

BUREAU OF Field Services



CONSTRUCTION • OPERATIONS • RESEARCH • SAFETY & SECURITY



BRIDGE FIELD SERVICES

2014 MAASTO Annual Meeting

Session 6B – Bridges

MDOT Implementation of Carbon Fiber Technology

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MDOT CFRP Considerations



•MDOT main interests:

- Using innovative materials in the pursuit of the 100-year service life bridge
- Fostering economic development by using innovative materials
- Ensuring the largest benefit, and longest service life using public dollars

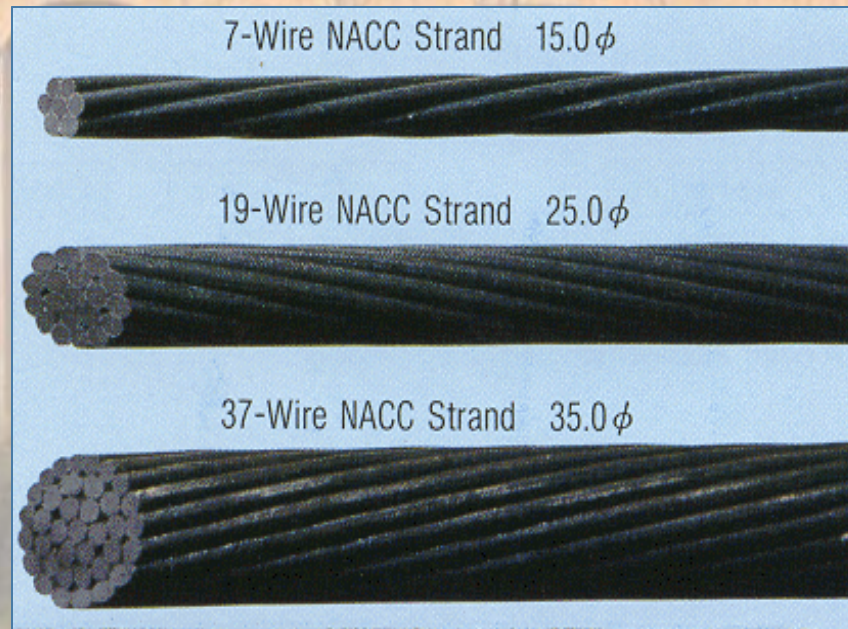
MDOT CFRP Considerations

•MDOT main interests:

- CFRP prestressing strands, and post tensioning tendons, for transverse PT, no grout is required for duct
- Currently no competitive material to uncoated ASTM A 416, Grade 270 low relaxation high strength strand
- CFRP offers non-corrosive alternate, only major behavioral difference is at ultimate strength, linear failure mode with no yield, and modulus of elasticity is roughly $2/3$ that of steel
- Design for no extreme concrete fiber tension

