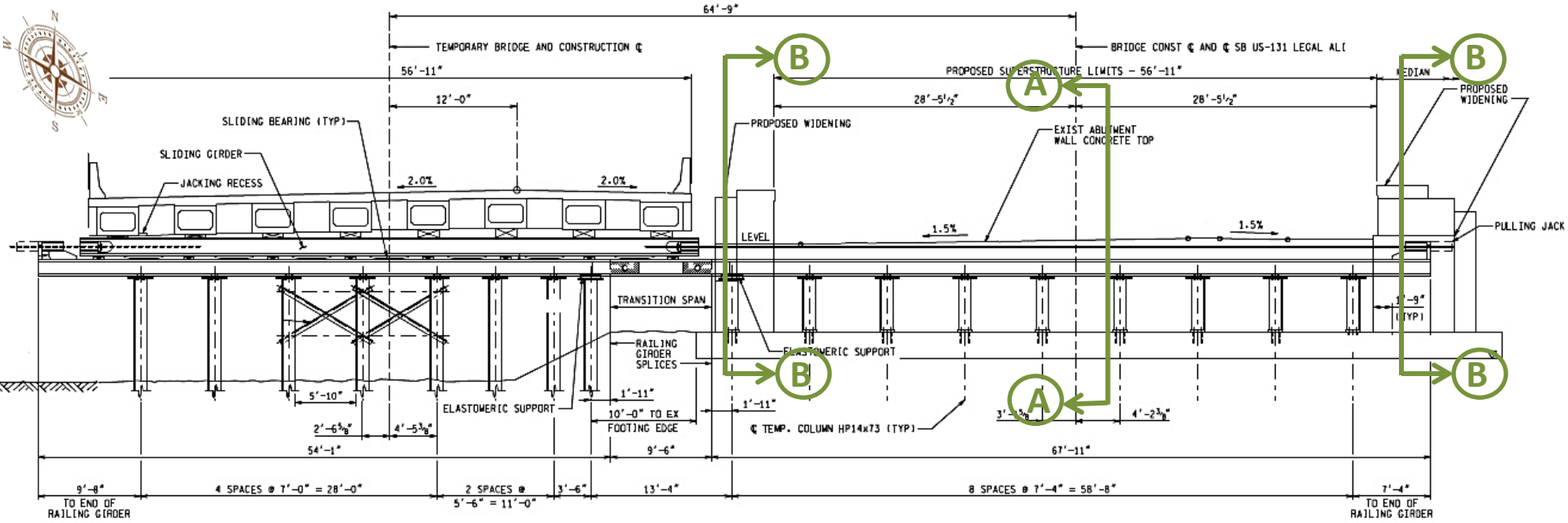
SECTION B-B

SECTION THRU EXIST ABUTMENT A

SOUTHWEST QUAD



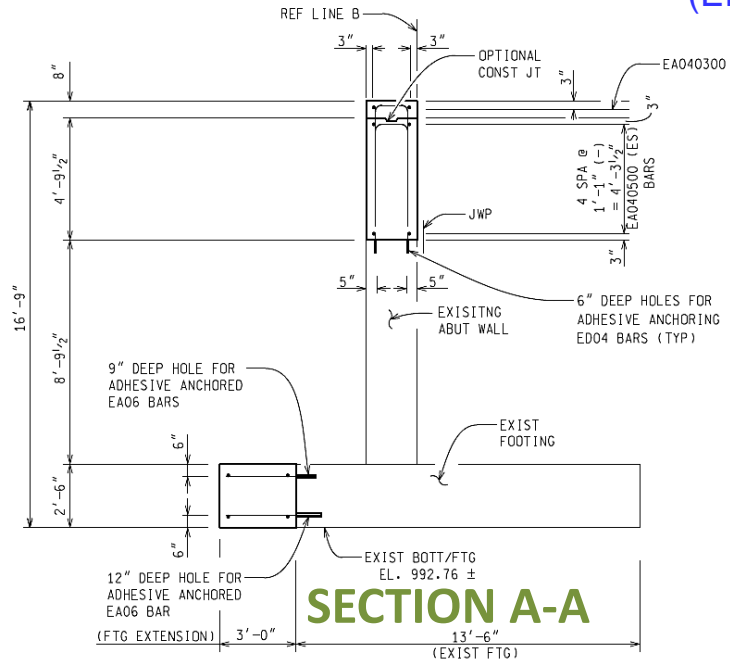
SB Br ABUT-A
(ELEVATION) (Looking South)



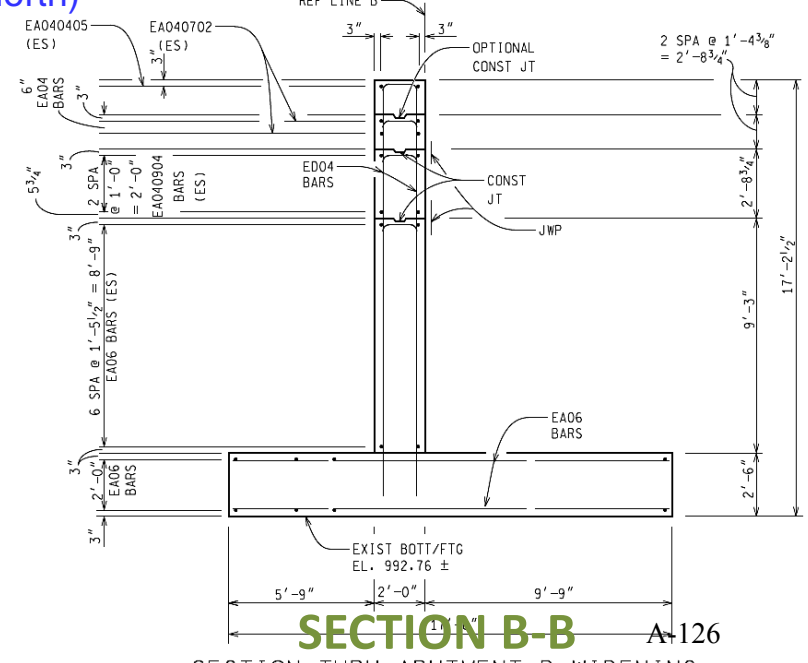
TEMPORARY ABUTMENT

EXISTING ABUTMENT WITH PROPOSED WIDENING

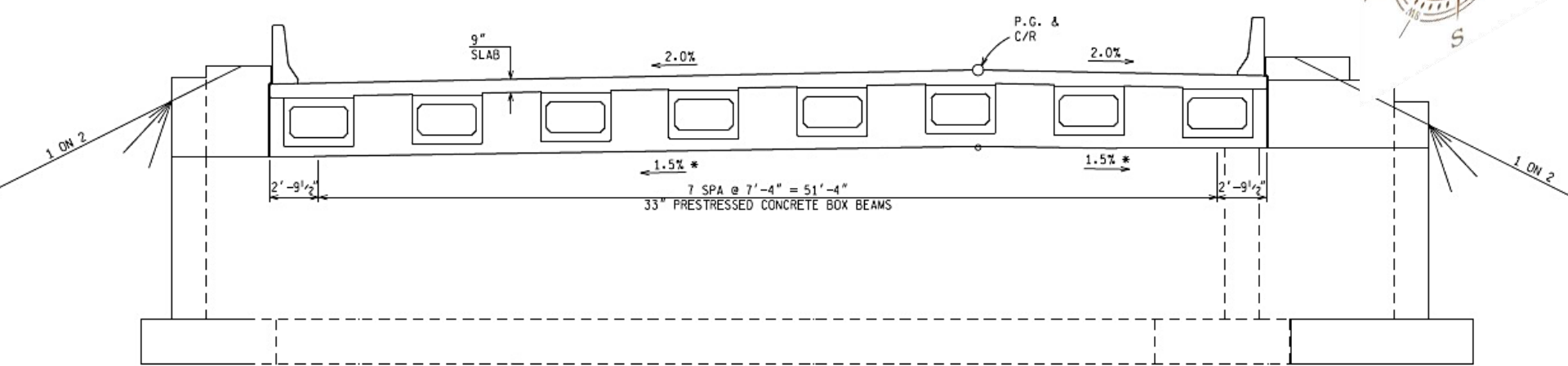
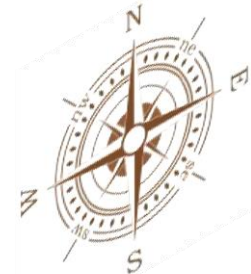
SB Br ABUT-B
(ELEVATION) (Looking North)



SECTION THRU EXIST ABUTMENT B



SECTION THRU ABUTMENT B WIDENING



SB Br ABUT-B
(ELEVATION) (Looking North)

M-50 over I-96

Slide bridge field visit documentation

Site: M-50 over I-96

Name: Abdul Wahed Mohammed

Date: 06/24/2014

- Temporary substructure components

Abut-A (images: 0025 to 0027)

Abut-A EB (east bound) span construction (images: 0028 to 0050)

Abut-B WB (west bound) span construction (images: 0051 to 0061)

- Sliding operation related equipments and mechanisms

Equipments on site (images: 0001 to 0024)

- Changes at the Job Site compared to planned

During this field visit the construction work was not in progress and there were no personnel on site.

Slide bridge field visit documentation

Site: M-50 over I-96

Name: Abdul Wahed Mohammed, Tim, and Lizmert

Date: 07/11/2014

MDOT personnel: Brent

The workers on the site were preparing formwork for the new deck

What is the updated schedule?

Beams were placed 1-week late of schedule.

What are the dates of Demolition?

In 3-4 weeks

Any changes to details?

Work orders changed. The end bent caps planned to be steel-I beams were now decided to be concrete end abutments.

Check the distance between the piles (for approach slab) and the abutment. [Plan shows a distance of 20ft to 25ft]

The measured distance on the site is 25 ft c/c.

On Temporary Pier-1 jacks are installed on one side (EB span side), What is the reason for this?

- a. Was it the camber requirement for the new bridge?
- b. Was it the underclearance requirement for I-96?
- c. Was it the tipping possibility of the bent cap because only one span is loaded with girders?

The underclearance requirement was 17 ft minimum for I-96 during the construction.

The jacks were installed/used because the diaphragms in Pier-1 were not aligned. In addition, only one span (EB span) was loaded with girders and the other span (WB span) was not loaded with girders; the jacks helped preventing rotation/tipping of the bent cap.

Were the jacks on the Temporary Pier-1 (EB span side) installed before placing the girders or after placing the girders?

- a. Was there any sequence in the jacking operation?

The jacks on Pier-1 were installed before placing the girders.

The jacks were installed in 4-step operation, each step of $\frac{1}{8}$ in. increment.

The jacks caused the bent cap to be $\frac{1}{2}$ in. out of level.

The jacks were removed after placing the other span (WB span).

Slide bridge field visit documentation

Site: M-50 over I-96

Name: Abdul Wahed Mohammed

Date: 08/01/2014

MDOT personnel:

What is the updated schedule?

Sliding in September, after Labor Day weekend; may be in the last week of September.

What are the dates of demolition?

August 01 evening to August 03

Scheduling:

It was a very busy schedule. Welding the piles and driving until the required bearing was achieved, were the most time consuming operations.

Maintenance of Traffic (MOT):

For demolition, I-96 was closed for 2 days. The I-96 traffic was rerouted through the exit and entrance ramps. M-50 traffic was detoured around the corner.

Workforce management:

The construction process is performed in the day times only. These workers do not work on weekends or night. However, the demolition work is performed on the weekend 24 hrs a day.

Permanent Substructure Components:

The spread footing is 4 ft wide, 9 ft deep, and as long as the width of the bridge.

While casting the deck, the concrete was poured in the middle and then moved towards the end. This was to allow rotation on the abutments and/or allow expansion towards the abutments.

Temporary Substructure Components:

The precast approach slabs for the temporary runaround are temporary. After the bridge is slid, these slabs will be replaced with permanent approach slabs.

The test pile borings were 90 ft only. They did not have data below the 90 ft depth. The contractor had to keep on driving the piles (way beyond 90 ft) until they obtained a bearing layer of at least 1 ft depth.

Any changes to details?

Usually piles ordered for temporary structure are 50 ft long. To reduce welding operation because of lack of certified welders, 60 ft long piles were ordered. The piles were tested using Ultrasonic testing technique on-site, to ensure the steel is uniform and no flaws in the material.

Sliding operation:

The complete bridge is planned to be *pushed* in 1½ hr operation as estimated by Mammoet.

Changes at the Job Site compared to planned:

A contingency plan was added, wherein the precast approach slabs on the temporary runaround have the option to be lifted (vertically rotated in place) from the new bridge and hold until the bridge is slid into place. This was to ensure that if something goes wrong during the slide operation, the slide operation can be halted and M-50 traffic can be reopened by placing the precast approach slabs that will be on hold.

Slide bridge field visit documentation

Site: M-50 over I-96

Name: Dr. Upul Attanayake

Date: 08/01/2014

MDOT personnel: Brent Goodwin, Consultant site inspector

What is the updated schedule?

Every construction activity is happening as planned.
Bridge construction is 2 weeks ahead of the schedule.

Permanent Substructure:

Pier will be supported on a spread footing. The bottom of the footing will be located about 9 ft below the existing surface of the median. Need to check the plans to get the actual depth.

Temporary Substructure:

Plans and soil borings indicated a strong soil layer about 80 ft below. Production pile capacity is 500 kips. Test pile load was 550 kips (10% more than the production capacity). Test piles are used to identify existence of false bottoms. During this project, test piles were driven about 80 ft and then continued to check false bottom. When a pile was driven about a foot into the designated strong layer, a soft layer was encountered. Hence, it was required to drive about 120 ft deep pile to achieve the capacity.

With the experiences gained by driving piles for the temporary structure, it is not sure, at this time, the depth of permanent abutment piles.

Note: "General View" picture folder in "M-50_over_I-96" folder contains pictures showing the general site condition, cleaning the deck of temporary detour on the new superstructure for lane marking, and other construction activities.

The images in "M-50_over_I-96" folder show the following:

- Pinned Pier Cap * - When traffic is allowed on the new superstructure sitting on temporary supports as a detour while the existing bridge is demolished and new substructure is constructed, bridge stability was a concern because the bridge is not constrained for longitudinal movement. Specially, concern was on breaking loads of trucks. Hence, steel plates were welded to the slide beam to prevent any movement. This was achieved by welding at the end of pier caps as well along the length. There were some steel plates already embedded in concrete to support the sliding rail. Additional plates were welded to these plates and connected to slide beam. This allowed girder ends over the abutments to accommodate any movements due to thermal loads and construction loads. During deck casting, girder ends moved towards the abutments proving the expected behavior.

- Temp Approach * - M-50 traffic was detoured using the new superstructure. Each approach span was formed by transversely posttensioned deck panels. One of the panels was supported on an abutment while the other end was supported on a sleeper slab. Sleeper slab was supported on steel H-piles. Panels were connected to the abutment using soft dowels (i.e., dowels without grout). As part of the contingency plan the dowels were not grouted. The expectation was to lift the abutment end of the panels using a crane during bridge move. In case, if the move is not completed as planned due to an unexpected event, the approach slabs will be placed securely on the abutment allowing traffic movement through a temporary detour.

Slide bridge field visit documentation

Site: M-50 over I-96

Name: Abdul Wahed Mohammed

Date: 09/29/2014

MDOT personal: Karl Datema

- Permanent substructure components

Permanent pier cap and columns were casted and their forms were being removed. Permanent abutment caps and backwalls were also complete. Permanent MSE wall construction was also complete and the backfill was being compacted. The permanent approach preparation was underway.

A significant crack was observed in the pier diaphragm centerline. A hairline crack was also observed in the deck, directly above the pier diaphragm center line.

- Temporary substructure components

A temporary steel column is planned to be placed at the transition (from temporary to permanent) location for supporting the sliding superstructure.

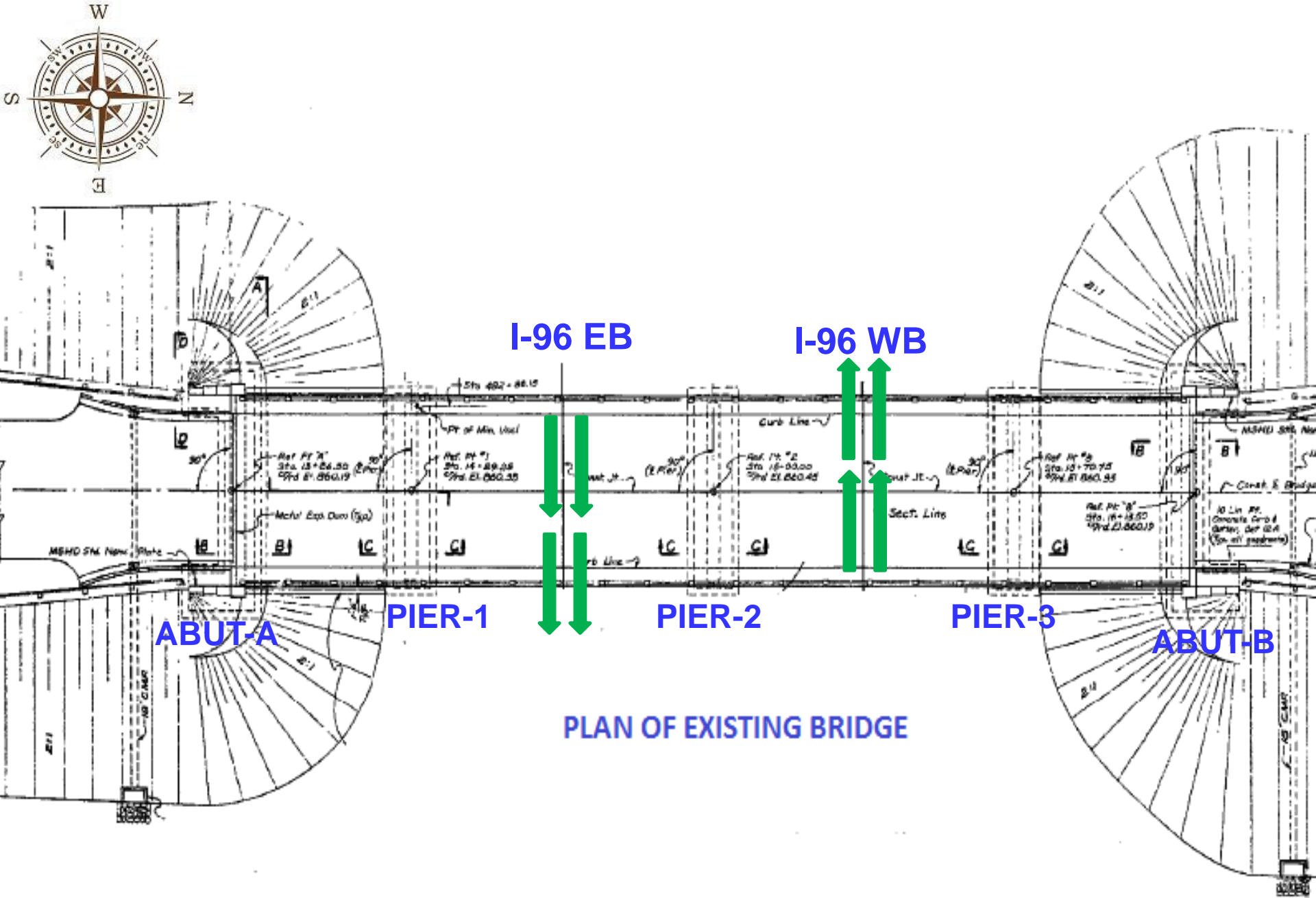
- Sliding operation related equipments and mechanisms

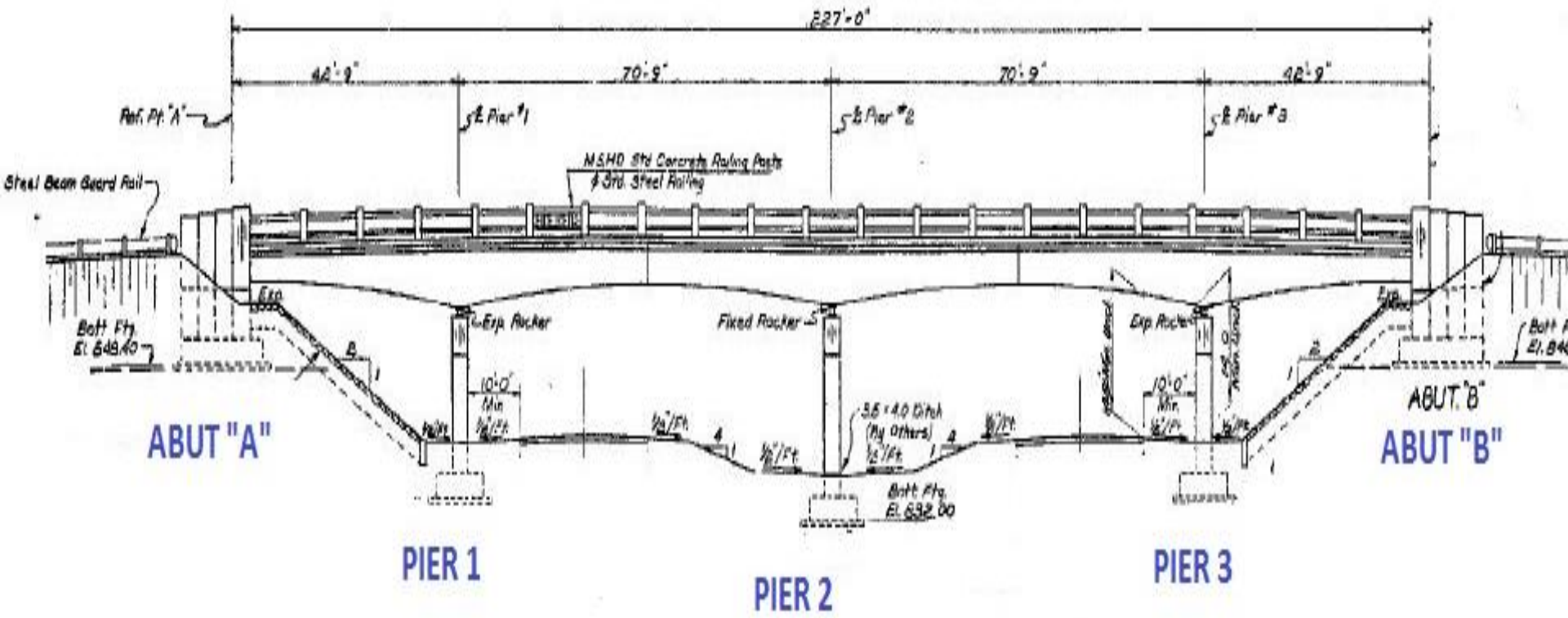
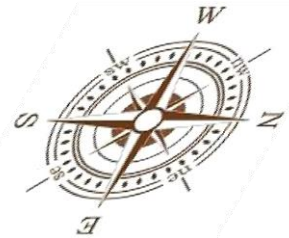
A groove is casted in the permanent pier cap for placing the permanent and temporary bearings, on which the sliding shoe will slide. Both temporary bearings and permanent bearings will have PTFE layer attached on them. The permanent bearing pads will stay as-it-is with the PTFE layer after the sliding operation. The temporary sliding bearings will be removed and the groove at those locations will be filled with grout.

