Causeways, Work Bridges, Cofferdams & Pier Construction

2018 Bridge Construction Inspection School

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Northern Area Construction Engineer

Morgan Ford Bridge Construction – Warren County
Pier Construction

- Be Prepared
  - Review the Specifications – Section 401, 404, 406
    - 401.03(b): Depths of Foundation
      - Elevations denoting the bottom of footings shown on the plans shall be considered approximate only. Foundations shall not be considered satisfactory until approved by the Engineer.
      - The contractor shall explore foundations by rod soundings or drillings to determine, to the Engineer’s satisfaction, the adequacy for the foundations to support the structure.
    - 404.03(a): Forms
      - Formwork shall be mortar-tight and of sufficient rigidity to prevent distortion attributable to the pressure of the concrete and other loads incidental to the construction operations
      - Forms shall be set and maintained to true line. When forms appear to be unsatisfactory, either before or during concrete placement, the Engineer may order the work stopped until defects have been corrected.
      - Forms shall be treated with an approved oil or form-coating material or thoroughly wetted with water immediately before concrete placement.
Pier Construction

404.03(c): Placement and Consolidation
- Individual placements of more than 25 yards of concrete shall be at the following rate:
  - 26-80 @ 25%/hr, over 80 @ 20 cu. yd./hr
- Dropping concrete a distance of more than 5 feet or depositing a large quantity at any point and running or working it along forms will not be permitted.
- Concrete shall be placed in continuous horizontal layers not more than 12 inches in thickness; however, slabs shall be placed in a single layer
- Concrete shall be thoroughly consolidated during and immediately following placement.

404.03(e): Pumping
- Placing concrete by pumping will be permitted provided concrete is pumped through a conduit system that is not aluminum (change from 2007)

404.03(j): Removing Formwork and Forming for and Placing Superimposed Elements:
- Formwork Removal – Side Forms or elements not immediately subjected to loading (Footing and walls or columns with height to width ratios less than 10:1) shall be 48 hours or 30 percent concrete strength (f'c); All other elements shall be 60 percent concrete strength (f'c)
- Forming for superimposed elements – Elements not immediately subject to loading (Footing and walls or columns with height to width ratios less than 10:1) shall be 48 hours or 30 percent concrete strength (f'c); All other elements shall be 60 percent concrete strength (f'c)
- Placing Concrete in forms for superimposed elements shall not be done until concrete has attained 60 percent concrete strength (f'c) except for footings, where they concrete may be placed when the footing has attained 40 percent f'c.

404.03(k): Curing Concrete
- Atmospheric Temperature above 40 degrees F in shade – Concrete cured for 7 days regardless of the strength obtained by control cylinders. A curing agent or medium shall be used.
- Atmospheric Temperature below 40 degrees F in shade – Curing shall be immediately resumed using insulated blankets or other approved methods that will retain or supply moisture and maintain the temperature at the outermost surfaces of the concrete mass above 50 degrees F for at least 72 hours immediately following concrete placement and above 40 degrees for at least 48 additional hours.

404.03(l): Protecting Concrete
- Silicone Treatment: When unpainted weathering steel is used in a structure and no other concrete waterproofing surface finish is specified, the contractor shall apply a 5 percent solids, solvent-based, clear, water repellent silicone treatment in two coats to the surface of the concrete substructure on exposed concrete surfaces below and including the bridge seats….treatment shall be applied after cleaning of the exposed substructure concrete surfaces and before any structural steel is erected.

406.03(b): Protecting Material
- Reinforcing steel shall be stored on platforms, skids, or other supports that will keep the steel above ground, well drained, and protected against deformation.