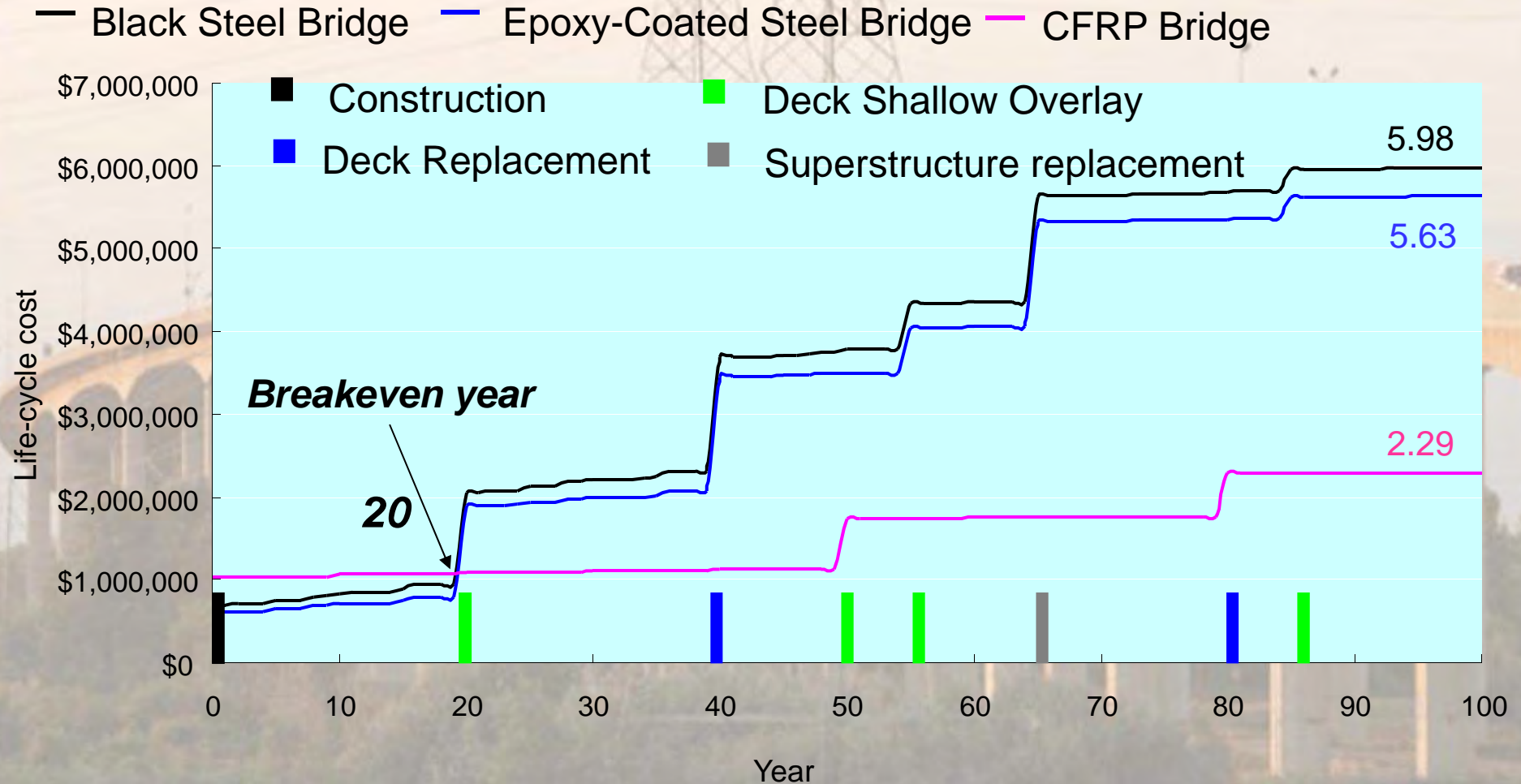
MDOT CFRP Considerations

- MDOT has been partnering with Lawrence Technological University on CFRP research since 2005
- Material specifications, stressing procedures, details and tolerances have been developed



MDOT CFRP Considerations

Bridge Life-Cycle Cost



MDOT CFRP Considerations

The background of the slide is a photograph of a multi-span concrete bridge with several tall, slender piers. In the foreground, there are some green bushes and a road with a car. In the background, several high-voltage power line towers are visible against a hazy sky.

- Based on actual life cycle data for uncoated steel, and epoxy coated steel rebar, and some long term testing of CFRP reinforcement, and theoretical deterioration rates, the life cycle cost to build and maintain these bridges can be quantified and compared
- Based on analysis, the initial cost for CFRP reinforced bridges is higher, however, the “break even” year is after 20 years of service, and for a 100 year service life, the total cost of the CFRP reinforced bridge is expected to be less

MDOT CFRP Considerations

- MDOT was recently named AASHTO Innovation Initiative (formerly TIG) Lead State Initiator for CFRP implementation
- Each year a highly valuable, but not largely recognized innovation in use at least one agency, are proven in use, and will be of significant benefit to other agencies.
- The program actively seeks out proven advancements in transportation technology, investing time and money to accelerate their adoption by agencies nationwide
- Lead State Responsibilities include:
 - Share their states' knowledge about the focus technology, and to advise potential users across the country of the possible benefits available to them
 - Develop a Marketing Plan consisting of:
 - Work Plan
 - Communications Plan
 - Performance Management Plan



MDOT CFRP Considerations

- AASHTO Innovation Initiative activities for CFRP implementation will be starting this calendar year with the formation of the Lead States Team, and development of the Marketing Plan and budget establishment
- MDOT has constructed several projects using CFRP prestressing and post tensioning, which will serve as examples of market ready deployments. Examples of these projects are as follows:

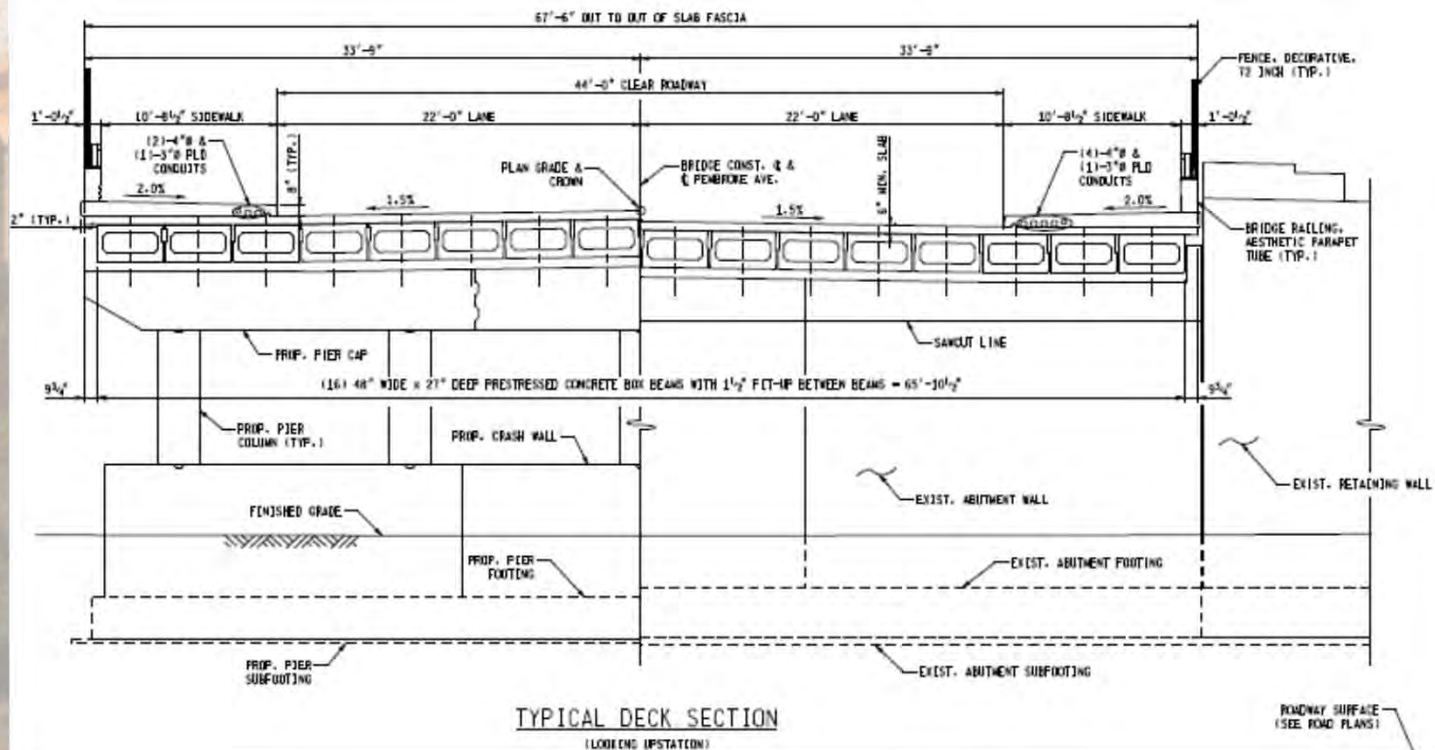
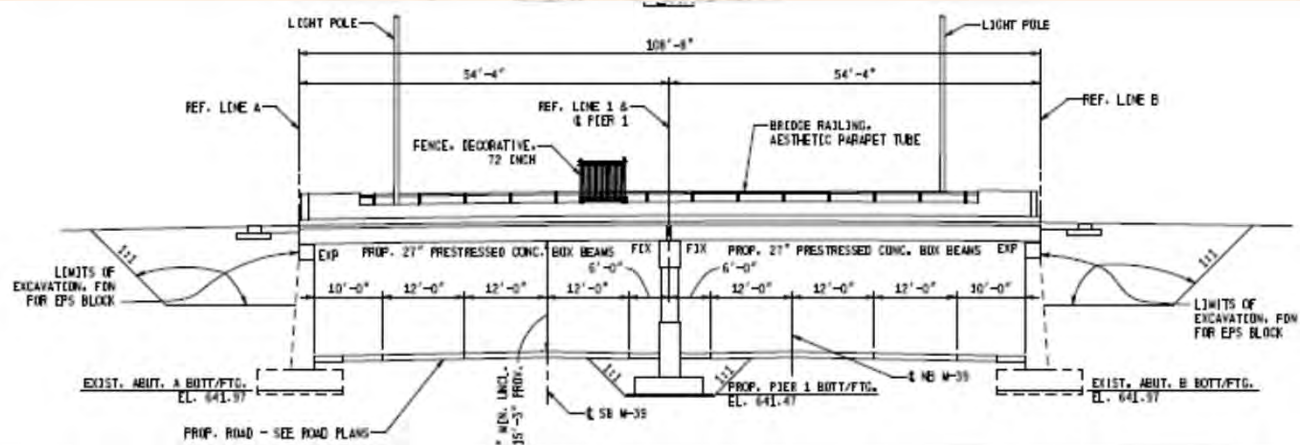