- Future Plan

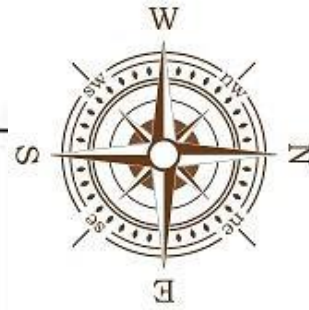
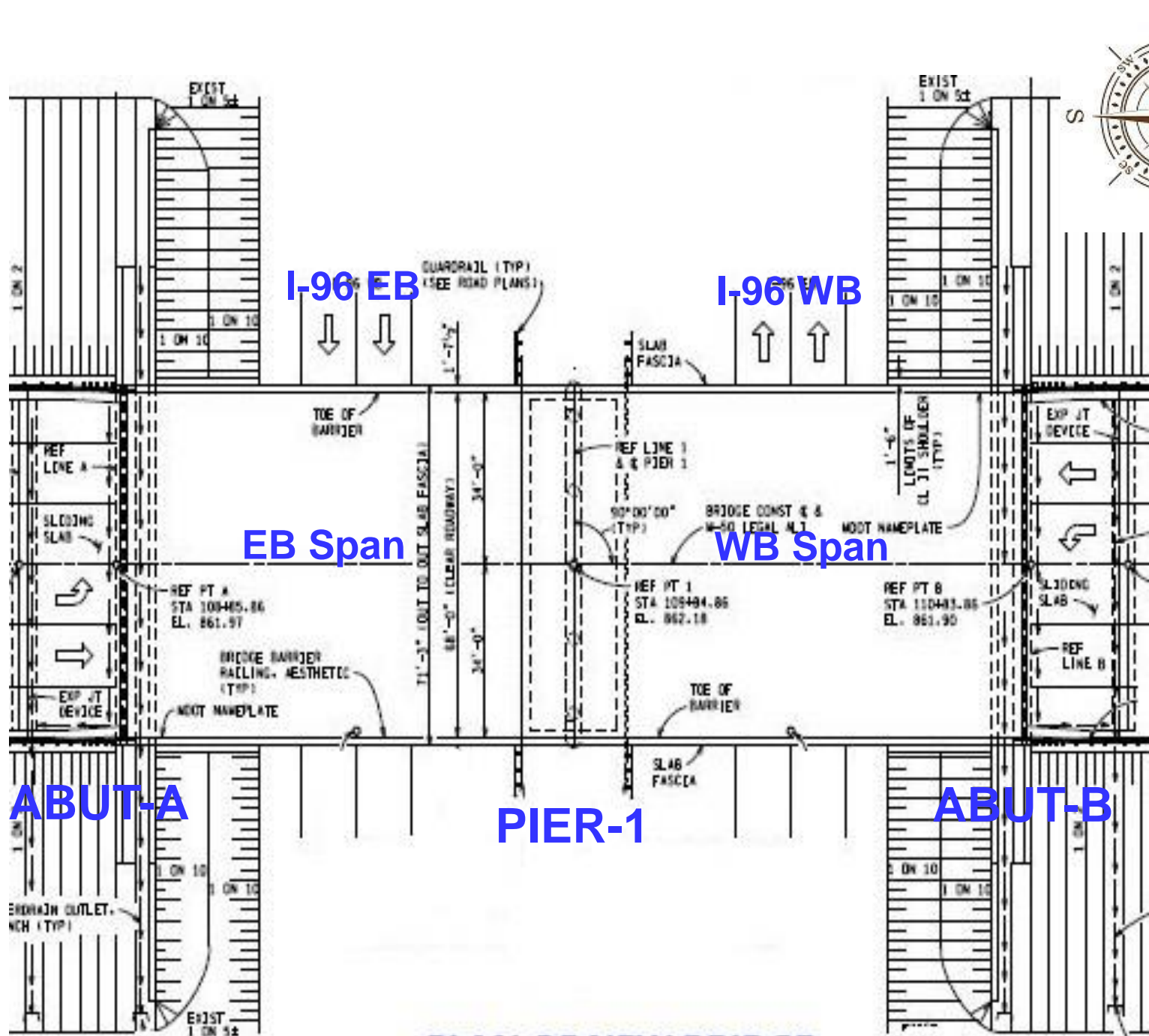
WMU team reviewed the site accessibility and decided to install metal plates on the 5 pier columns (diameter = 2'6") for mounting the laser-tracker sensors. One sensor is also planned to be mounted on temporary steel column at the transition. A total of 6 sensors are planned to be used for monitoring the vertical settlement of the pier during the sliding operation. Laser-tracker is planned to be placed within the right-of-way of EB I-96 on the South side.

Metal plates with a curvature of radius of 1'4" are planned to be fabricated. The size of the metal plates is decided as 10" × 8"

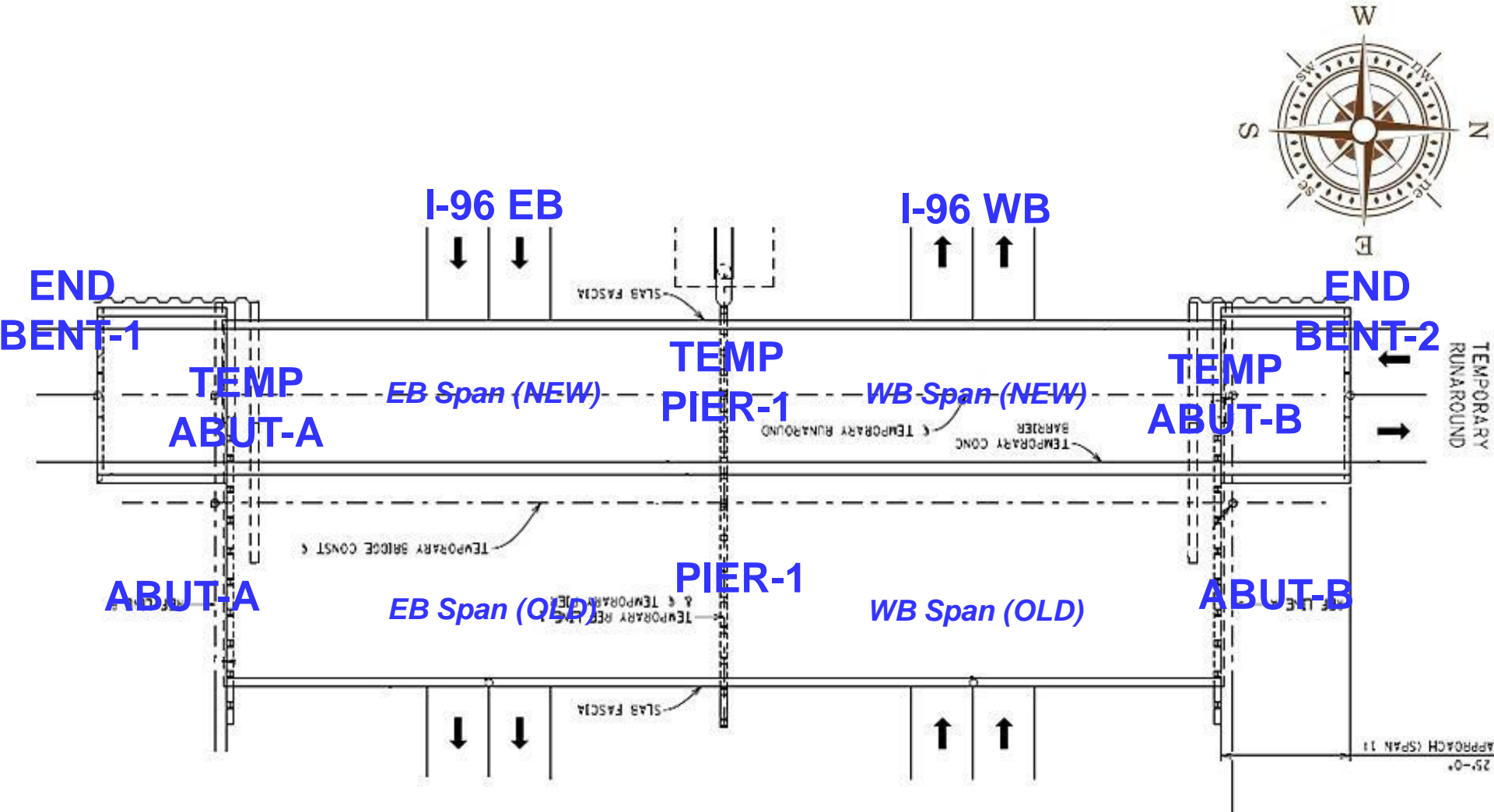




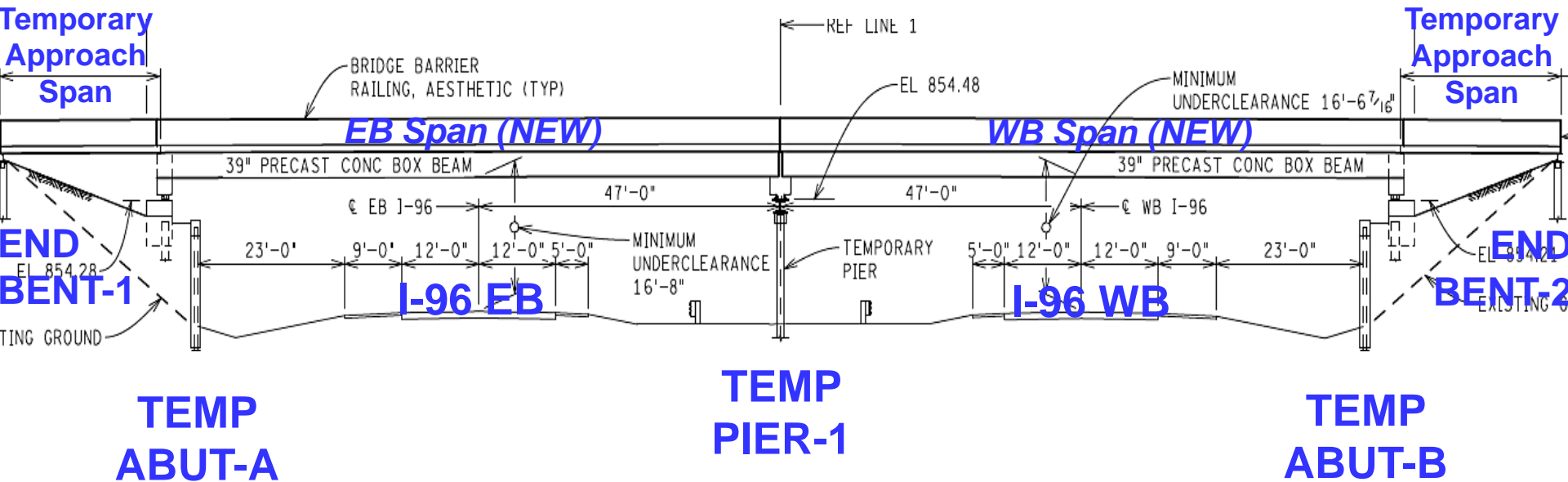
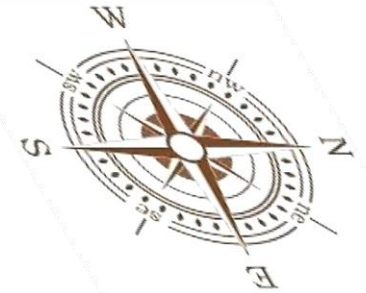
ELEVATION OF EXISTING BRIDGE



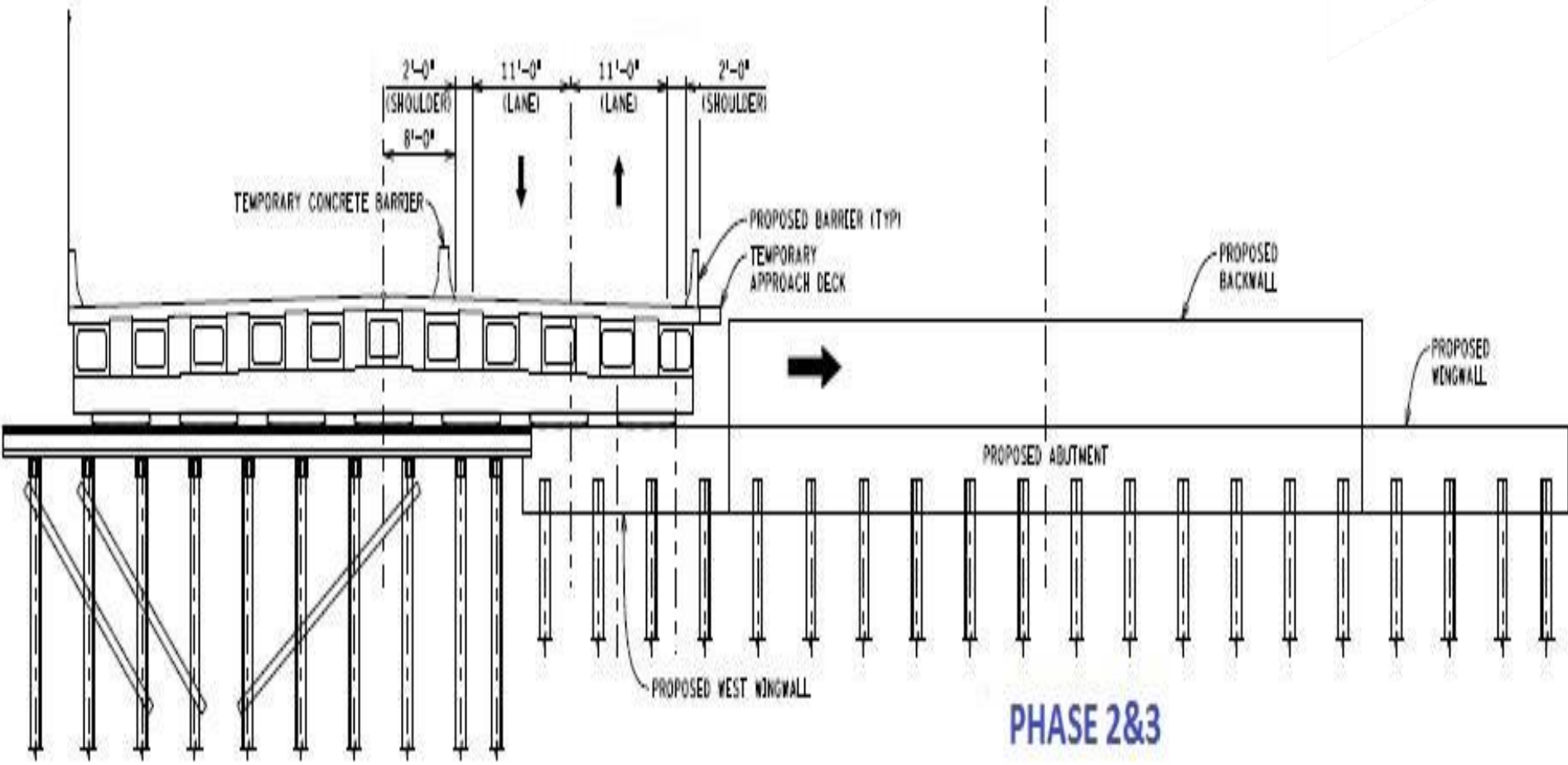
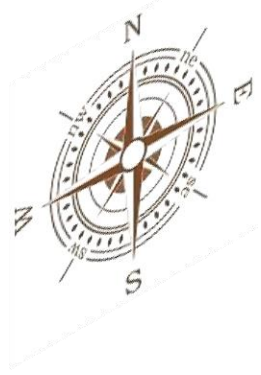
PLAN OF NEW BRIDGE



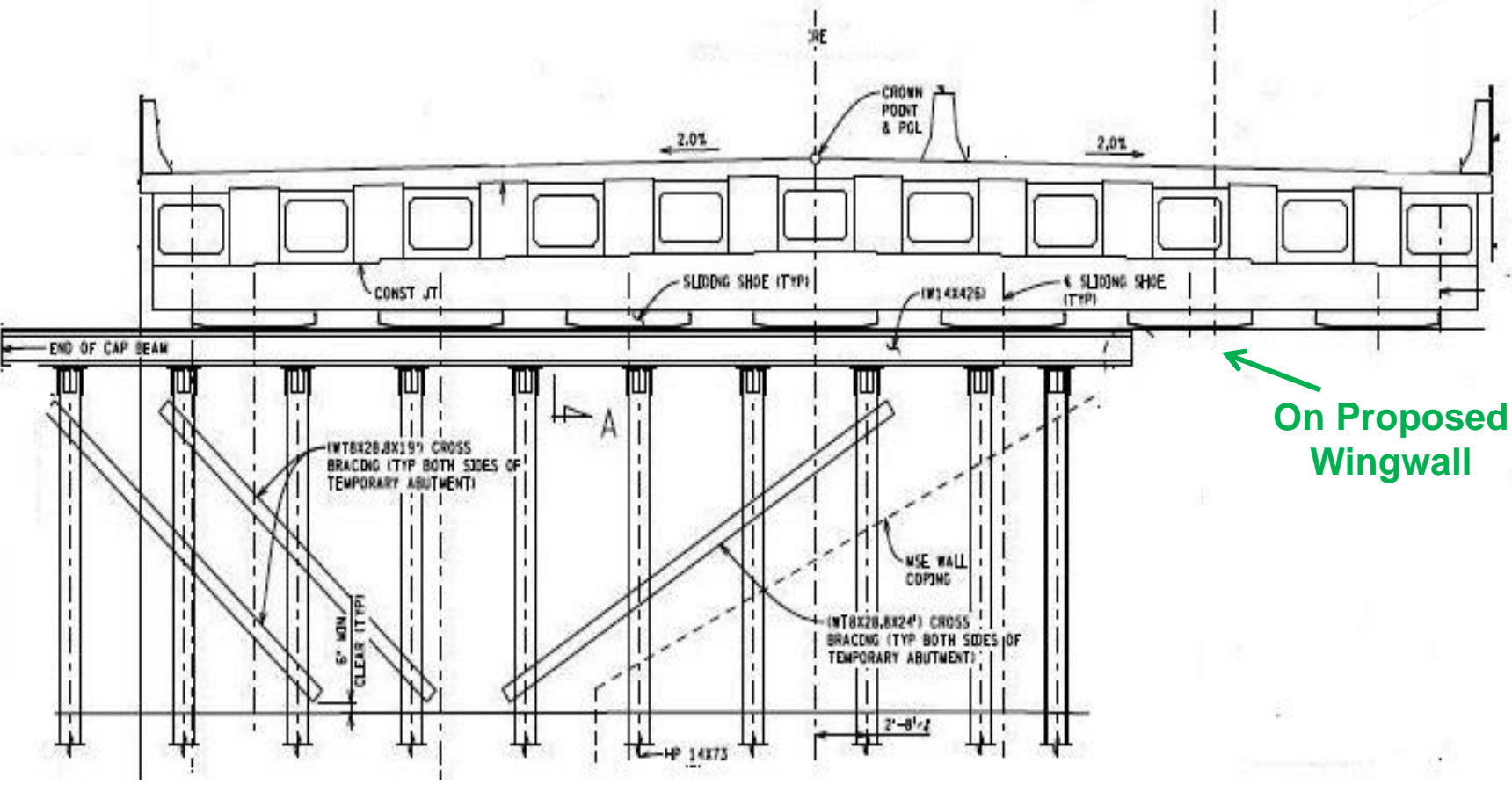
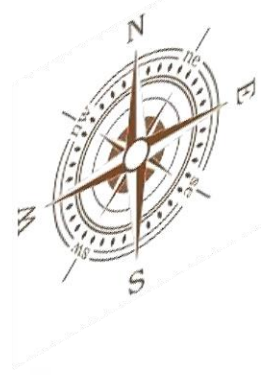
**PLAN
(TEMPORARY STRUCTURE & EXISTING STRUCTURE)**