406.03(d): Placing and Fastening
- In substructures, the cover shall be at least 3 inches except as follows:

**Remember**
1. Abutment neat work and pier caps: 2 ½ inches
2. Spirals and ties: 2 inches
Pier Construction

• Be Prepared - Review your Contract
  • Review the environmental permits in the contract. (TOYR)
  • Review Provisions for Maintenance of Navigation
  • Review Special Provisions and Supplemental Specifications in the contract

  • Possible Pay Items:
    • Cofferdams – Specification Reference 401
    • Temporary Causeways/Work Bridges – Reference usually denoted in Permits/Plans
    • Structure Excavation – Specification Reference 401
    • Reinforcing Steel – Reference 406
    • Concrete Class A3 – Reference 404
    • Piling – Driven or Pre-Bore
    • Drilled Shafts
    • Micropiles
    • PDA Testing
    • Concrete Footing Collar

Pier Construction

• Be Prepared – Review Plans
  • Ensure you have the latest, approved set of plans
  • Boring Logs
  • Bridge General Notes – Temporary Shoring, Causeway, Work Bridges, etc.
  • Pier Layout – Dimensions, size, foundation, etc.
  • Reinforcing Steel Schedule and Layout – Review and check for accuracy
All reinforcing steel shall be deformed and shall conform to ASTM A615, Grade 60 except for reinforcing steels noted as ORR corrosion resistant reinforcement which shall conform to the applicable specifications noted in the special provisions. All reinforcing bar dimensions on the detailed drawings are to centers of bars except where otherwise noted and are subject to fabrication and construction tolerances.

All footings shall be keyed a minimum of 6" into bedrock and shall bear on competent rock. Footings have been designed for a factored bearing resistance of 7.0 tons/ft².
Morgan Ford – Sheet 3

ESTIMATED QUANTITIES – SUBSTRUCTURE ONLY

| Concrete | Rebar | Cylinders / Sheets | Concrete Pumps | Reinforcing Steel | Sheet Pile | Sheet Pile | Pipe Piles | Tieback Piles | Excavation | Mass Drift | Added Load | Cofferdam | Pile Driving | Tonnage | Steel Truss Load | Material | Cylinders | Tonnage |
|----------|-------|--------------------|----------------|-------------------|------------|------------|------------|--------------|-------------|------------|------------|------------|------------|-------------|---------|----------------|----------|-----------|---------|
| Abutment A: | | | | | | | | | | | | | | | | | | | | |
| React | 44.1 | | | | | | | | | | | | | | | | | | | |
| Fooring | 45.6 | | | | | | | | | | | | | | | | | | | |
| Pier 1: | | | | | | | | | | | | | | | | | | | | |
| React | 37.1 | | | | | | | | | | | | | | | | | | | |
| Fooring | 29.3 | | | | | | | | | | | | | | | | | | | |
| Pier 2: | | | | | | | | | | | | | | | | | | | | |
| React | 46.1 | | | | | | | | | | | | | | | | | | | |
| Fooring | 29.3 | | | | | | | | | | | | | | | | | | | |
| Pier 3: | | | | | | | | | | | | | | | | | | | | |
| React | 42.4 | | | | | | | | | | | | | | | | | | | |
| Fooring | 42.4 | | | | | | | | | | | | | | | | | | | |
| Pier 4: | | | | | | | | | | | | | | | | | | | | |
| React | 42.4 | | | | | | | | | | | | | | | | | | | |
| Fooring | 42.4 | | | | | | | | | | | | | | | | | | | |
| Pier 5: | | | | | | | | | | | | | | | | | | | | |
| React | 42.4 | | | | | | | | | | | | | | | | | | | |
| Fooring | 42.4 | | | | | | | | | | | | | | | | | | | |
| Abutment E: | | | | | | | | | | | | | | | | | | | | |
| React | 24.3 | | | | | | | | | | | | | | | | | | | |
| Fooring | 24.3 | | | | | | | | | | | | | | | | | | | |
| Total | 50.1 | | | | | | | | | | | | | | | | | | | |

Denotes items to be paid for on the basis of plan quantities in accordance with current Road and Bridge Specifications.