MDOT CFRP Deployment

- Pembroke over M-39 Superstructure Replacement



MDOT CFRP Deployment



MDOT CFRP Deployment



- Public outreach to explain the benefits of CFRP materials to customers and stakeholders

MDOT CFRP Deployment



- **Materials delivered to MDOT**

MDOT CFRP Deployment



MDOT CFRP Deployment

- Transverse post tensioning cables = 40 mm, 37 wire strand, with a guaranteed breaking load of 269 kips
- Cables are socketed into a stainless steel anchorage with a highly expansive material (HEM)
- Load from stressing chair is imparted on to anchorage, and nut is locked into position
- Transverse PT load = 169 kips, capacity of cable = 269 kips. Actual stress = $0.63 \cdot f_{pu}$

MDOT CFRP Deployment



- Tendons stressed from one end, load measured at dead end via load cell

MDOT CFRP Deployment



- NEFMAC Grid installation

MDOT CFRP Deployment



- NEFMAC Grid installation

MDOT CFRP Deployment



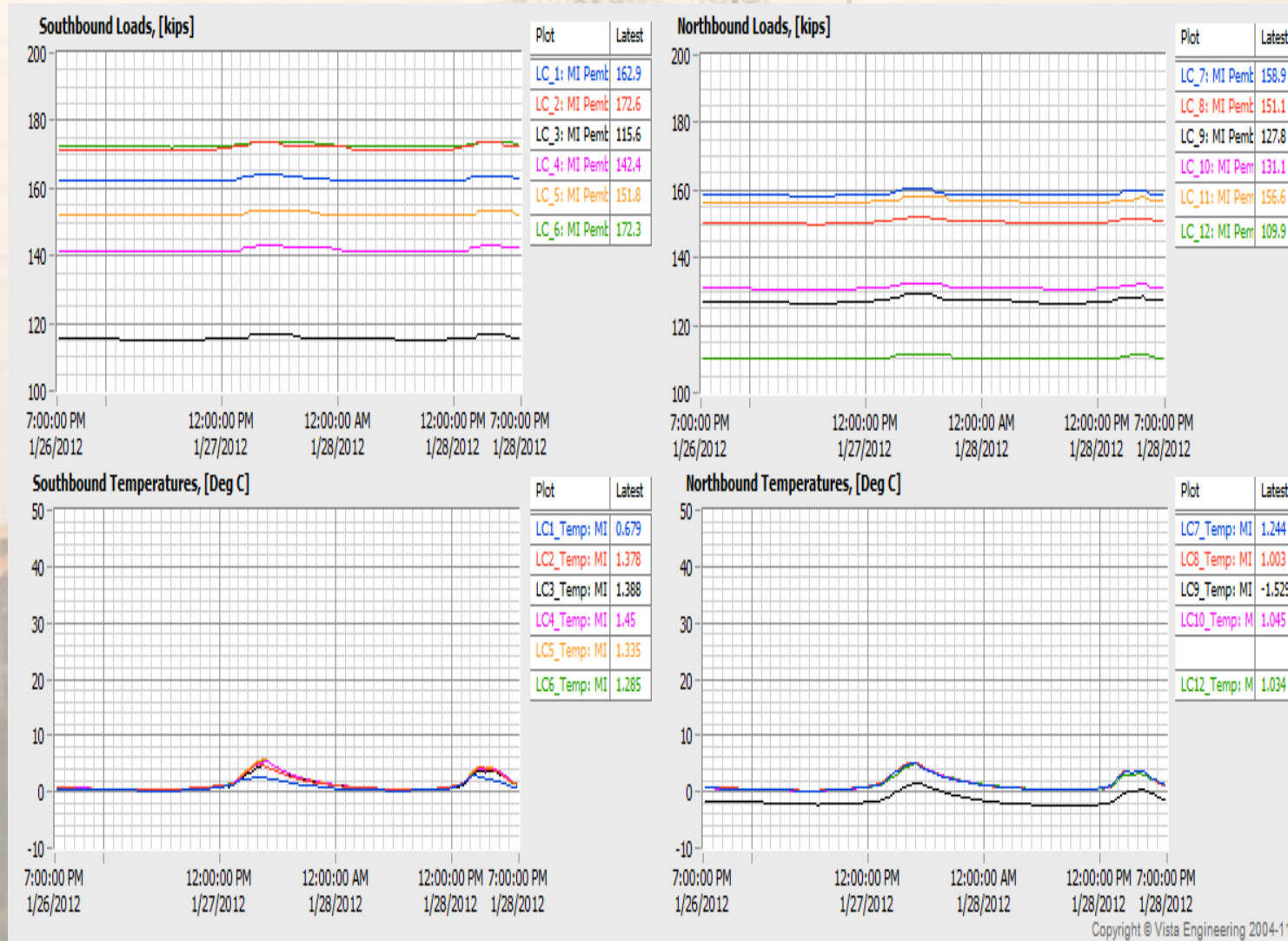
- NEFMAC Grid installation

MDOT CFRP Deployment



- Strain gages, load cells and LVDT deflectometers installed

MDOT CFRP Deployment



- Measuring deck deflections, deck strains, and PT tendon loads

MDOT CFRP Deployment



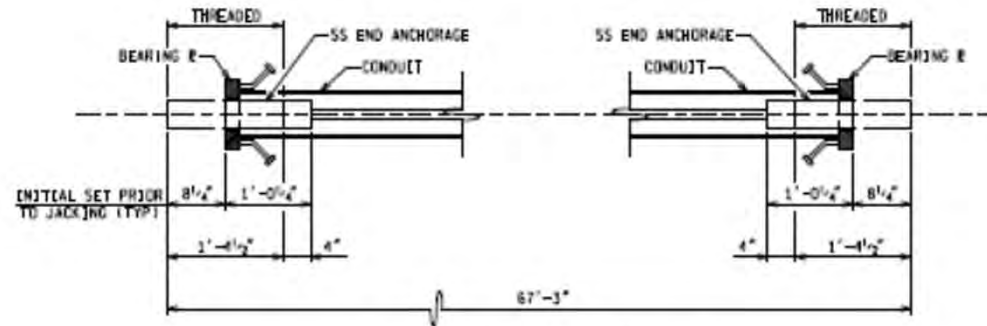