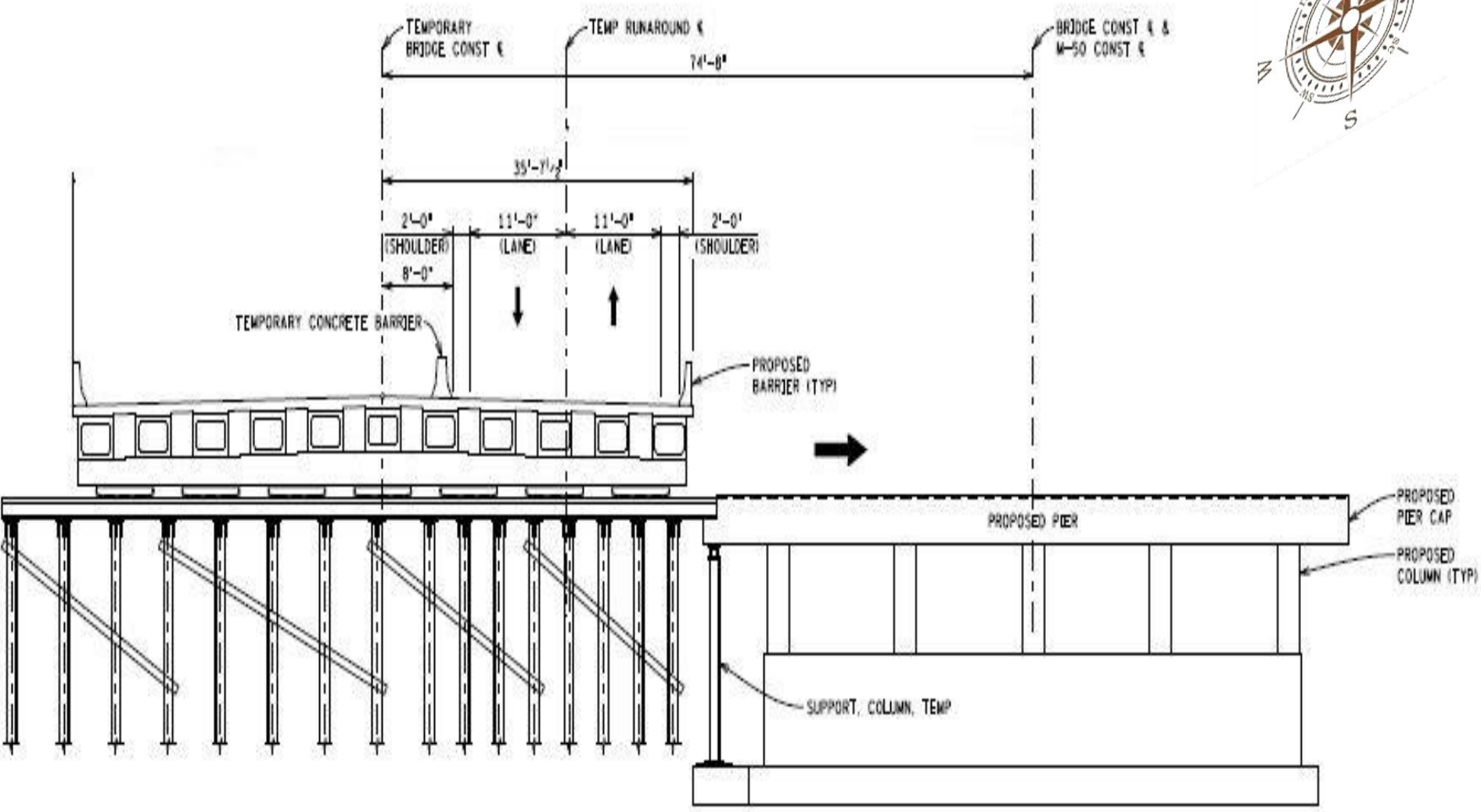
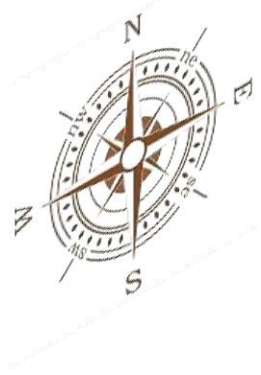
**ELEVATION
(TEMPORARY STRUCTURE) (Looking West)**



**Sliding at ABUT-B
(ELEVATION) (Looking North)**

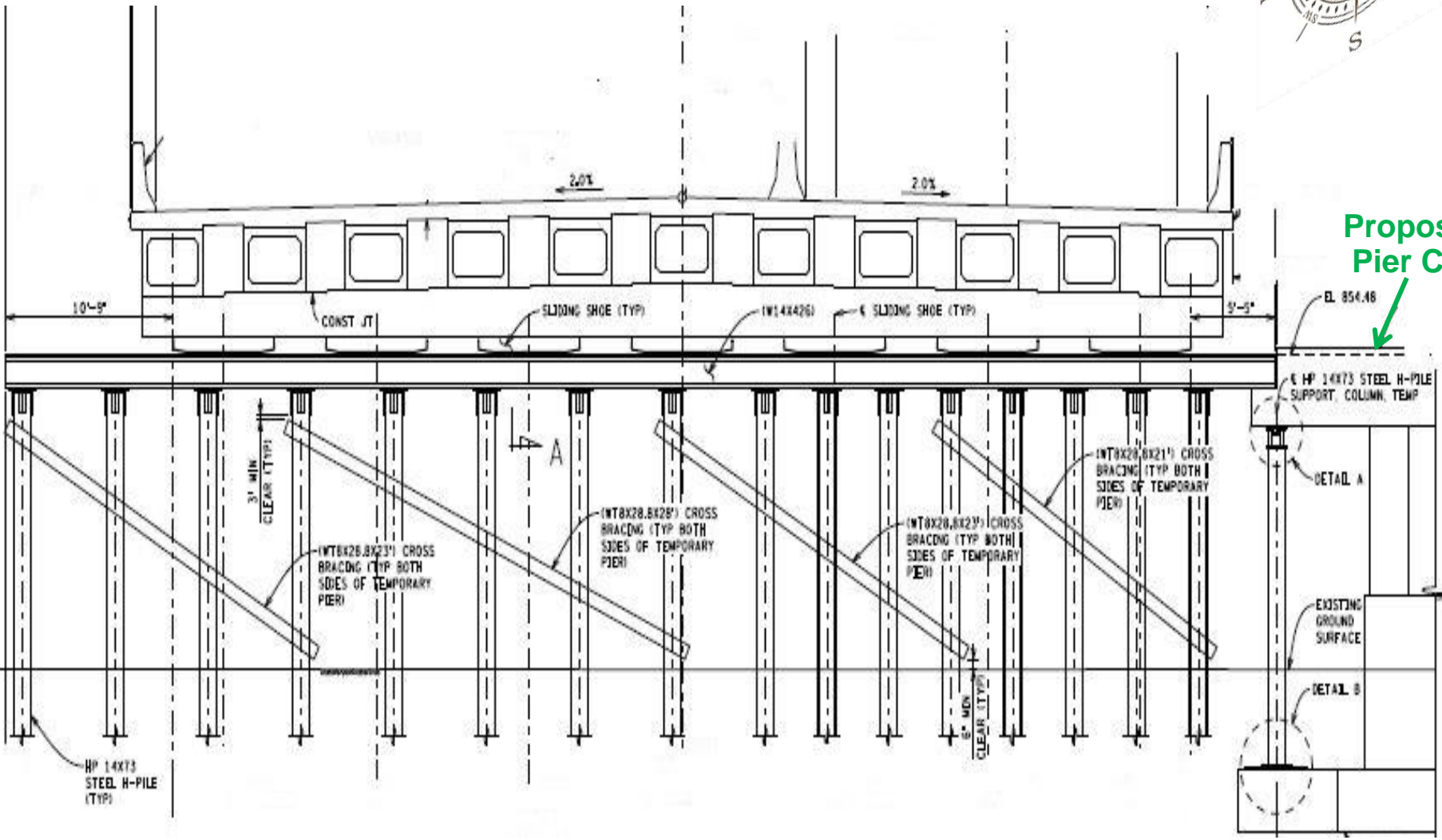
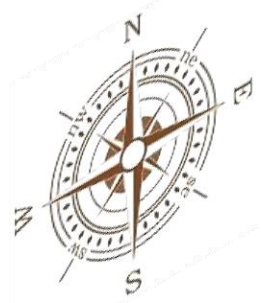


**TEMP ABUT-B
(ELEVATION) (Looking North)**



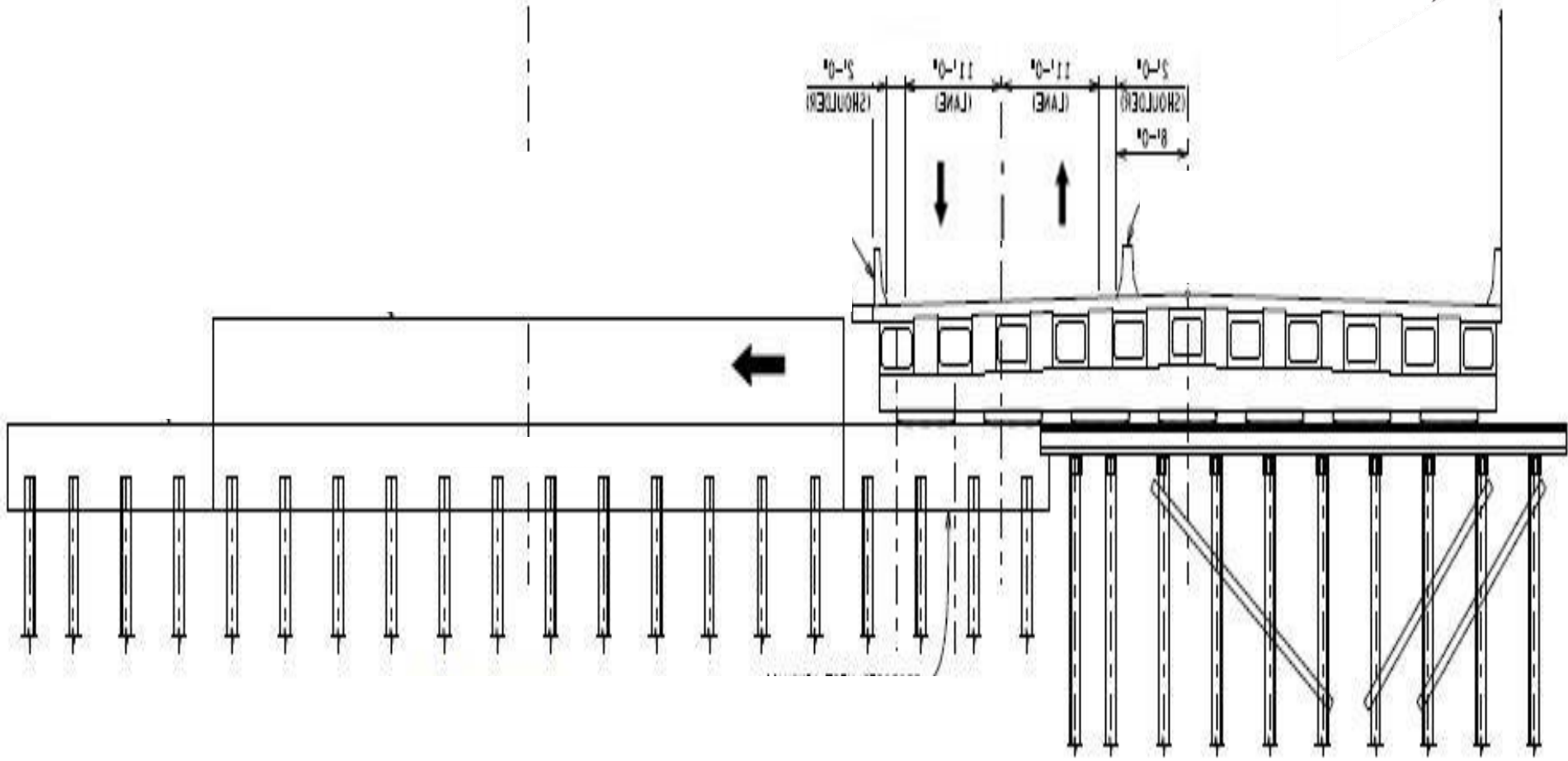
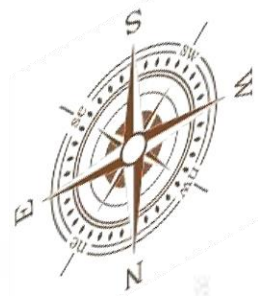
PHASE 2&3

**Sliding at PIER-1
(ELEVATION) (Looking North)**

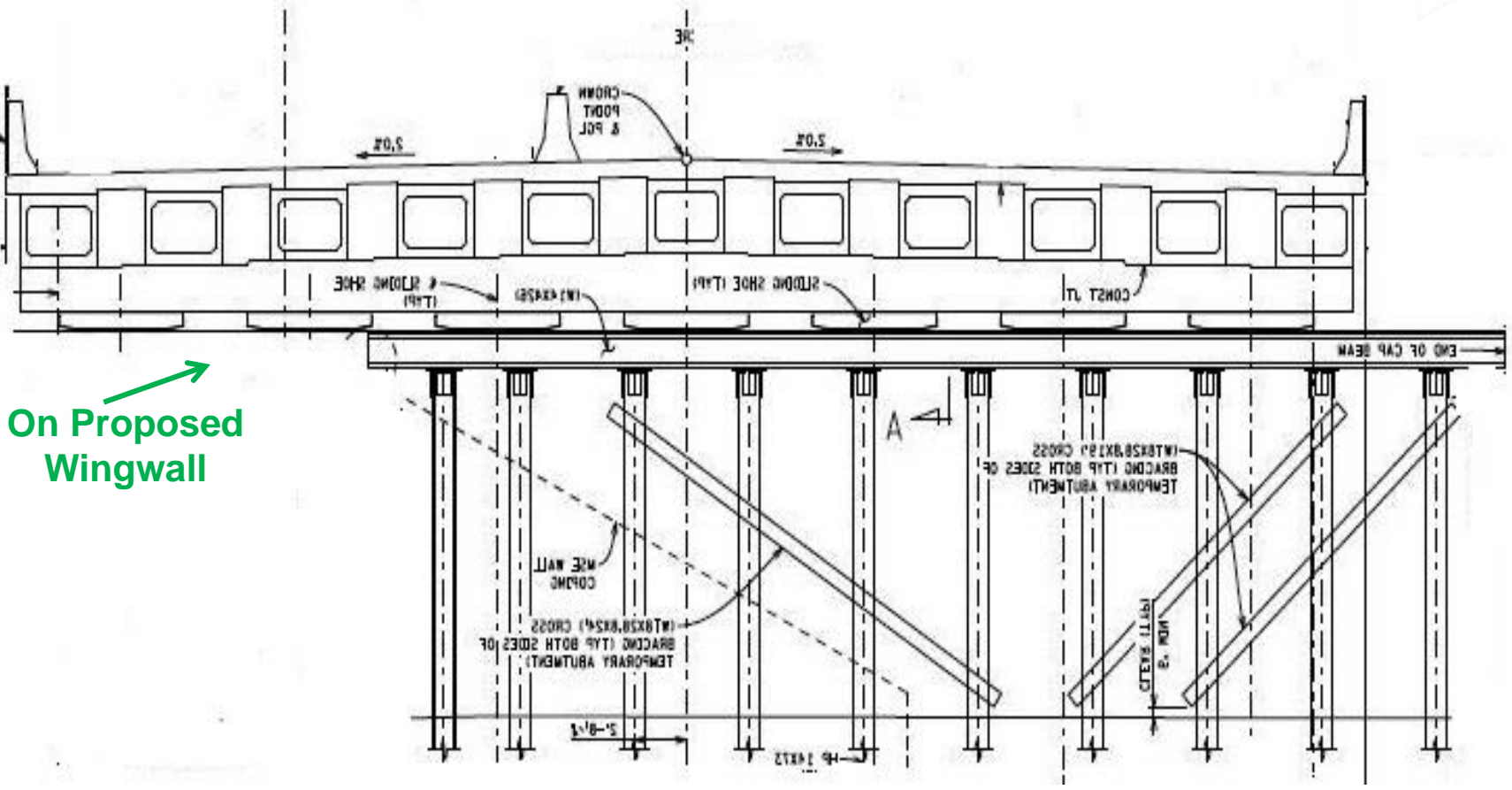
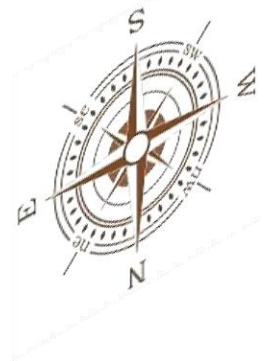


Proposed Pier Cap

**TEMP PIER-1
(ELEVATION) (Looking North)**

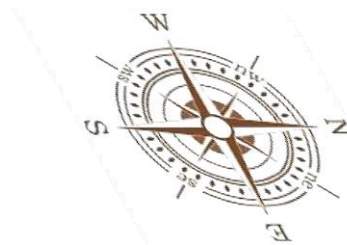
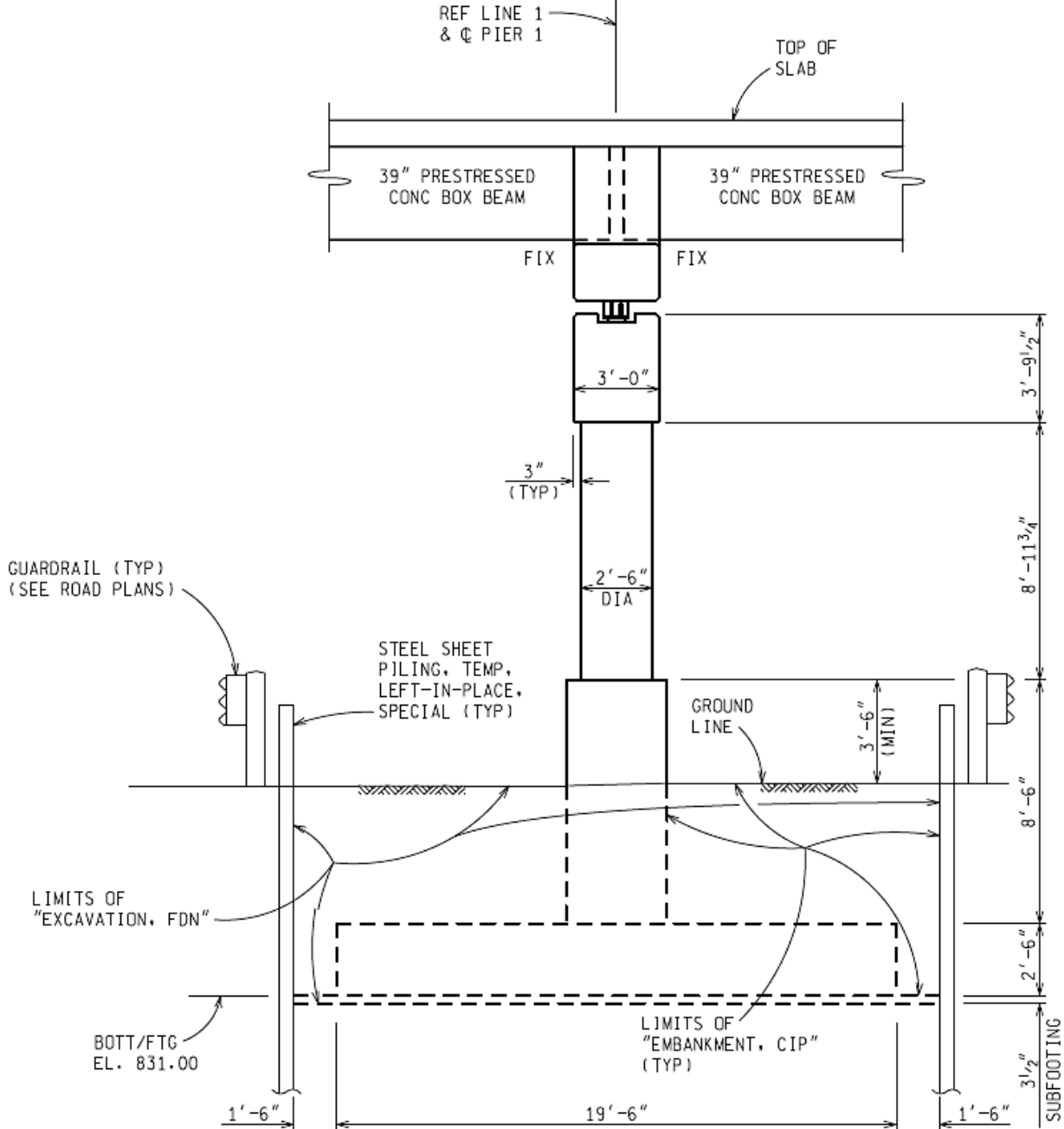