** Structural Excavation is estimated after removal of existing structure.
CONCRETE BACKFILL AND KEY IN DETAIL
- Limits of payment for concrete backfill and structure excavation.
- Concrete Class A3 shall be used for the concrete backfill of plan.
- Portion of backfill and excavation outside of the limits of payment
  will be the contractor's responsibility. No additional payment will be allowed.

Not to scale
Pier Construction

- Be Prepared - Review Submittals
  - Revised Permit Sketches
  - In-Stream/Dewatering Plans
  - Work Bridge Designs
  - Cofferdam Designs
  - Temporary Shoring Designs
  - Navigation Plans
  - Pile Driving Submittals
    - (hammers, welders, etc.)
  - PDA Firm Resume and Approval
  - Manufactured Form System Specifications
  - Contractor’s Schedule
  - Ensure all material documentation has been submitted and approved.

Be prepared to keep CM, ACE & Bridge informed of plans and progress (CM & ACE also need to be informed of overruns and underruns)
Pier Construction – Causeways/Work Bridges

- **Causeways** – A raised road or path through low or wet ground that will provide access during construction and/or demolition operations
  - These are typically set up as Lump Sum Pay Items in contracts
  - Terms of payment and design requirements are usually in the contract or plans
  - The contractor will need to install per the permit or provide a submittal to acquire a permit modification to deviate from the approved permit
  - Payment generally includes installation and removal
  - Maintenance during construction is generally included in the Lump Sum but you should review your contract to be certain
  - The width, height and footprint are controlled by environmental permits
  - The Time of Year Restriction (TOYR) in the permit will also control when the contractor can install this item.
  - They will generally consist of non-erodible material
  - Pipes are often included in the design to account for hydraulic flows
    (Be certain to check for counter-sinking requirements)

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Overall Bridge

**NOTES:**
The temporary construction causeway shall be constructed with non-erodible material. Existing bridge to remain as pedestrian bridge and to be maintained by VDOT. Existing gravel road in front of the proposed area to be maintained during and after construction.
Pier Construction – Causeways/Work Bridges

Overall Bridge

<table>
<thead>
<tr>
<th>Pier Construction – Causeways/Work Bridges</th>
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<td>![Diagram with tables]</td>
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| Overall Bridge |
• **Work Bridge** – Temporary bridges used for similar purposes as causeways. These are generally installed to allow for more hydraulic capacity and come into play on projects with higher potential for flooding events.
  • These are typically set up as Lump Sum Pay Items in contracts
  • Terms of payment and design requirements are usually in the contract or plans
  • A licensed Virginia PE is normally required to stamp the design. The design will be submitted to Bridge for review prior to installation
  • The contractor will need to comply with permit requirements – they have some flexibility on the design as long as the intent of the permits are maintained – This will be reviewed and determined by the ACE or designee
  • Payment generally includes installation and removal
  • Maintenance during construction is generally included in the Lump Sum but you should review your contract to be certain
  • The width, height and footprint are controlled by environmental permits
  • The TOYR will also control installation of the work bridges.
Pier Construction – Causeways/Work Bridges

Artz Road
Work Bridge
Contractor Design

Pier Construction – Causeways/Work Bridges

Artz Road
Pier Construction – Causeways/Work Bridges

Artz Road

Artz Road
Pier Construction – Causeways/Work Bridges

South Fork Bridge

Pier Construction

- **Cofferdams**
  - Cofferdams/Sheeting should be reviewed by the CM and ACE for compliance with the permits.
  - Cofferdam/Sheeting should be reviewed by Bridge for structural design requirements.
  - Ensure the Contractor’s cofferdam/sheeting allows extra room in case the bottom of footing needs to be lowered. Slopes vary depending upon soil and water conditions.
  - There should also be sufficient room within the cofferdam to allow for a low area outside the footer for a sump
  - Review the submitted design prior to construction.
  - Discuss concerns with getting a functional cofferdam with the contractor. Clarify their game plan in order to help seal leaks and control water infiltration.
  - Discuss pump location, sizes and access to dewatering areas/devices with the Contractor.
Pier Construction – Cofferdams