- Complete Pembroke Structure

MDOT CFRP Deployment

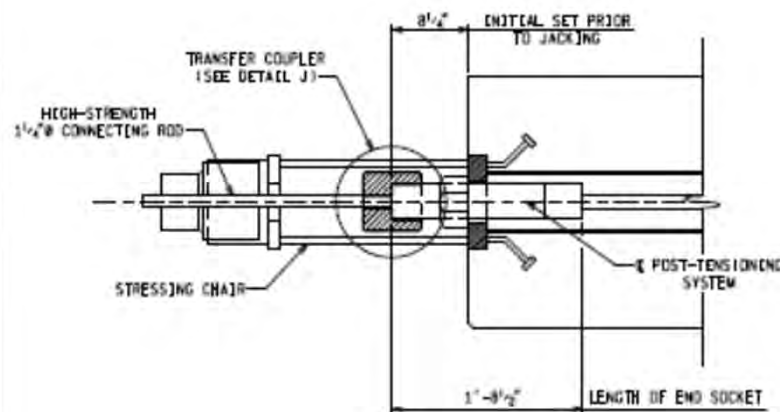


- M-50/US-127 BR over NS RR Bridge Replacement

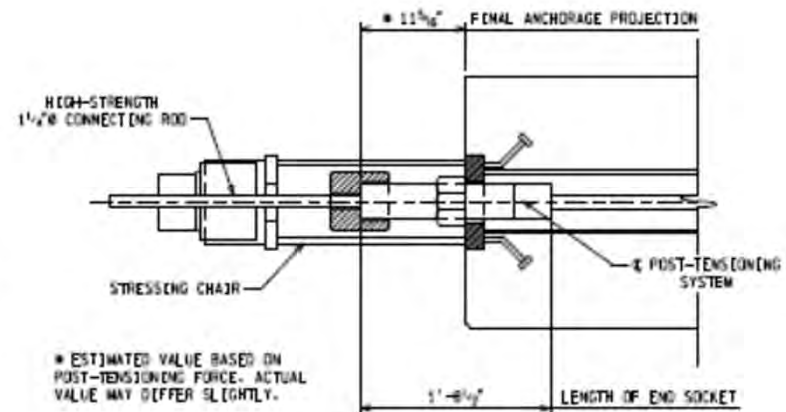
MDOT CFRP Deployment



TENDON LENGTH DIAGRAM



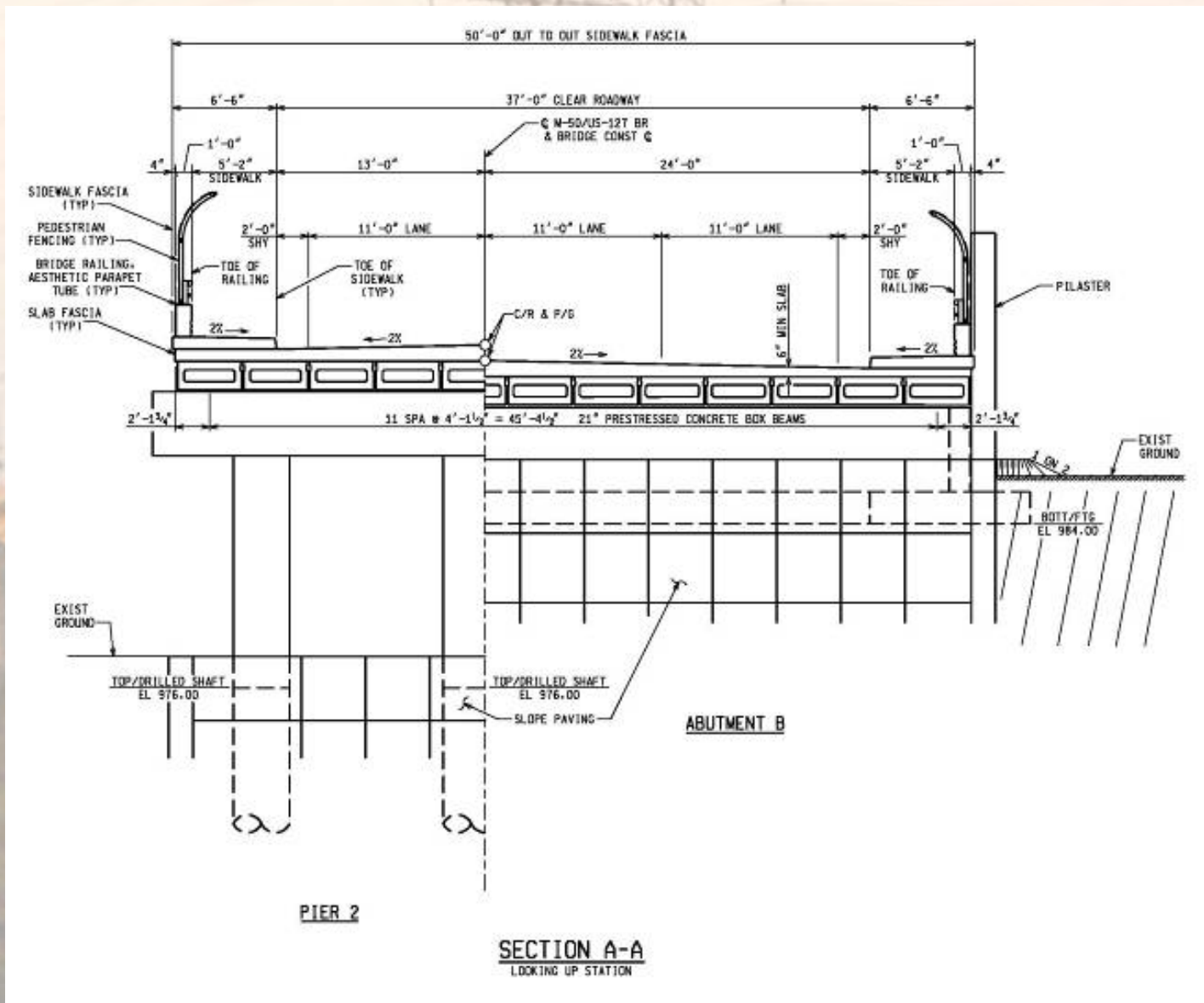
POST-TENSIONING LAYOUT
(BEFORE TENSIONING)



POST-TENSIONING LAYOUT
(AFTER TENSIONING)

- 40 mm, 37 wire CFCC post tensioning tendon

MDOT CFRP Deployment



- 21" side by side prestressed box beams

MDOT CFRP Deployment



- Cables were sheathed and fed into 5" PVC conduits

MDOT CFRP Deployment



- cable installation

MDOT CFRP Deployment



- cable installation