**Sliding at ABUT-A
(ELEVATION) (Looking South)**

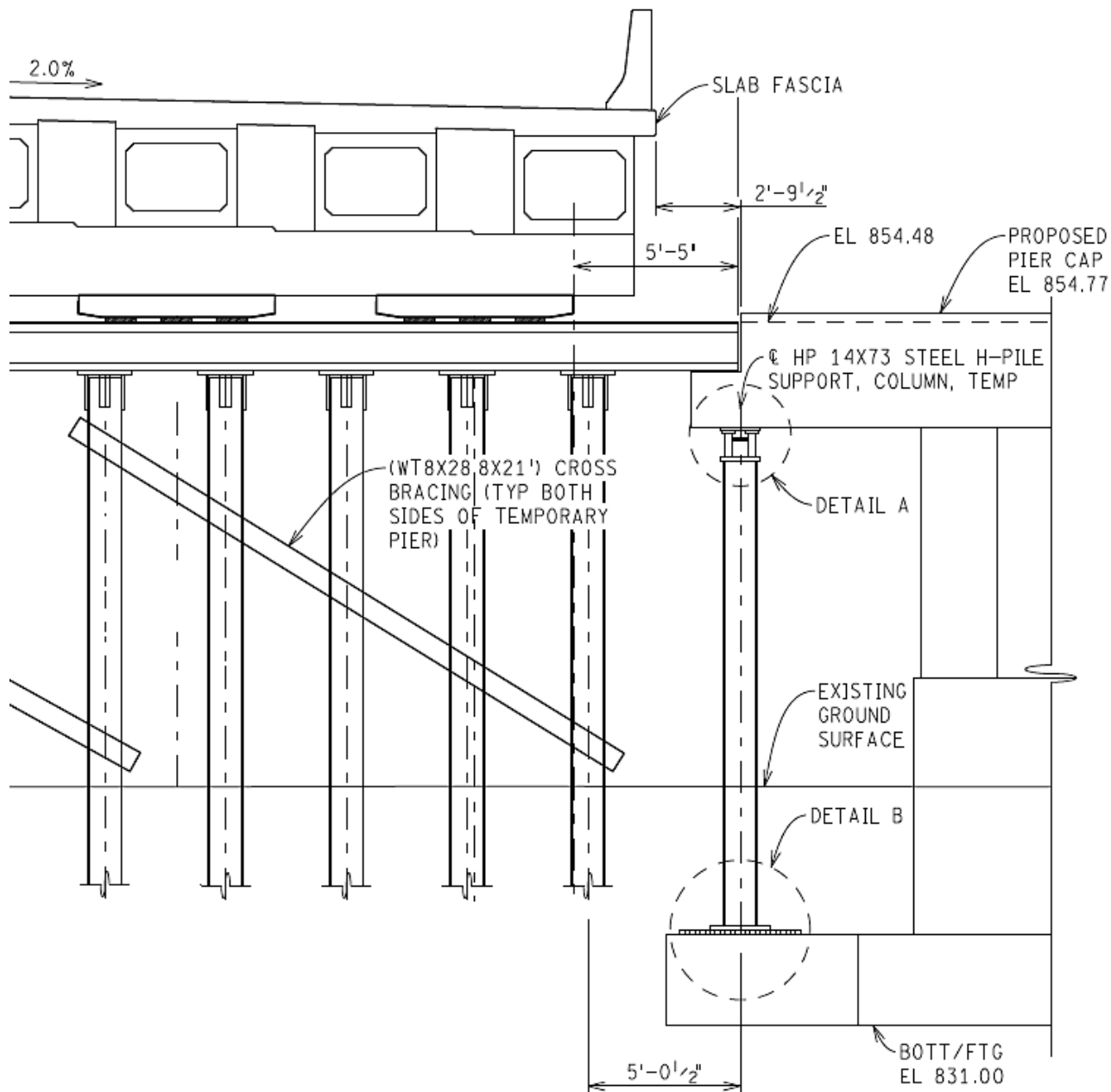


On Proposed Wingwall

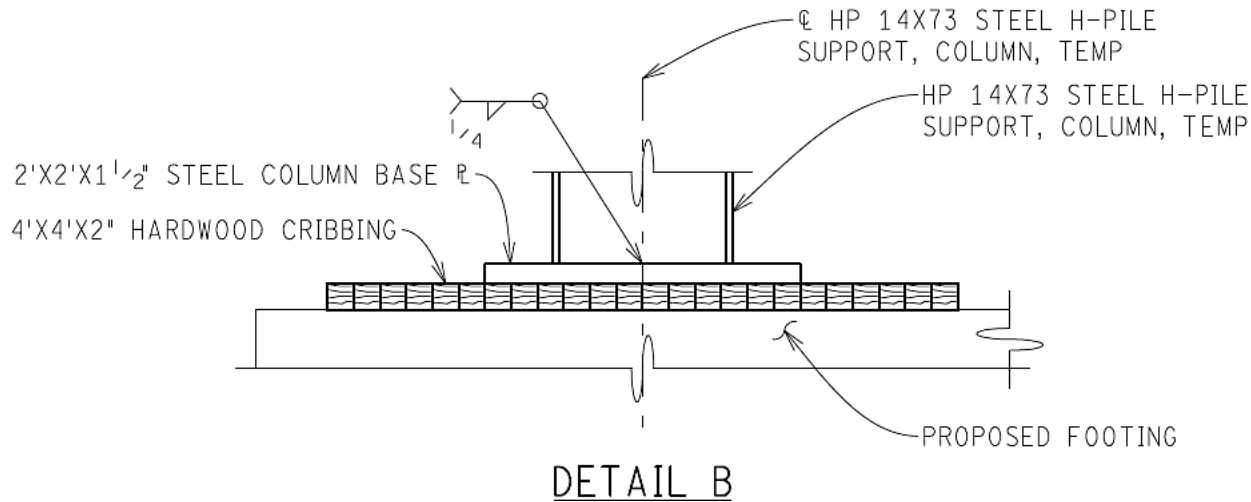
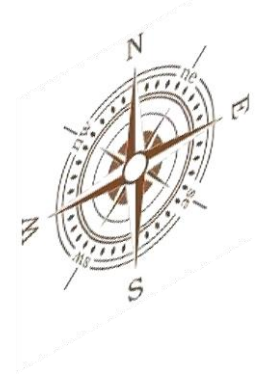
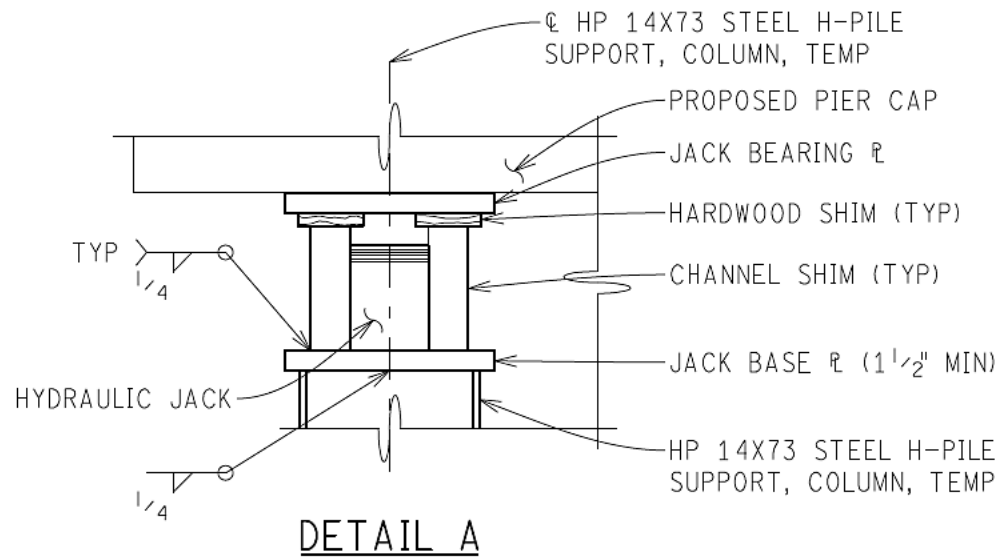
**TEMP ABUT-A
(ELEVATION) (Looking South)**



PIER-1
(SECTION – Final Location) (Looking West)



PIER-1
(ELEVATION @ Transition from Temporary to Permanent) (Looking North)



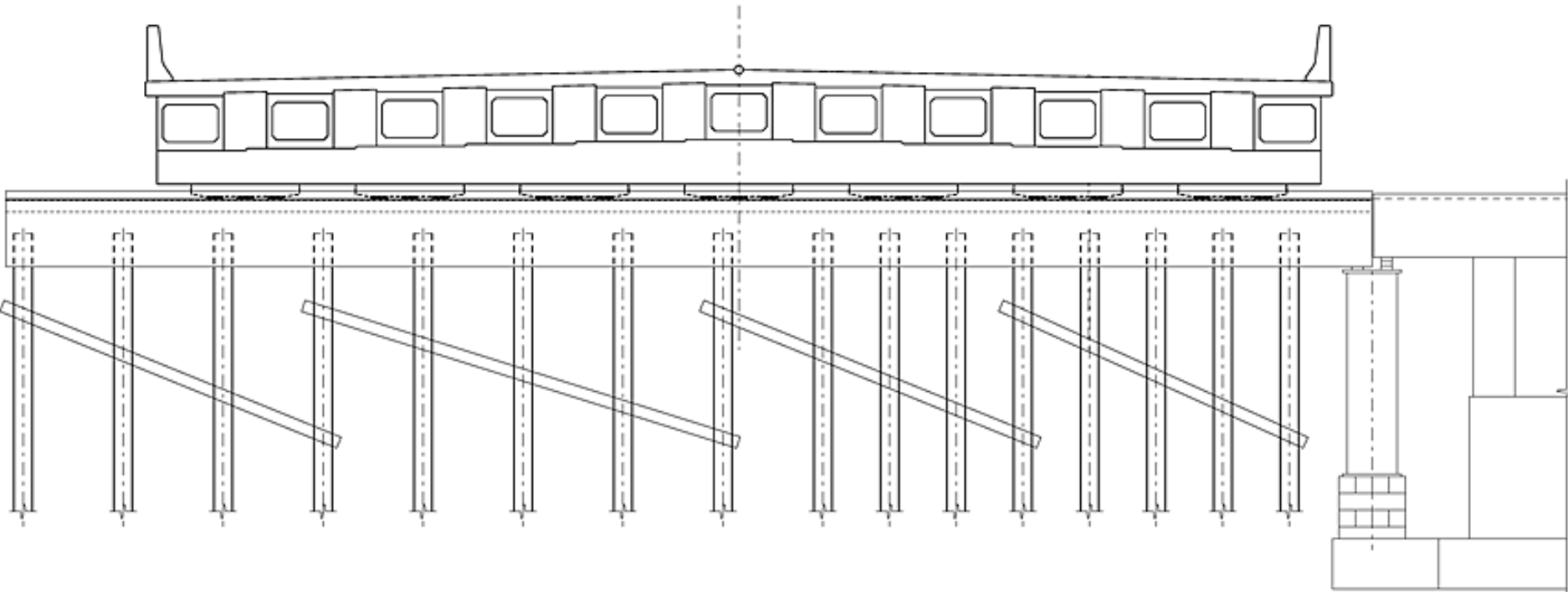
PIER-1

**(Details of Temporary Column @ Transition from Temporary to Permanent)
(Looking North)**

APPENDIX G

FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

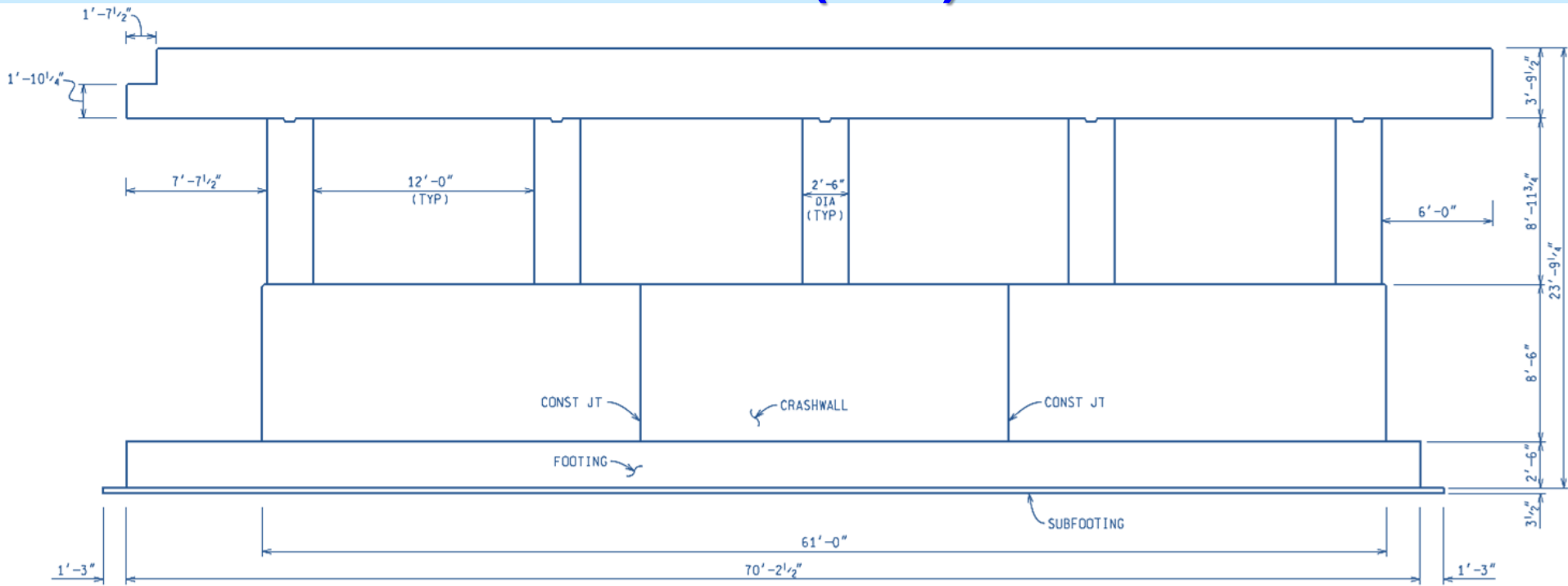
M-50 OVER I-96 BRIDGE (NEW SUPERSTRUCTURE)



	Weight (kips)
Length	198 ft
Width	71.25 ft
Spans	2
Girders per span	11
Sliding shoes	7

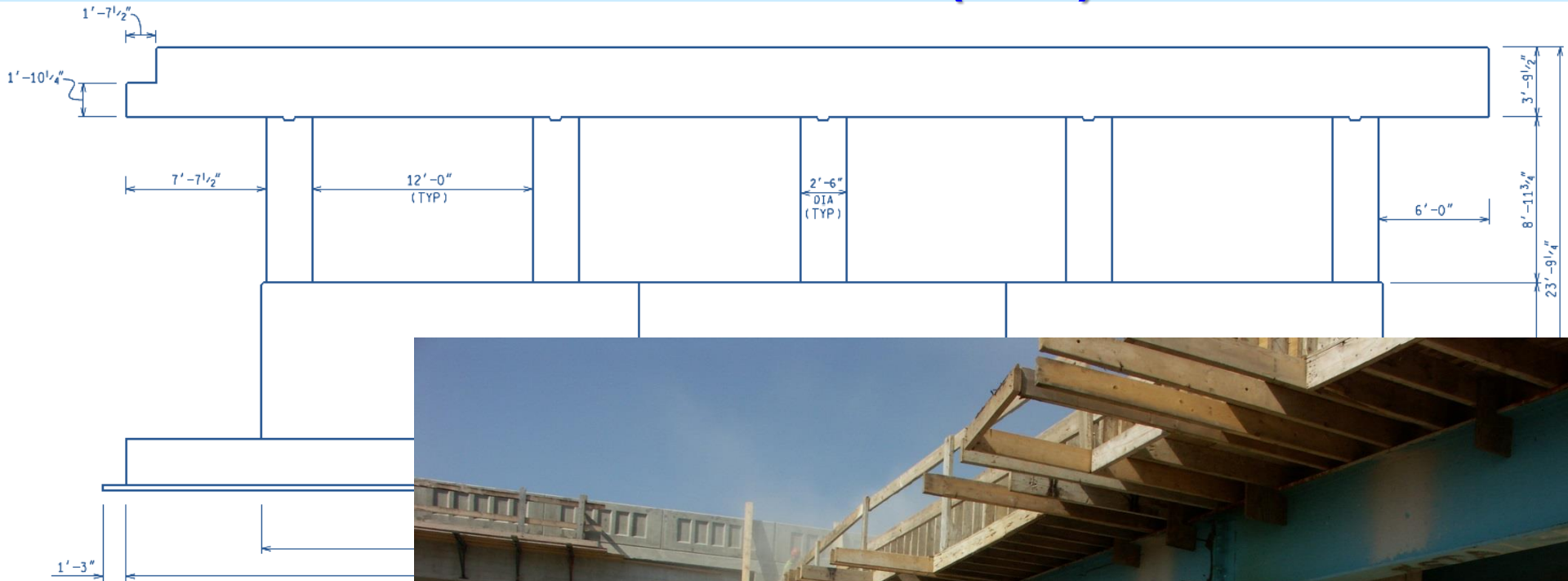
	Weight (kips)
Deck	1587
Girders	1775
Barriers	188
Pier diaphragm	167
Backwalls	264
Total weight	≈4000 kips

M-50 BRIDGE PIER (NEW) ELEVATION

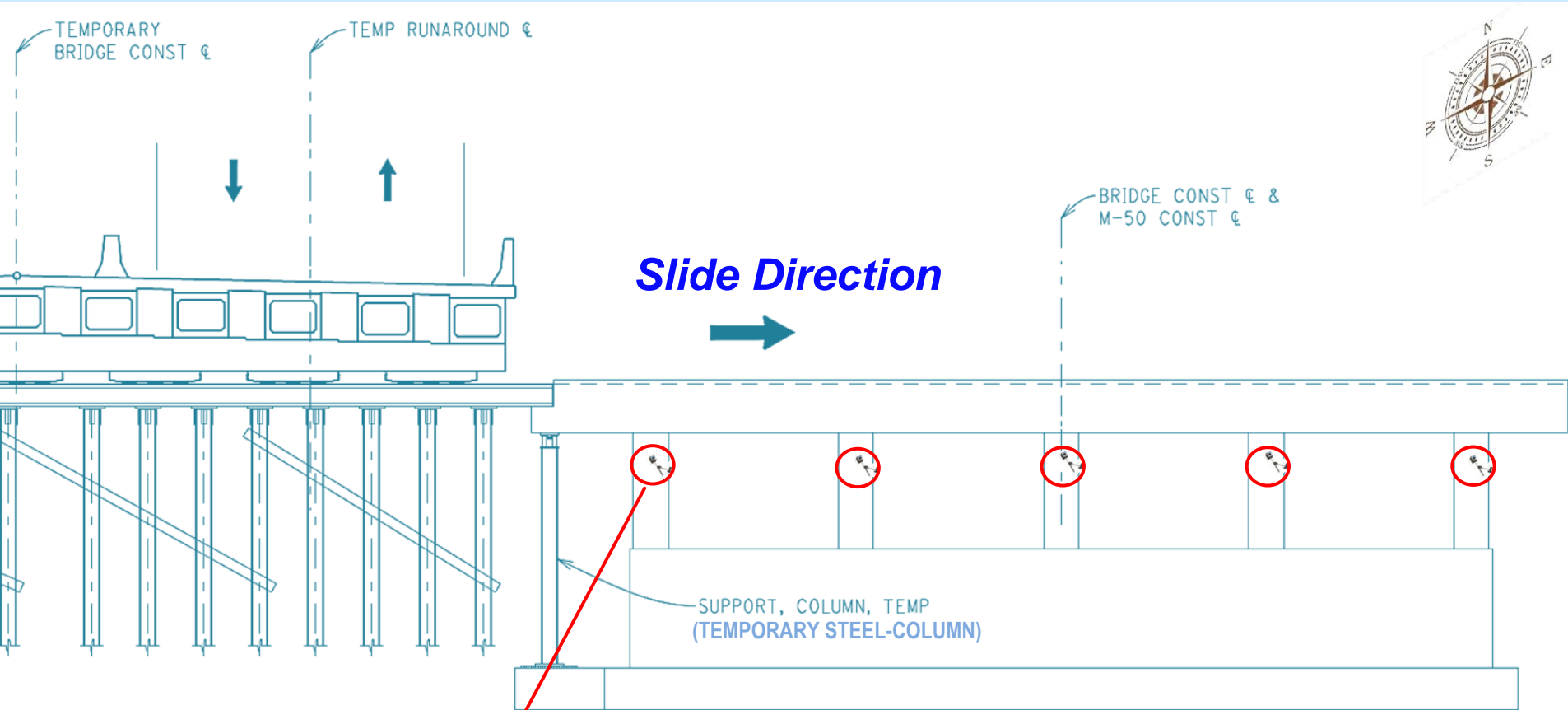


	Weight (kips)
Footing	513
Crashwall	233
Bent (bent cap & 5 pier columns)	157
Total weight	≈904

M-50 BRIDGE PIER (NEW)



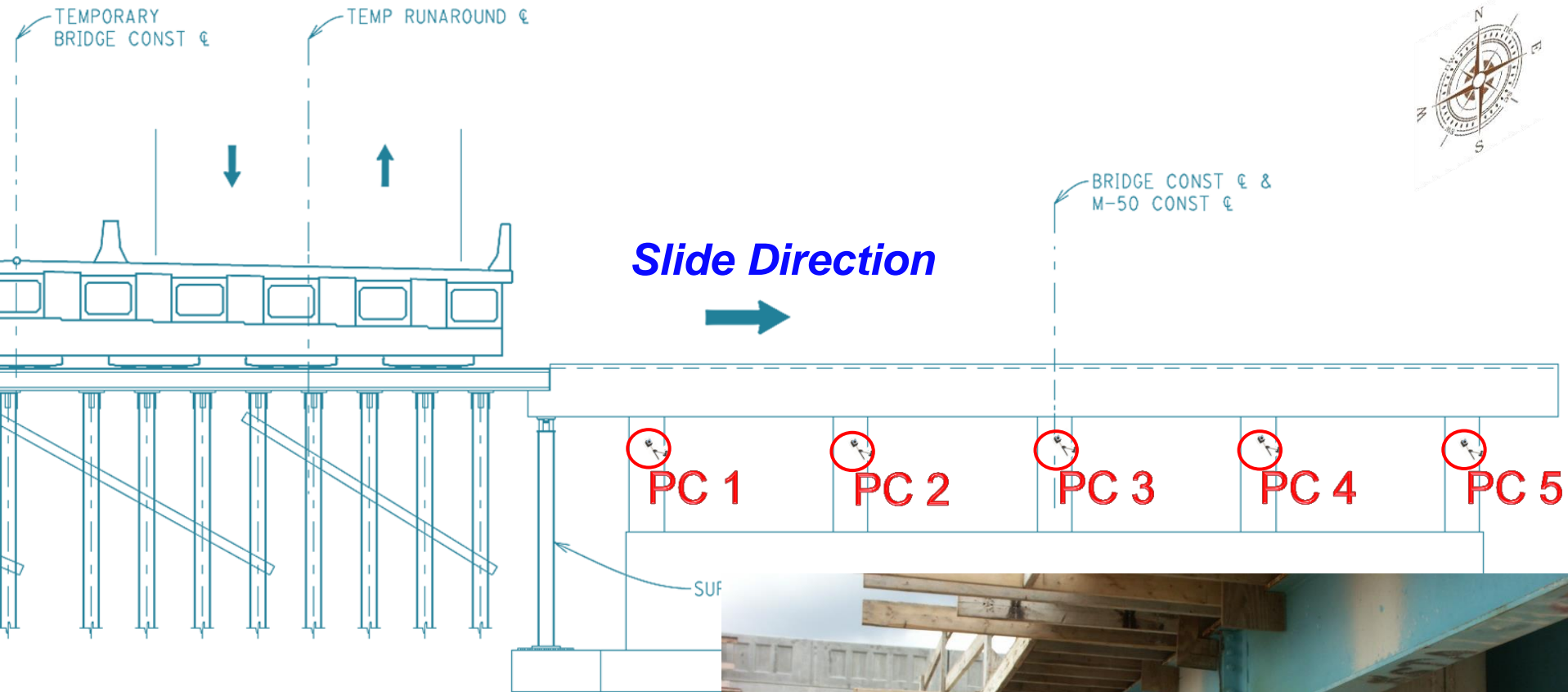
M-50 BRIDGE PIER MONITORING DURING SLIDE