Sheet Pile
PZC-18
Ø 20' Length
4 Sides

Cofferdam Pier 3 & 5

Permit Plan
55'X31' Pier 3
55'X29' Pier 5

Sheet Pile
PZC-18
Ø 25' Length

Pier Footing
Pier 3 - 8'X32'
Pier 5 - 6'X32'

BOF Elevation
Pier 3 - 415.55'
Pier 5 - 417.30'

Not to Scale

Pier Construction – Cofferdams

Sheet Pile
PZC-18
Ø 20' Length
Typical - All Sides

Cofferdam Pier 4

18'
44'

Not to Scale
Pier Construction – Cofferdams

Morgan Ford Pier 5

Pier Construction -Cofferdam

Morgan Ford Pier 4
Pier Construction - Cofferdams

Morgan Ford Pier 4

Morgan Ford (Checked with Army Corp and VMRC on barges)
Pier Construction

• **Structure Excavation for Piers**
  • Structure Excavation is setup in most projects as plan quantity.
  • Verify existing ground elevations before disturbing the area.
  • The contractor can challenge plan quantity. Having your own information will help evaluate any discrepancies.
  • Keep in mind that plan quantities are based on digital elevation models developed from the survey before the piers are even located. There is some degree of approximation in the quantities because of the methods used in computing the elevations.
  • It can also be many years between the original survey and the start of construction. Elevations often change due to floods and meandering of the streams.
  • Do not accept plan quantities as absolutely correct without checking them. Structure excavation prices are much higher than regular excavation so the stakes are much higher if there is an error.
  • Keep the Bridge Section informed of planned operations. If they need to evaluate a foundation to keep the contractor moving, keep them informed ahead of time.

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401.03 – If the foundation is rock or the footing is supported on piles, other than for shelf abutments, dewatering need to performed only during concrete and backfill operations

401.03(c) – When concrete is to rest on an excavated surface other than rock, the bottom of the excavation shall not be disturbed. The Contractor shall not perform the final removal of foundation material to grade until just prior to concrete placement.

*Footings below groundwater or stream level that are not founded on rock or piles must be dewatered continuously until poured. Certain Shale in Staunton District will turn from competent rock that can not be ripped to mush in a single day after exposure to air and water. If water is allowed to fill up in the hole at night and is pumped down each morning the soils may become saturated and unstable. This creates constructability issues as well as safety concerns.*
Pier Construction

- **Structure Excavation for Piers (continued)**
  - The contractor should excavate to plan elevation if the footing is to be supported on piles.
  - The contractor should excavate to plan elevation or higher if rock is encountered above plan grade.
  - The District Bridge Engineer (or designee) should be consulted if rock is encountered above plan grade rather than just continuing down to grade.
  - Footings are to be keyed into rock. Remove high spots in the rock. Low areas may need to be filled with sub-footings - this should be reviewed and approved by the Bridge Engineer.
  - The contractor is to perform soundings for footings that bear on rock.
  - The soundings are normally drilled 5’ in depth and recommended at each of the corners and 10’ along the sides. Look for potential weak areas in the center and perform soundings in those areas. We are looking to expose any weaknesses in the foundation.
  - The inspector should observe and record the drilling to see if drill bit drops through mud seams or the rate of penetration varies between holes which might indicate soft areas. The location of the soundings should be noted on a drawing of the footing, along with any relevant observations or information.
  - This information is very helpful in determining if the bearing strata are adequate to support the footing.

- **Structure Excavation for Piers - Subfootings**
  - Sub-footings are usually wider than the actual footing by a foot or more on each side. Bridge Section should be consulted as there are many variables when determining the appropriate sub-footing size.
  - The top of a sub-footing should be left rough to provide a good bond with the footing if it is not poured monolithically with the footing.
  - The contractor may want to finish the area right where the footing form will be set so it will provide a level base for the form.

  - Footings should be reviewed/inspected by the District Bridge Engineer unless he has delegated that responsibility to someone else.