PIER ELEVATION

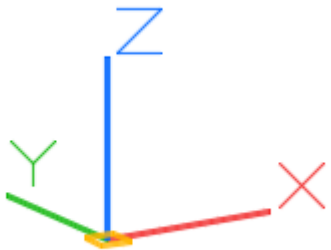
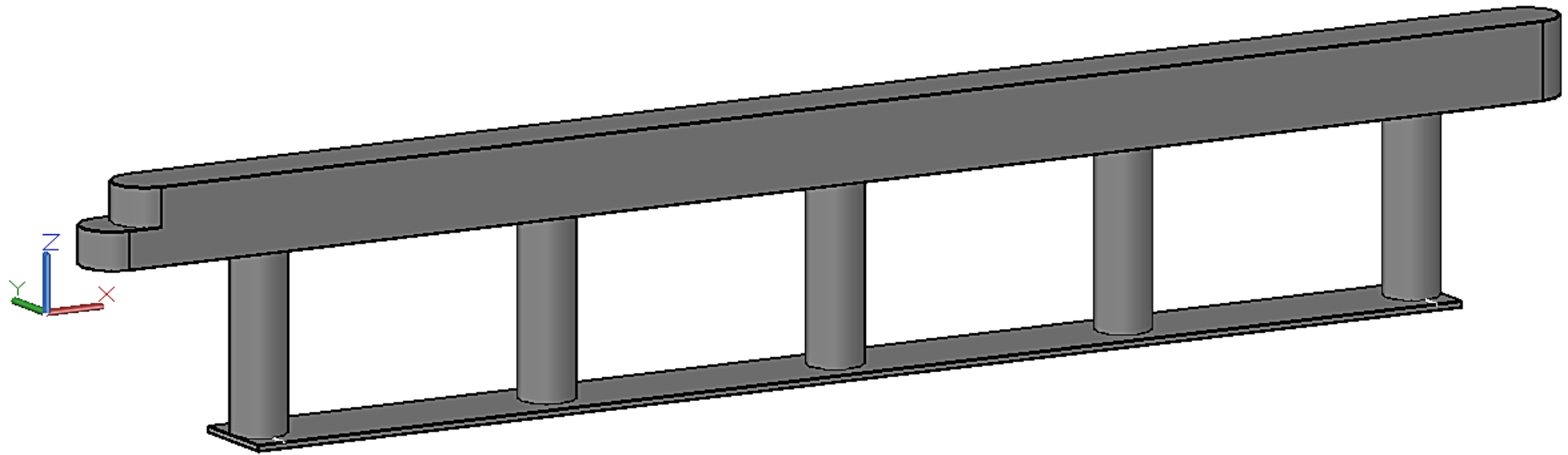


M-50 BRIDGE PIER MONITORING DURING SLIDE



M-50 BRIDGE PIER MONITORING DATA ANALYSIS

- Axes for the pier



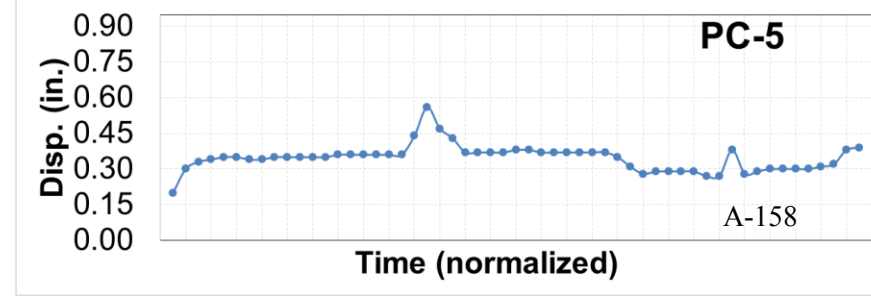
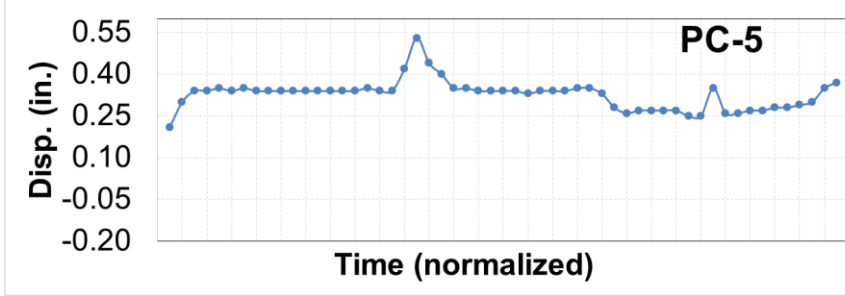
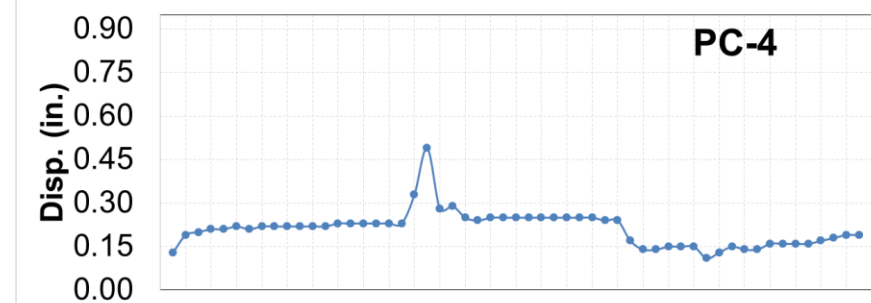
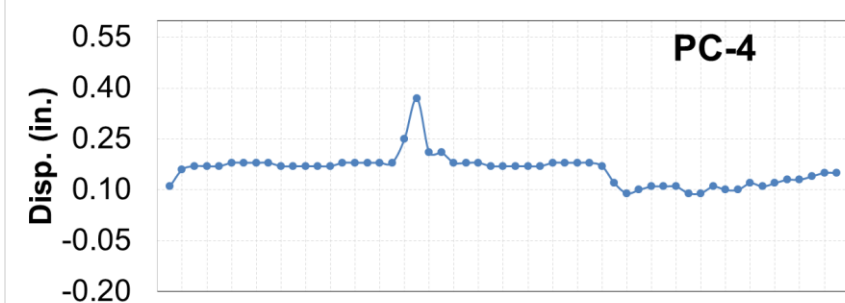
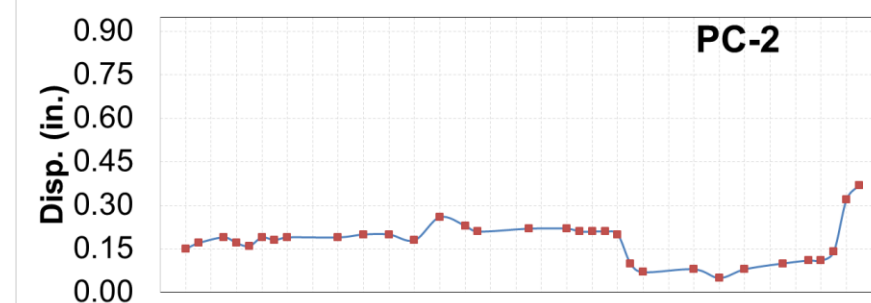
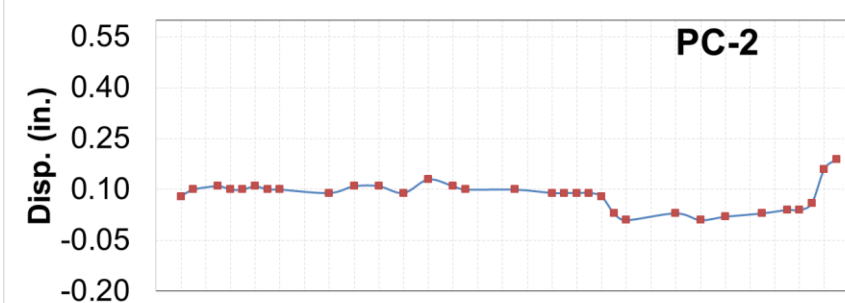
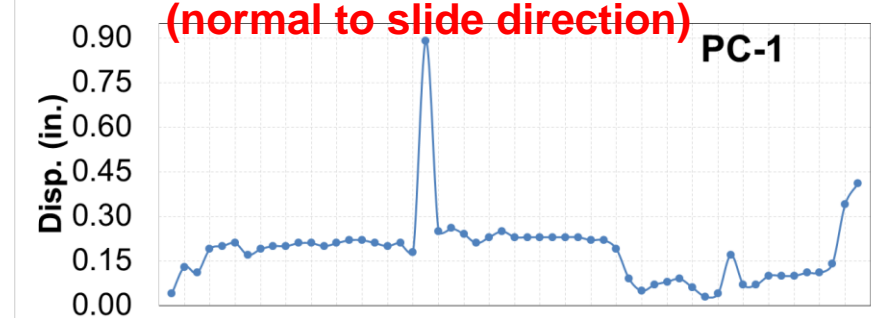
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

X – Displacement

(in the direction of slide)

Y – Displacement (lateral drift)

(normal to slide direction)

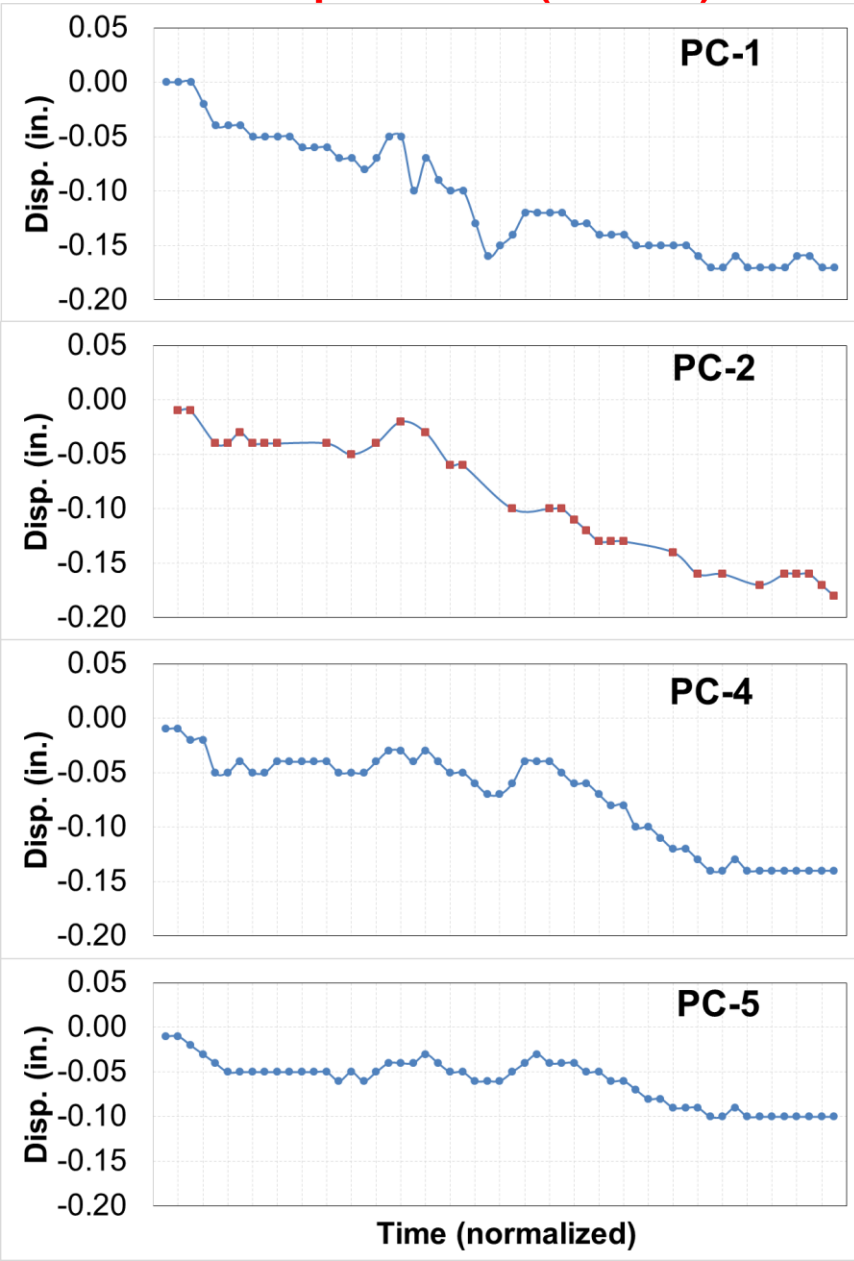


Time (normalized)

Time (normalized)

FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

Z – Displacement (vertical)



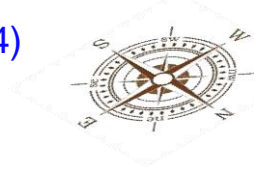
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Selected observations for plotting displacements (18 of 56 obs.)

Obs. no.	Time	PC 1 [in.]			PC 2 [in.]			PC 4 [in.]			PC 5 [in.]		
		X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
1	11:59 PM	0.01	0.04	0				0.11	0.13	-0.01	0.21	0.2	-0.01
2	12:04 AM	0.07	0.13	0	0.08	0.15	-0.01	0.16	0.19	-0.01	0.3	0.3	-0.01
5	12:24 AM	0.1	0.2	-0.04	0.11	0.19	-0.04	0.17	0.21	-0.05	0.35	0.35	-0.04
8	12:41 AM	0.1	0.19	-0.05	0.11	0.19	-0.04	0.18	0.22	-0.05	0.34	0.34	-0.05
16	1:07 AM	0.11	0.22	-0.07	0.11	0.2	-0.05	0.18	0.23	-0.05	0.34	0.36	-0.05
18	1:18 AM	0.1	0.2	-0.07	0.11	0.2	-0.04	0.18	0.23	-0.04	0.34	0.36	-0.05
20	1:24 AM	0.09	0.18	-0.05	0.09	0.18	-0.02	0.25	0.33	-0.03	0.42	0.44	-0.04
21	1:32 AM	0.43	0.89	-0.1				0.37	0.49	-0.04	0.53	0.56	-0.04
22	1:38 AM	0.12	0.25	-0.07	0.13	0.26	-0.03	0.21	0.28	-0.03	0.44	0.47	-0.03
25	1:48 AM	0.1	0.21	-0.1	0.1	0.21	-0.06	0.18	0.24	-0.05	0.35	0.37	-0.05
27	2:15 AM	0.1	0.25	-0.16				0.17	0.25	-0.07	0.34	0.37	-0.06
32	2:32 AM	0.1	0.23	-0.12	0.09	0.22	-0.1	0.18	0.25	-0.04	0.34	0.37	-0.04
38	2:52 AM	0	0.05	-0.14	0.01	0.07	-0.13	0.09	0.14	-0.08	0.26	0.28	-0.06
44	3:17 AM	0	0.04	-0.16	0.01	0.05	-0.16	0.09	0.13	-0.13	0.25	0.27	-0.09
45	3:21 AM	0.07	0.17	-0.17				0.11	0.15	-0.14	0.35	0.38	-0.1
49	3:37 AM	0.03	0.1	-0.17	0.03	0.1	-0.17	0.11	0.16	-0.14	0.27	0.3	-0.1
52	3:46 AM	0.04	0.11	-0.16	0.04	0.11	-0.16	0.13	0.17	-0.14	0.29	0.31	-0.1
55	3:57 AM	0.19	0.41	-0.17	0.19	0.37	-0.18	0.15	0.19	-0.14	0.37	0.39	-0.1

FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

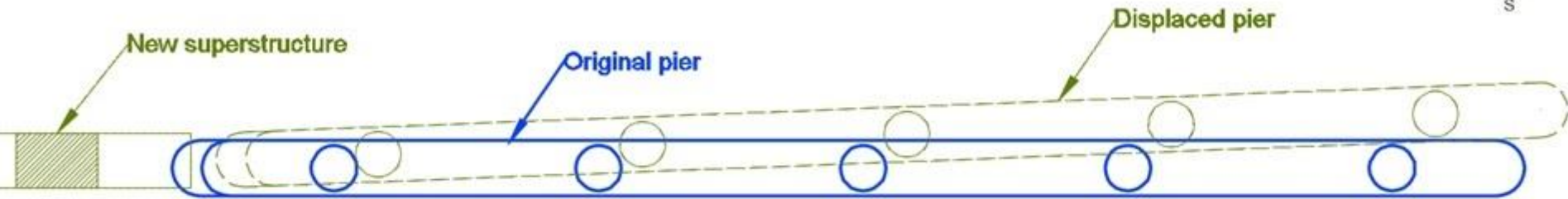
- Data acquisition starts at 11:59 PM with slide (Oct 17, 2014)



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

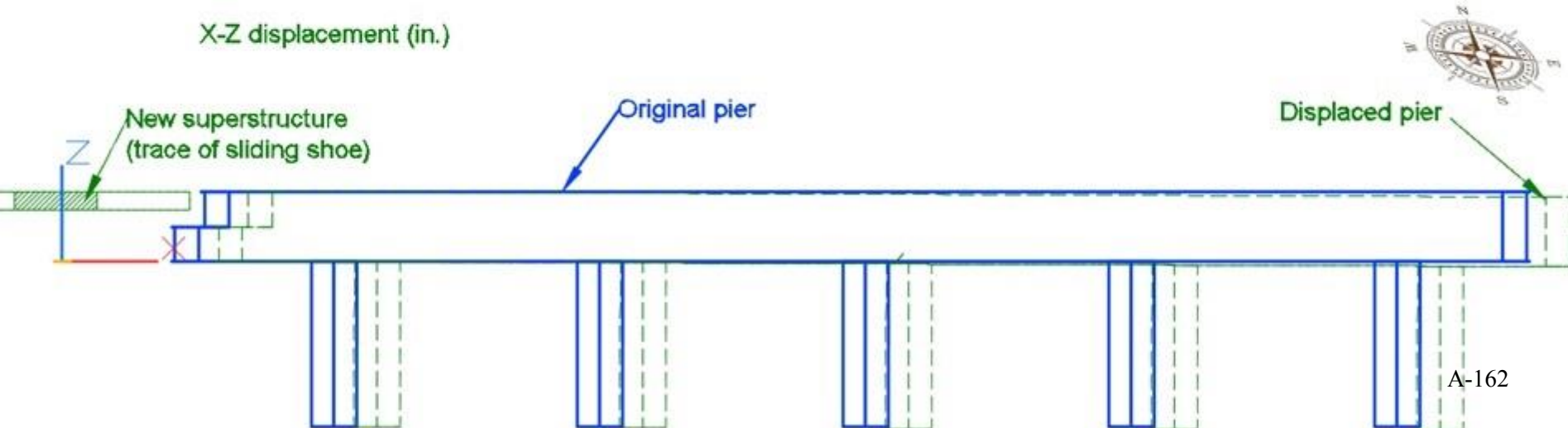
- Observation-1 at 11:59 PM (Oct 17, 2014)

Displacement amplified 200 times
X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
1	11:59 PM	0.14	0.11	-0.01

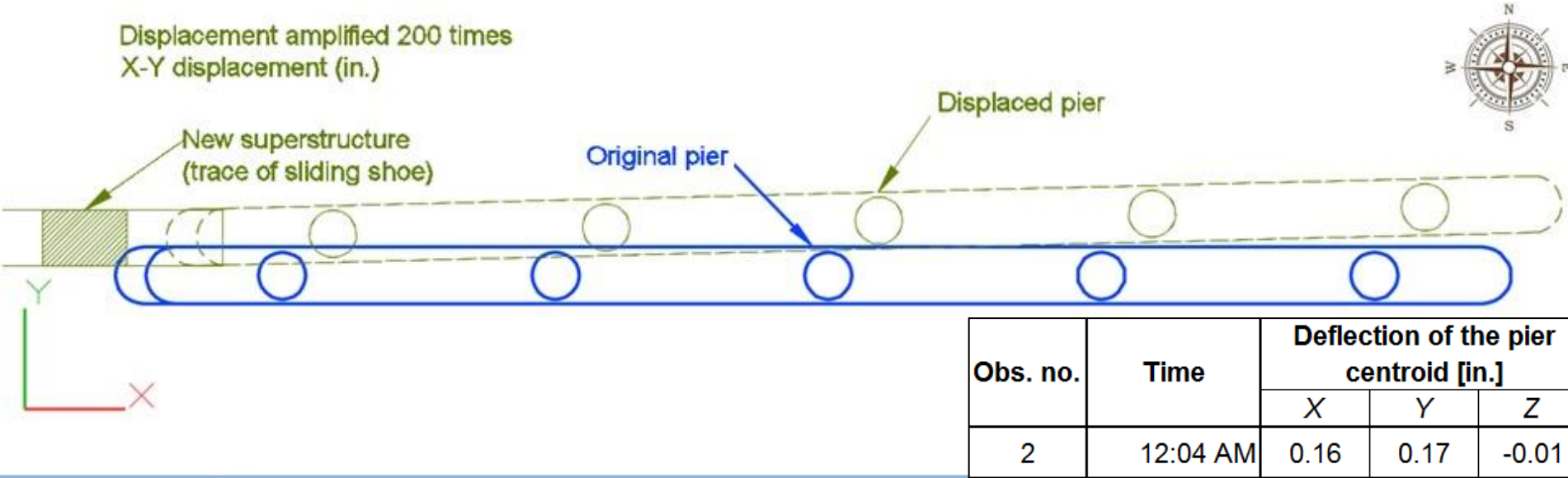
X-Z displacement (in.)



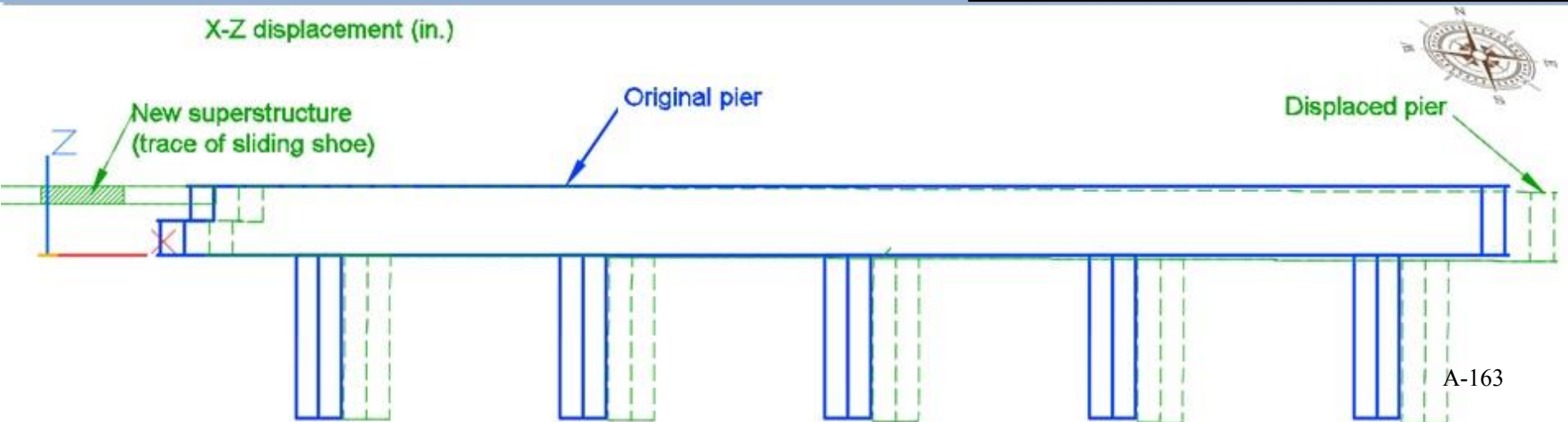
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-2 at 12:04 AM (Oct 18, 2014)
 - First sliding shoe approaching temporary steel-column at the transition

Displacement amplified 200 times
X-Y displacement (in.)



X-Z displacement (in.)

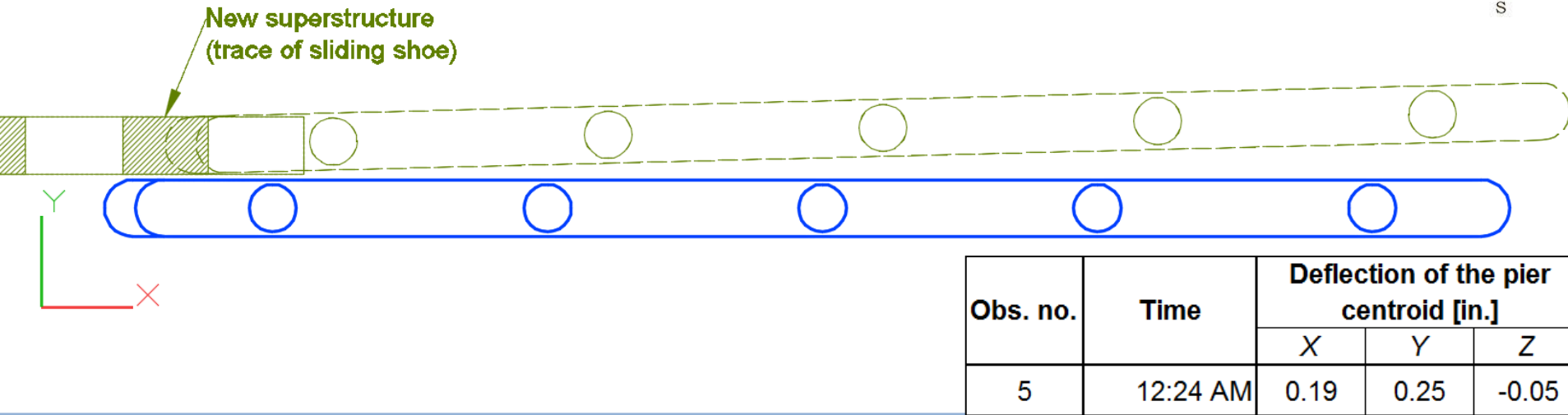


FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

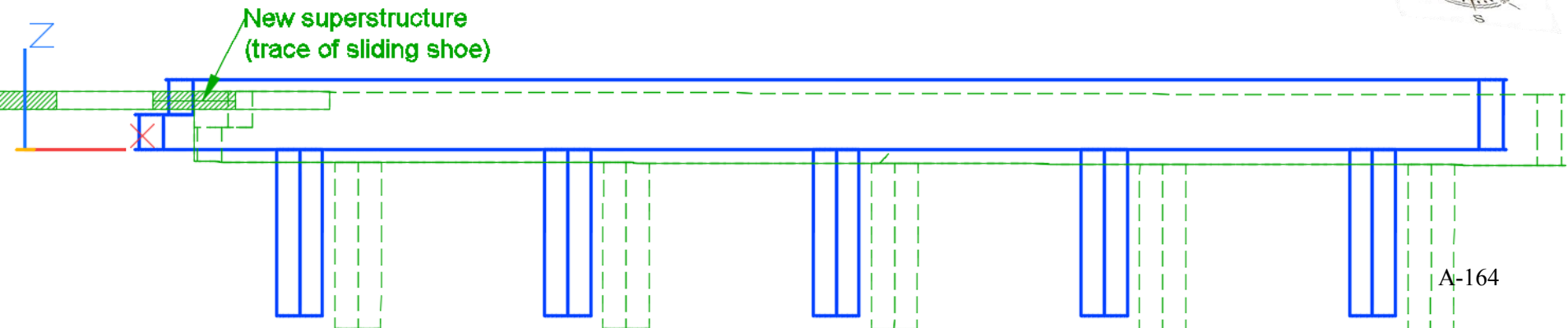
■ Observation-5 at 12:24 AM

- First sliding shoe at temporary steel-column at the transition

X-Y displacement (in.)



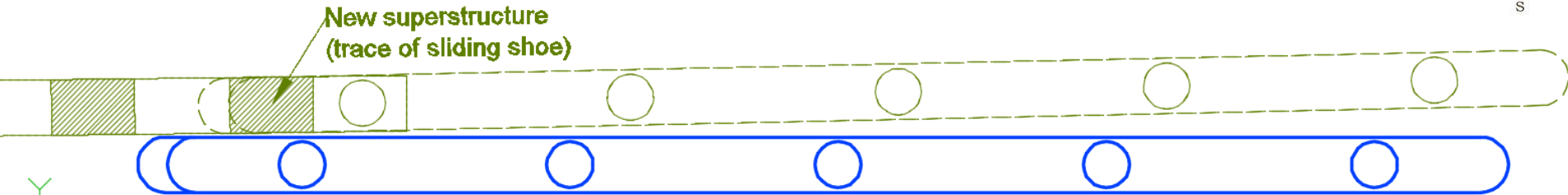
X-Z displacement (in.)



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

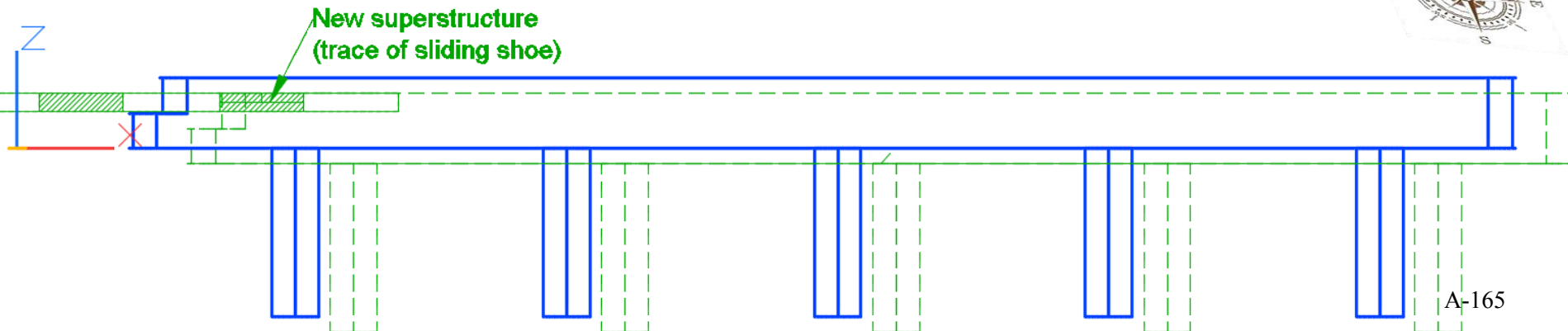
- Observation-8 at 12:41 AM
 - First sliding shoe completely on new pier before col.-1 (first column)

X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
8	12:41 AM	0.20	0.24	-0.05

X-Z displacement (in.)



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

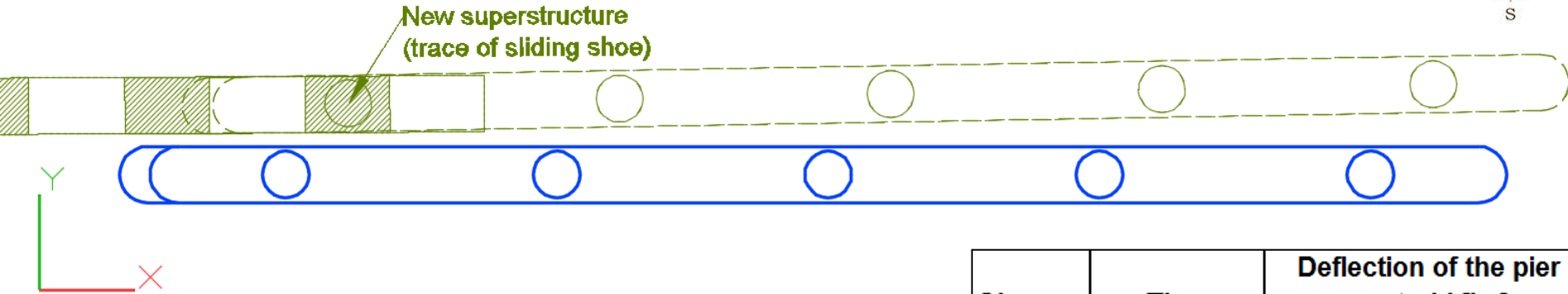
- Observation-16 at 01:07 AM
 - First sliding shoe over col.-1 of new pier



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

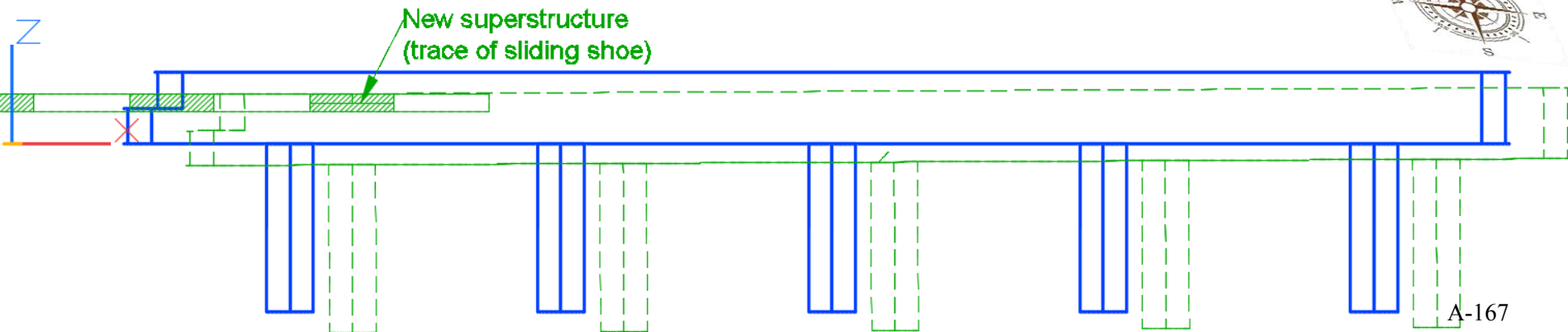
- Observation-16 at 01:07 AM
 - First sliding shoe at col.-1 of new pier

X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
16	1:07 AM	0.20	0.26	-0.06

X-Z displacement (in.)

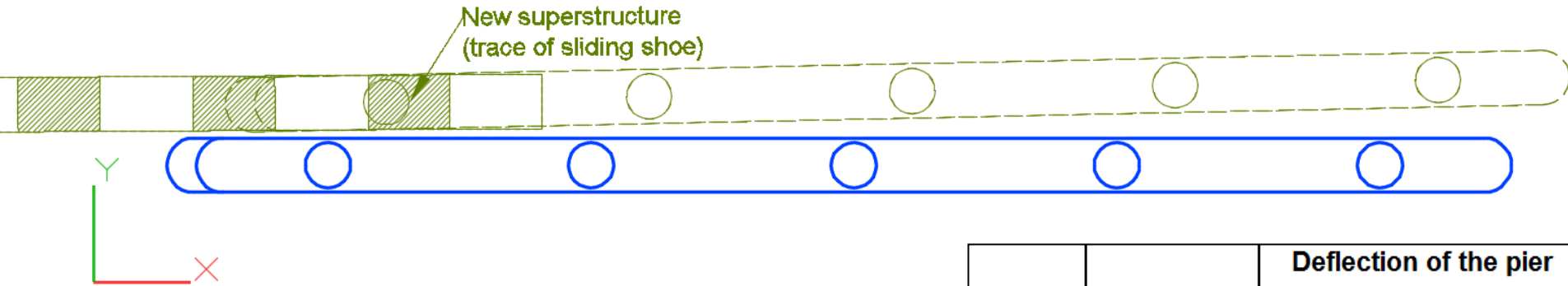


FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-18 at 01:18 AM
 - Second sliding shoe at the temporary steel-column at transition

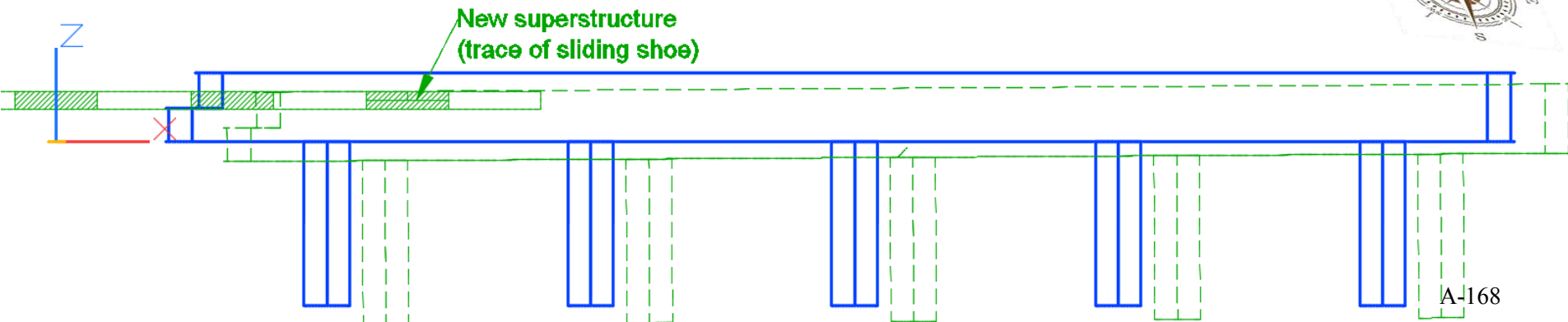


X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
18	1:18 AM	0.19	0.24	-0.05

X-Z displacement (in.)

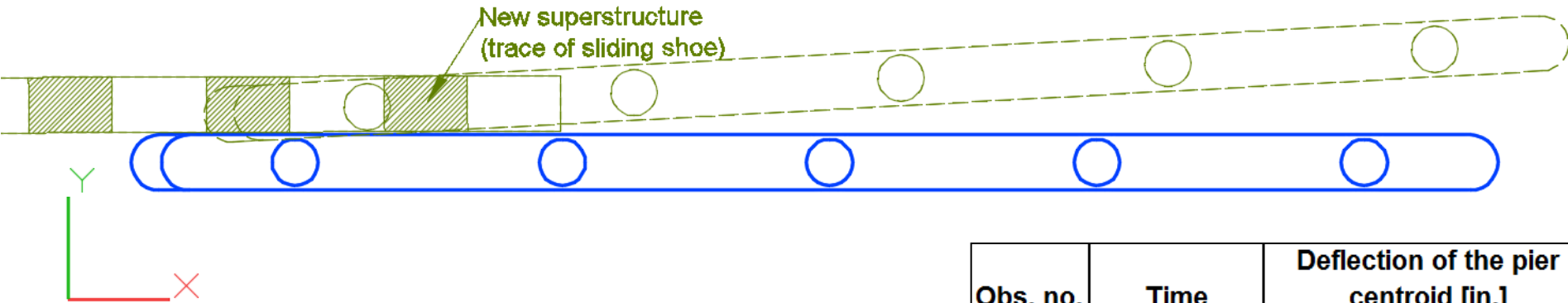


FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-20 at 01:24 AM
 - Second sliding shoe moving over the temporary steel-column
 - First sliding shoe just after col.-1

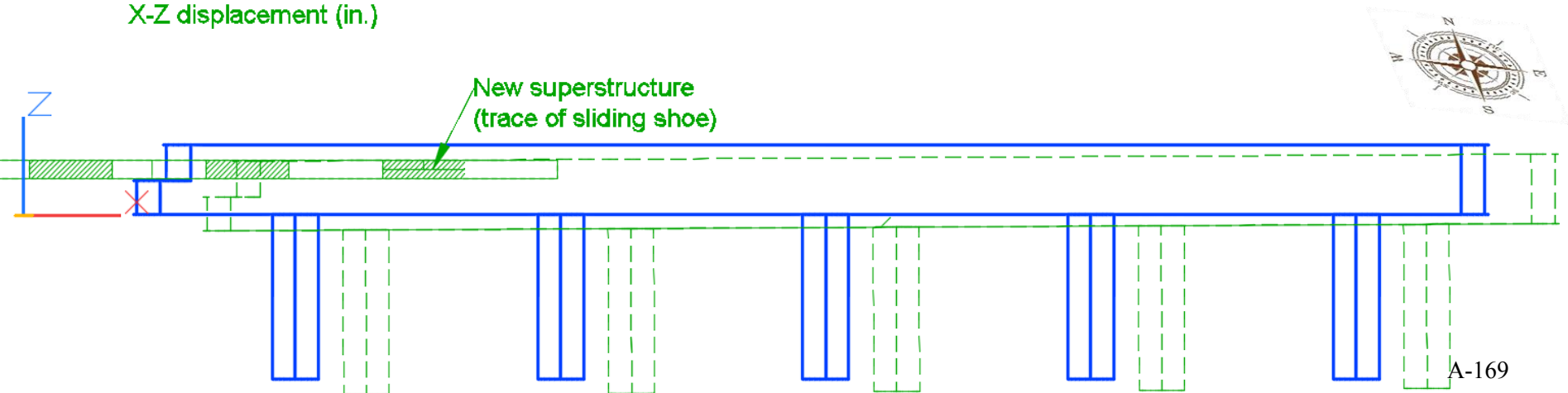


X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
20	1:24 AM	0.23	0.27	-0.04

X-Z displacement (in.)



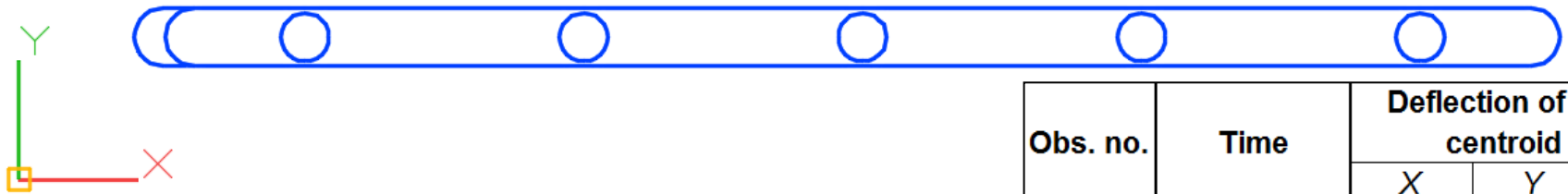
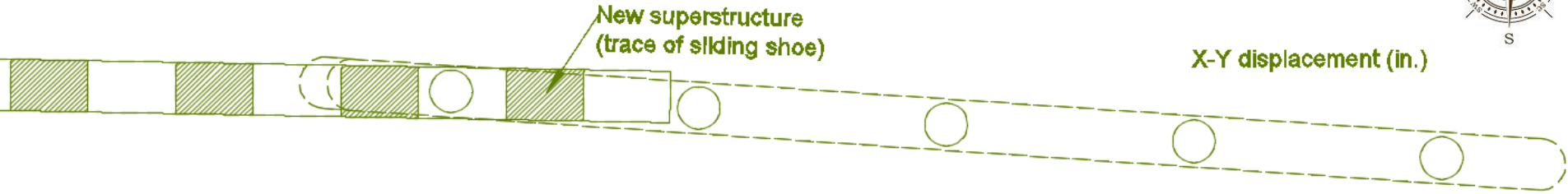
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-20 at 01:24 AM
 - First sliding shoe beyond col.-1



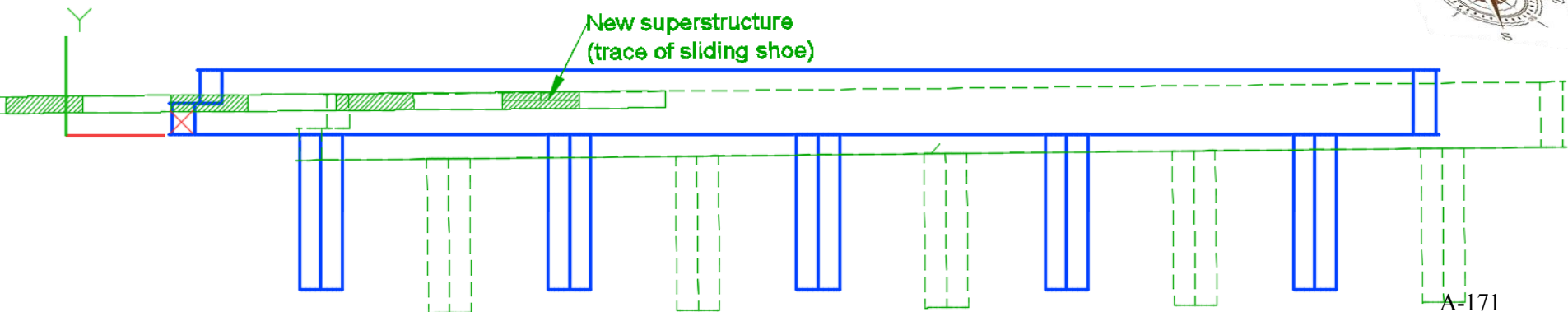
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-21 at 01:32 AM
 - Second sliding shoe completely on new pier



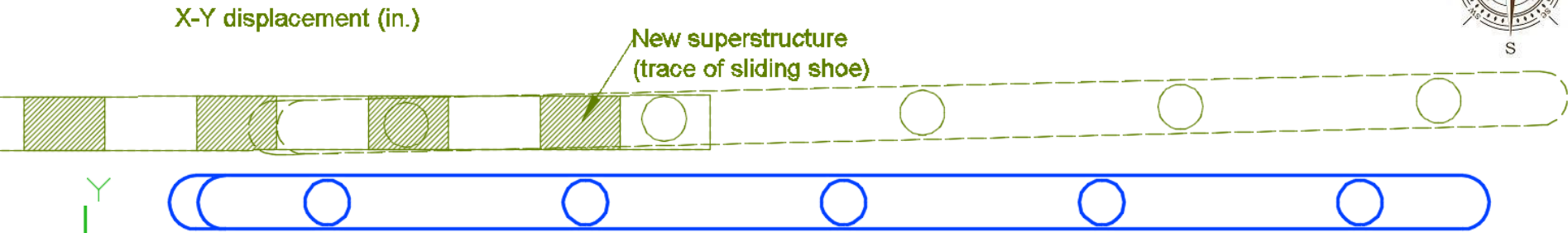
Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
21	1:32 AM	0.43	0.60	-0.06

X-Z displacement (in.)