  - If blasting is allowed on your project make sure it is not done close to existing or new structures. Blasting for the approach work, utility work, or drainage pipes or structures should be scheduled so that it is done beforehand.
Pier Construction

- **Structure Excavation for Piers (continued)**
  - Structure excavation will be measured in cubic yards of material removed from within the limits of the vertical planes 18 inches outside the neat lines of footings or within vertical planes 18 inches outside of the neetwork that does not have footings directly beneath it, such as curtain walls or cantilevered wingwalls.
  - Concrete and structure excavation are paid for as plan quantities.
  - If the contractor elects to eliminate forms and fill the hole to top of footing with concrete, this must also be discussed ahead of time with Bridge as additional reinforcement steel or other adjustments may be needed.
  - There are occasions when we want to pour bank to bank. There should be a note on the plans and appropriate pay items included in the contract.
  - Adjustments of quantities require adequate supporting documentation.
    - We need sketches showing location and depth of the bottom of footing (even when paid by truckload count)
    - Photos are very helpful
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Before pouring the stem section verify that the bottom of cap, top of cap, and seat elevations do not have to be revised by the contractor to account for pot bearing heights different from the plan dimensions.

Before starting a pour, verify anchor bolt location and embedment, seat elevations, and distances to any other substructure units already poured.

Check that forms are braced and will not move during concrete placement. Forms should be braced adequately but clearances need to be maintained to railroad tracks, roadways, haul roads, etc.

Forms should be cleaned and oiled before they are placed to keep oil off reinforcing steel and footings.

Slope cap between seats to drain.

Do not pour stem concrete higher than bottom of cap elevation or there will be insufficient space for cap concrete under the main cap rebar.

Make sure that the contractor has adequate handrails in place and tie off points for personnel forming and pouring the pier concrete.

Concrete - use hoppers and chutes to prevent concrete segregation. No drops more than 5'.
Wind loads on a tall pier just after it has been poured are often the most critical loads on a pier as it has low concrete strength and no superstructure on it to connect it to other elements at this stage of construction.

Stripping forms - Make sure the cylinders are cured under the same conditions as the outermost edge of the concrete, not in a curing box. Refer to the specifications for details.
Pier Construction

Backfilling Piers

Don't backfill unevenly. Be extremely careful when backfilling a pier that is in a slope – it may be pushed out of plumb or even overturn if the material on one side is compacted more tightly than on the other. Do not backfill until design strength has been attained.

Pier Construction – Bridge Seat Bearing Areas

- Specification Section 404.06
- Finished plane and level
- Not more than 1/16 inch from plane or more than 1/32 inch per foot from level or from the slope specified
- Areas shall be clean and tested for planeness and levelness
Pier Construction

Reinforcing Steel in Piers
- Contractor should use plastic or plastic tipped chairs to maintain positions of reinforcing steel mats in stems and caps. (epoxy also allowed)
- Contractor should use concrete blocks in footing.
- No wood or brick.
- The contractor may use wood to hold the reinforcing mats away from the form face while pouring the concrete. Extra care must be taken to ensure that all wood is removed ahead of placing the concrete.
- Contractor should build a frame to hold dowels in footing in the correct position. The inspector should check embedment depth. (Don’t let him stick the rebar into the footing concrete after it has set).

Reinforcing Steel Storage

406.04(b): Protecting Material
- Reinforcing steel shall be stored on platforms, skids, or other supports that will keep the steel above ground, well drained, and protected against deformation.

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Cub Run
(preferably cover with plastic to shield from moisture)

Pier Construction

Cub Run Pier Foundation
Pier Construction

Cub Run

Pier Construction

Cub Run
Pier Construction

Cub Run

Pier Construction

Cub Run
Pier Construction

Cub Run

Pier Construction

Cub Run
75

Pier Construction

Cub Run

76

Pier Construction

Cub Run
Pier Construction

Cub Run

Pier Construction

South Fork