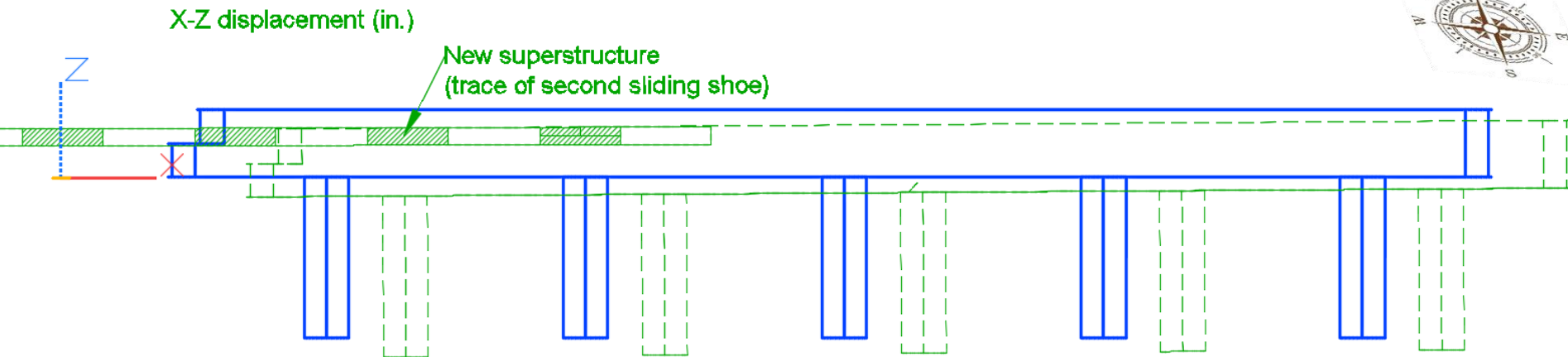


FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-22 at 01:38 AM
 - Second sliding shoe at col.-1

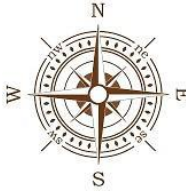


Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
22	1:38 AM	0.27	0.30	-0.05

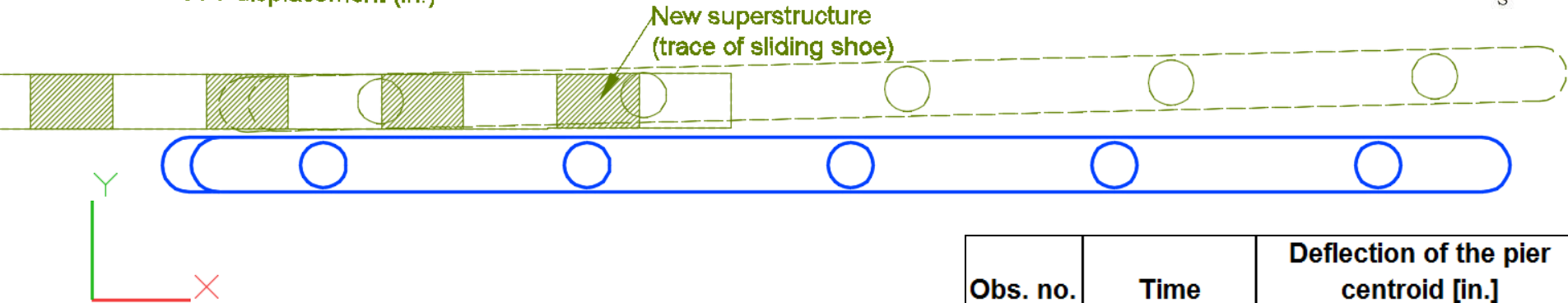


FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-25 at 01:48 AM
 - Third sliding shoe on temporary steel-column at the transition

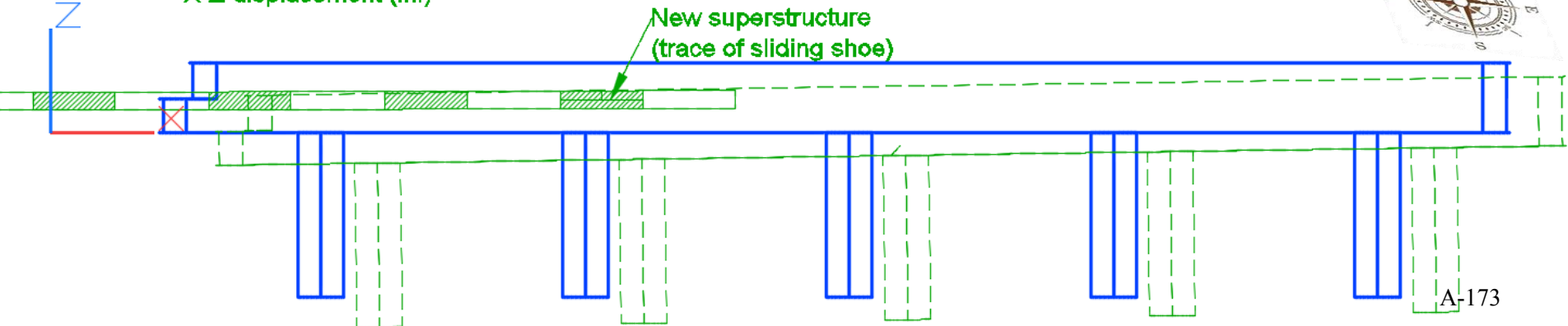


X-Y displacement (in.)



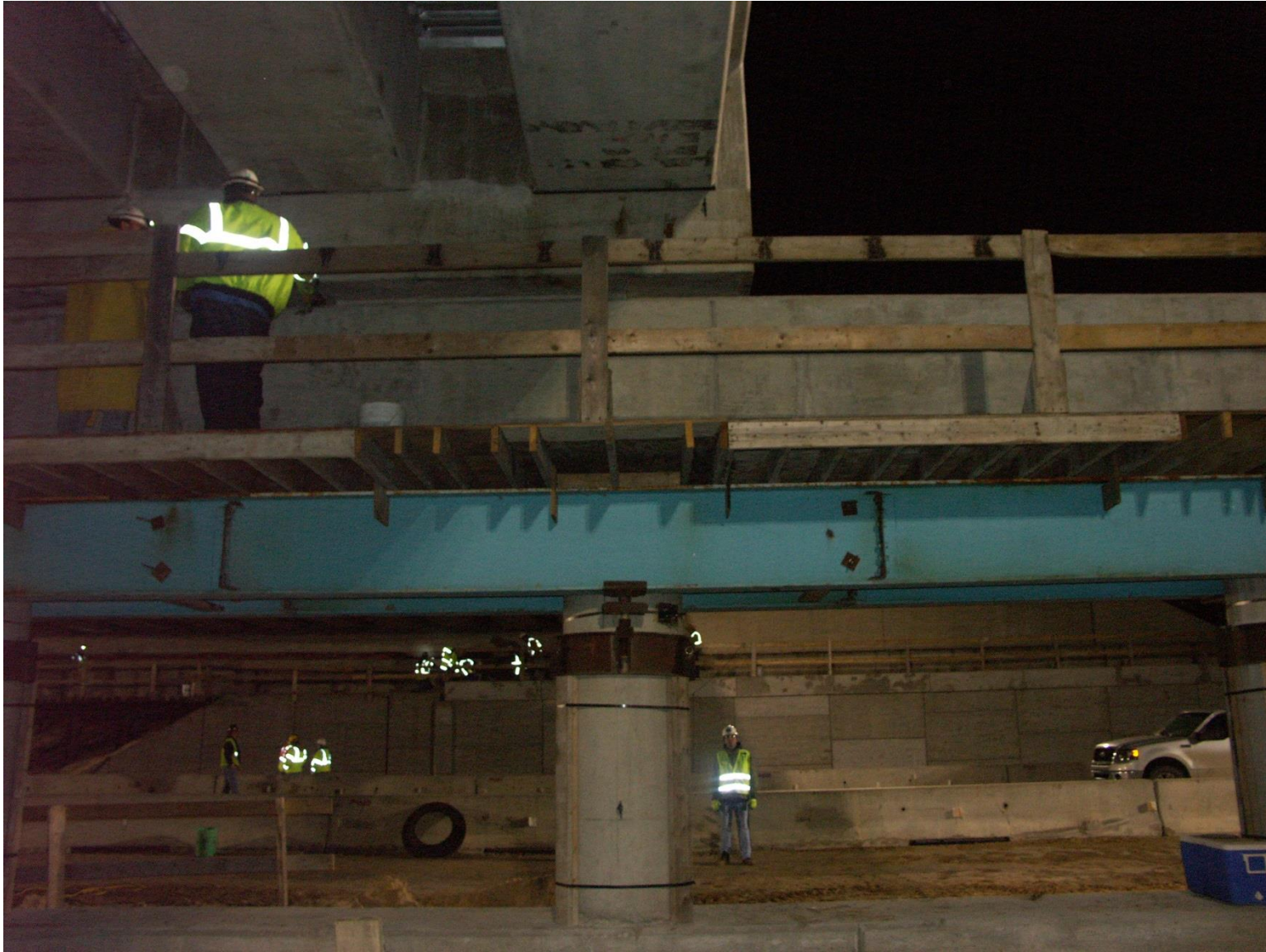
Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
25	1:48 AM	0.19	0.25	-0.08

X-Z displacement (in.)



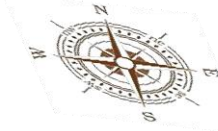
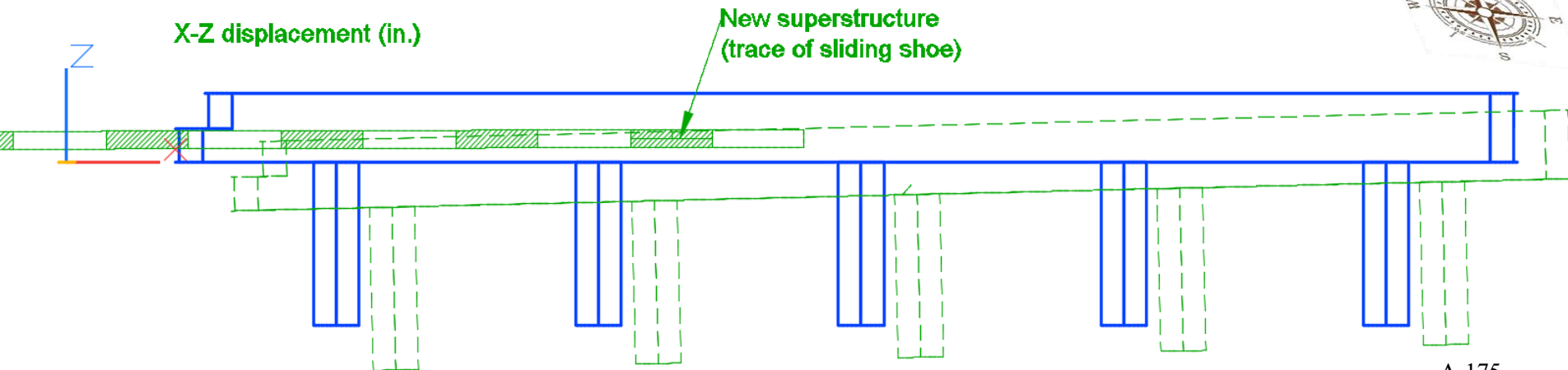
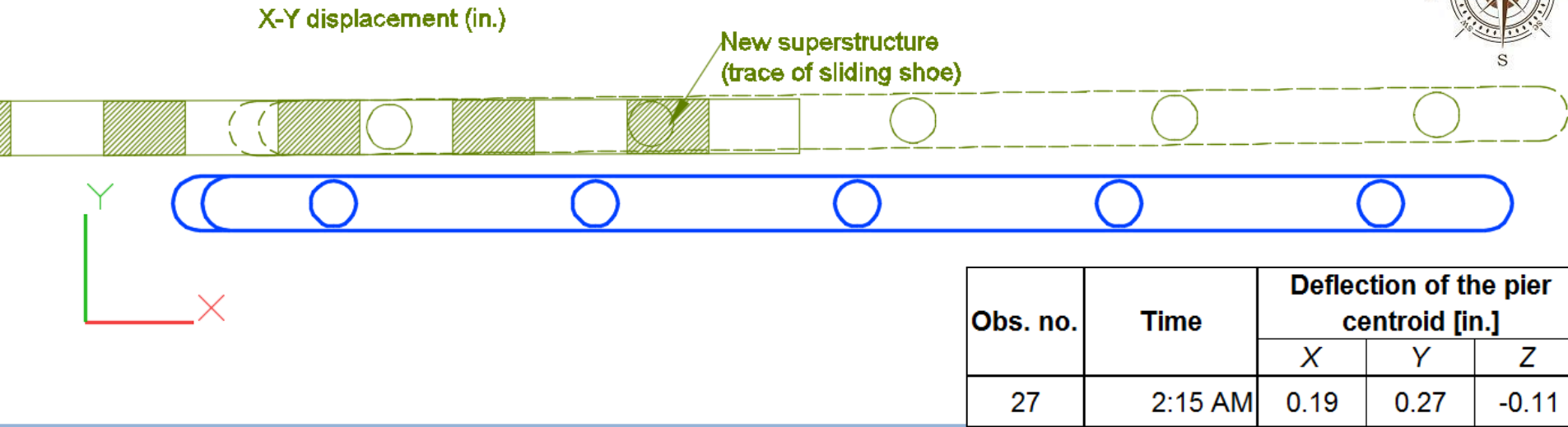
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation- at 02:05 AM
 - First sliding shoe partly over col.-2



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

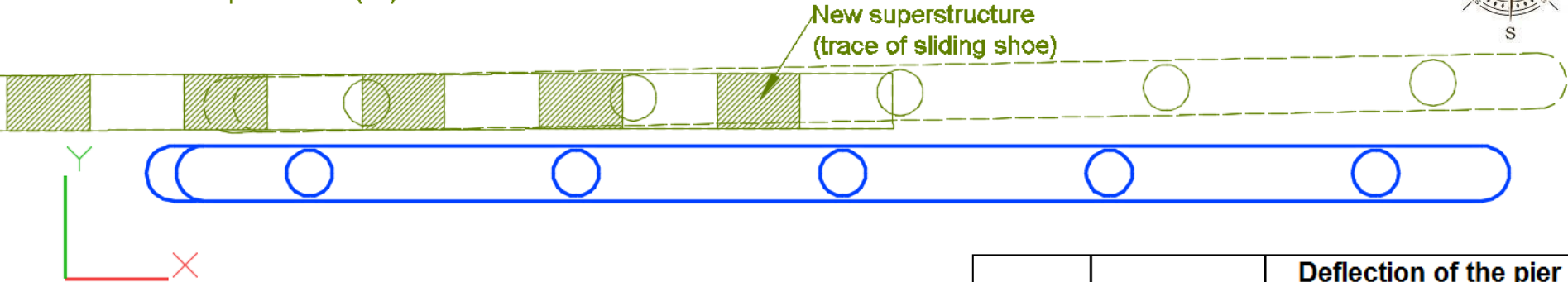
- Observation-27 at 02:15 AM
 - First sliding shoe at col.-2



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

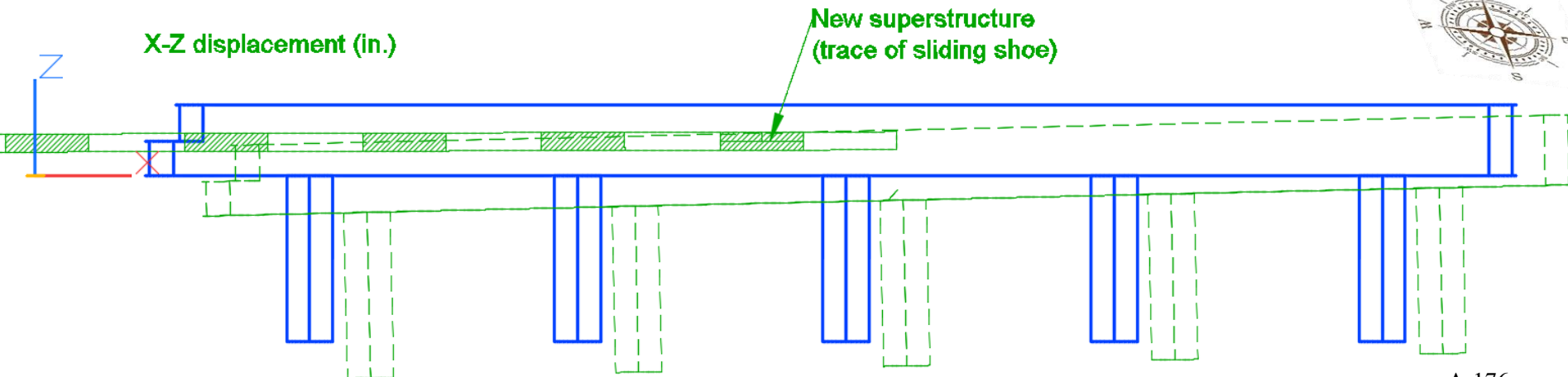
- Observation-32 at 02:32 AM
 - Fourth sliding shoe on temporary steel-column at the transition

X-Y displacement (in.)



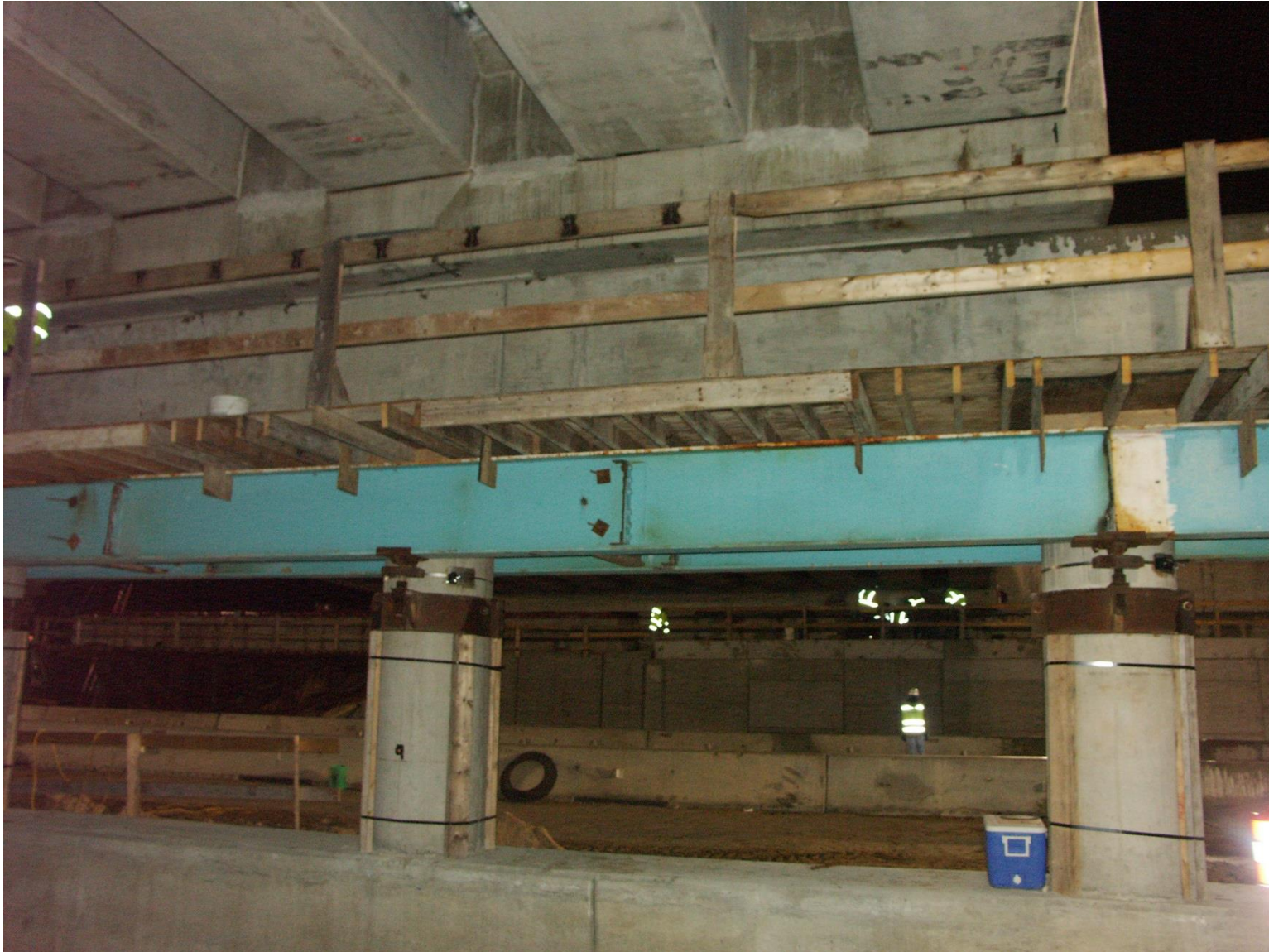
Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
32	2:32 AM	0.19	0.26	-0.08

X-Z displacement (in.)



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation- at 02:42 AM
 - First sliding shoe approaching col.-3

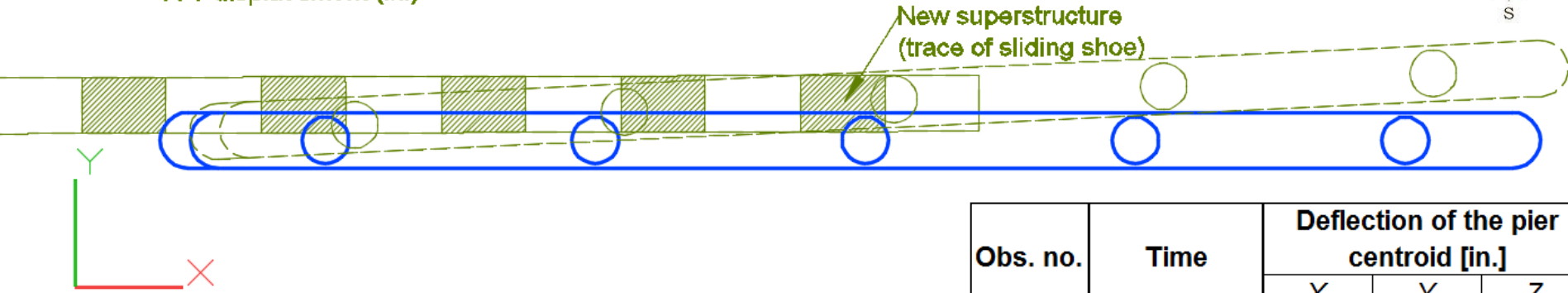


FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-38 at 02:52 AM
 - First sliding shoe partly on col.-3

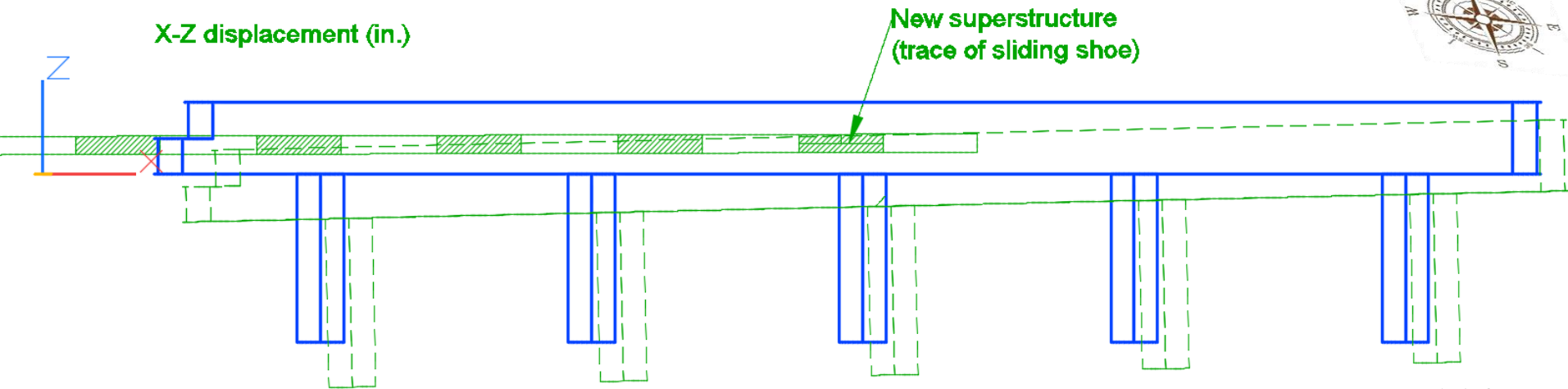


X-Y displacement (in.)



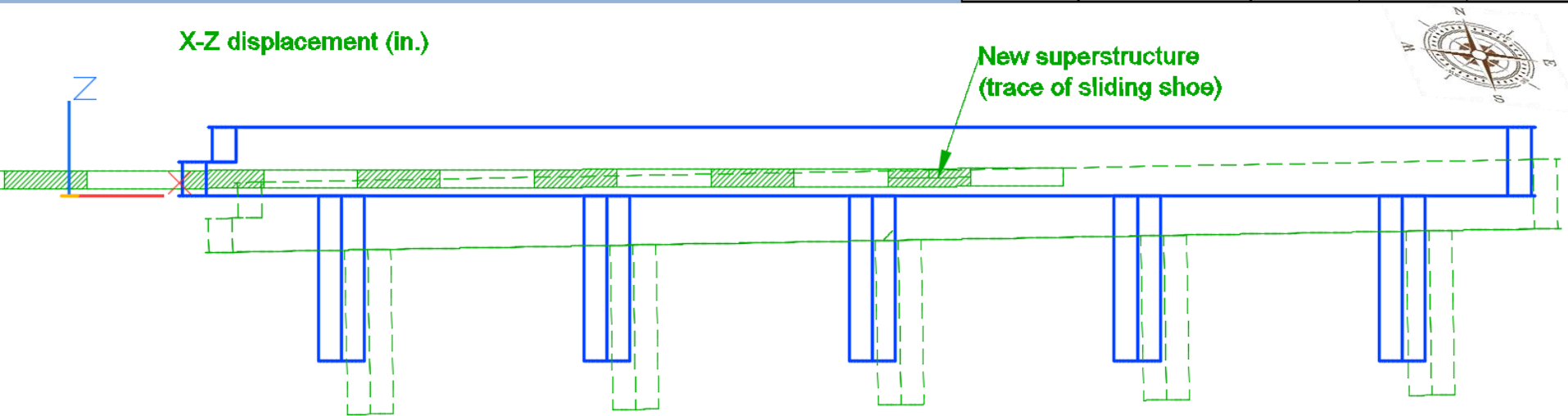
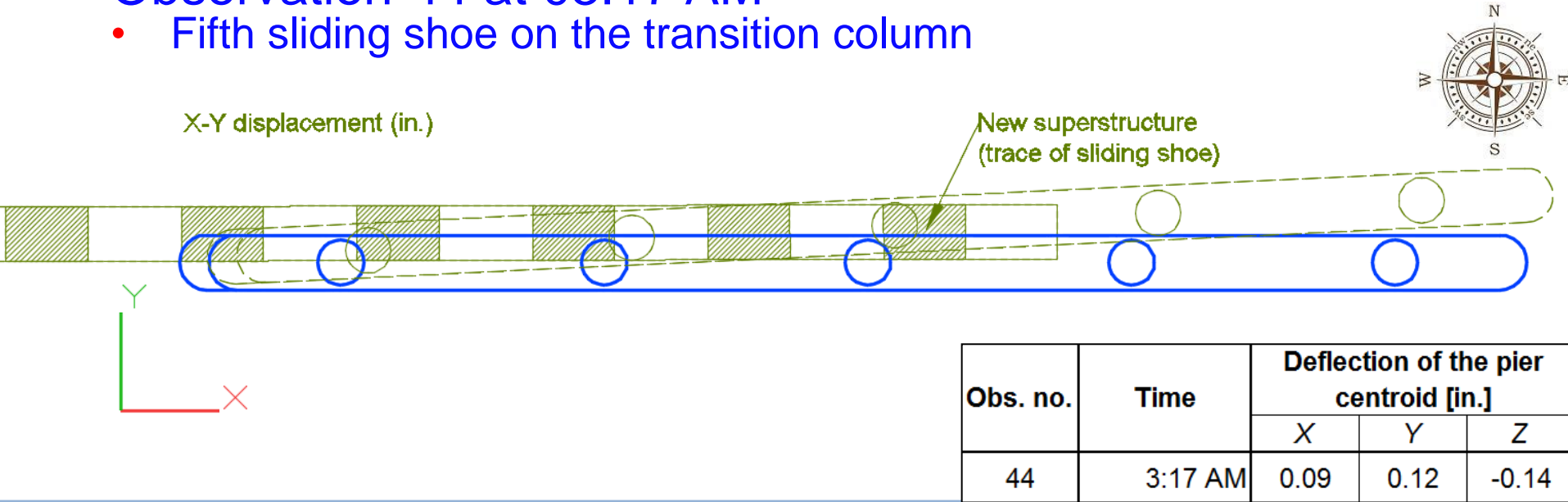
Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
38	2:52 AM	0.09	0.13	-0.10

X-Z displacement (in.)



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-44 at 03:17 AM
 - Fifth sliding shoe on the transition column



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

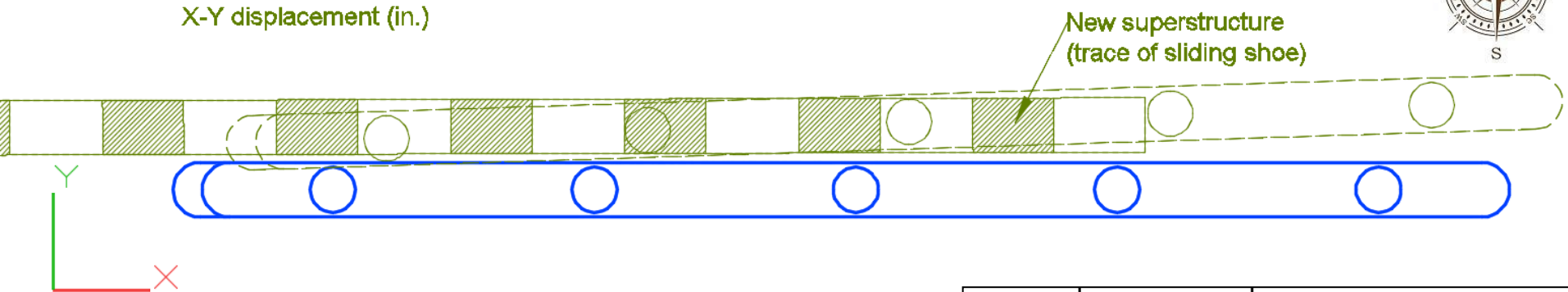
- Observation-44 at 03:17 AM
 - Fifth sliding shoe over the transition column



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

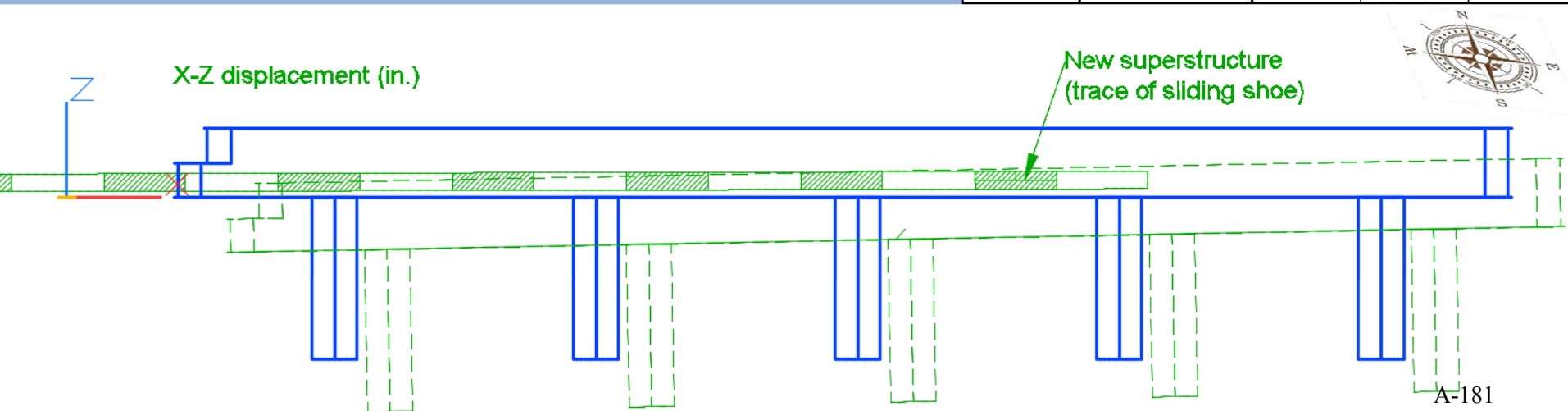
- Observation-45 at 03:21 AM
 - Fifth sliding shoe completely on pier

X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
45	3:21 AM	0.18	0.22	-0.15

X-Z displacement (in.)



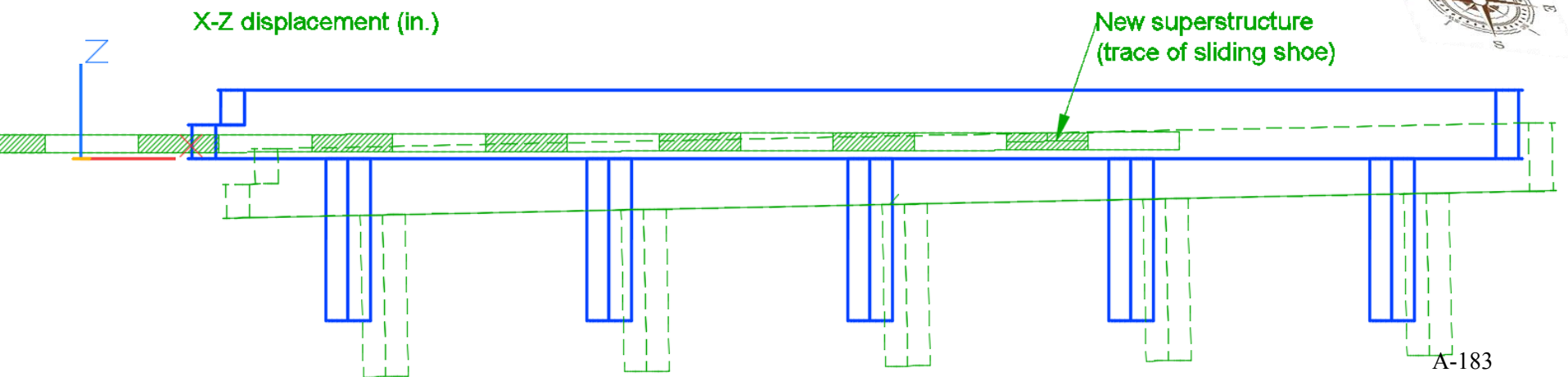
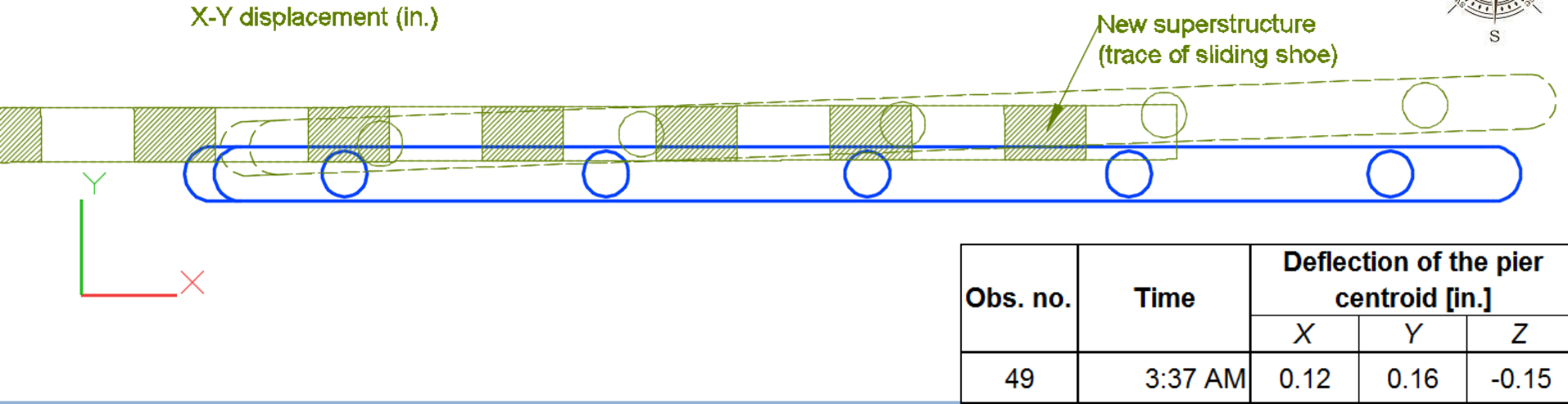
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-45 at 03:21 AM
 - First sliding shoe between col.-3 and col.-4



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

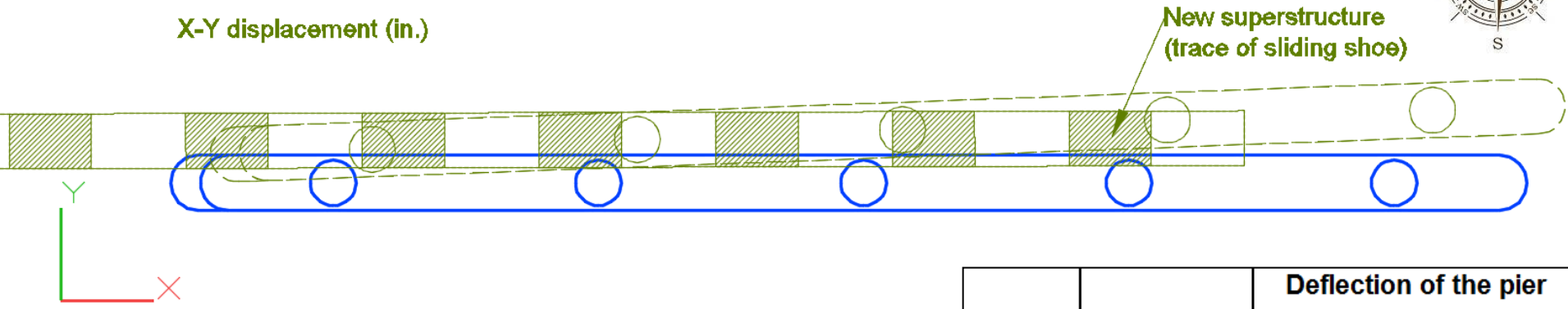
- Observation-49 at 03:37 AM
 - First sliding shoe between col.-3 and col.-4



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

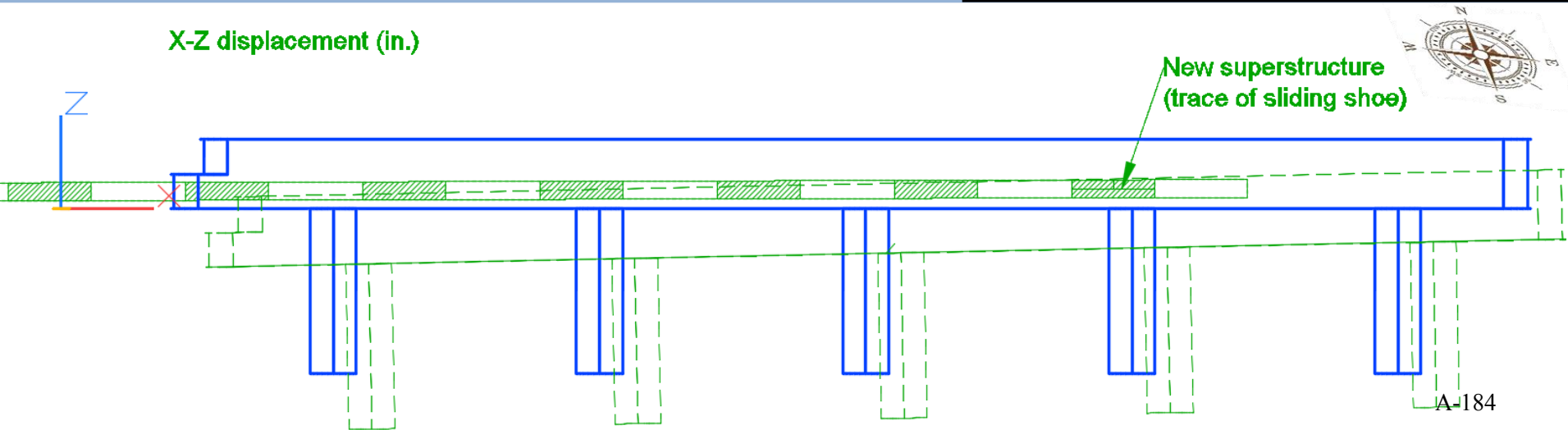
- Observation-52 at 03:46 AM
 - Sixth sliding shoe on temporary steel-column at the transition

X-Y displacement (in.)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
52	3:46 AM	0.13	0.17	-0.15

X-Z displacement (in.)



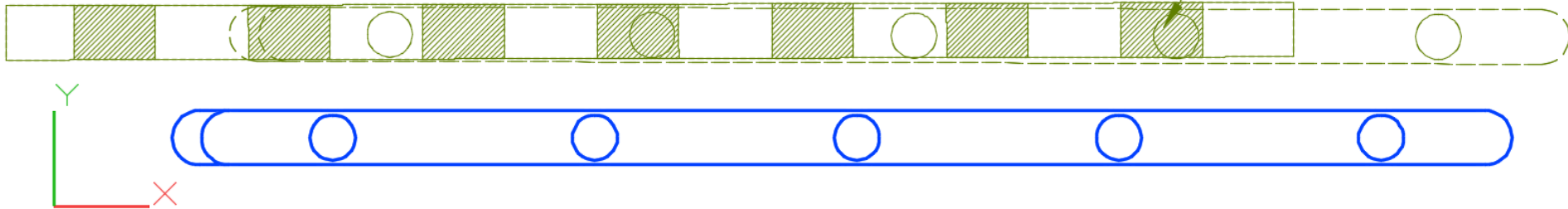
FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-55 at 03:57 AM (last observation)
 - First sliding shoe at col.-4



X-Y displacement (in.)

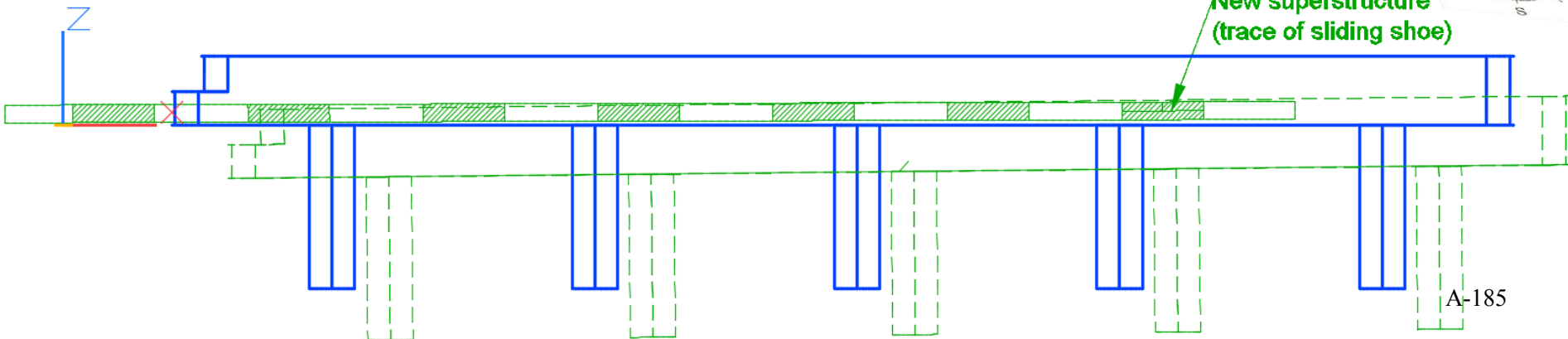
New superstructure
(trace of sliding shoe)



Obs. no.	Time	Deflection of the pier centroid [in.]		
		X	Y	Z
55	3:57 AM	0.19	0.34	-0.16

X-Z displacement (in.)

New superstructure
(trace of sliding shoe)



FIELD MEASURED DISPLACEMENTS OF M-50 BRIDGE PIER

- Observation-55 at 03:57 AM (last observation)
 - First sliding shoe at col.-4
 - Sliding was halted for more than an hour after this time.

