PRECAST CONCRETE SUBSTRUCTURES GENERAL NOTES

INTRODUCTION

This document contains general design and contract drawing notes for precast concrete substructures. These notes are intended to provide guidance on the design and detailing of precast concrete substructures. The notes cover general information on reinforcement detailing, material notes, and general design specifications.

MATERIAL NOTES

PRECAST ELEMENT CONCRETE

Element concrete compressive strength and flexural strength must be in accordance with the project specifications. These strengths are required to ensure the integrity of the substructure.

REINFORCEMENT

Provide grade 60 reinforcing steel bars that meet the requirements of ASTM A615. The reinforcing steel bars shall be in accordance with the project specifications. The reinforcing steel bars shall be identified.

Conducting a thorough review of the precast concrete substructure design and detailing is essential to ensure the structural integrity of the project.

PRECAST UNIT DESIGN AND CONTRACT DRAWING NOTES

This document contains general design and contract drawing notes for precast concrete substructures. These notes are intended to provide guidance on the design and detailing of precast concrete substructures. The notes cover general information on reinforcement detailing, material notes, and general design specifications.

GENERAL NOTES

This document contains general design and contract drawing notes for precast concrete substructures. These notes are intended to provide guidance on the design and detailing of precast concrete substructures. The notes cover general information on reinforcement detailing, material notes, and general design specifications.
The document contains a detailed description of a structural concrete component, including definitions, calculation methods, and payment adjustments for low-strength components. It appears to be a technical specification or instruction, possibly for a construction project, detailing how to evaluate, disassemble, and adjust for the strength of concrete substructures. The text is formatted in a formal, structured manner, typical of engineering or architectural documentation.
PRECAST FOOTING NOTES

1. CONTRACTOR TO DETERMINE SIZE AND SPACING OF FOOTING BASED ON SITE DESIGN AND THE SPREAD REINFORCING DESIGN.

2. LOCATION TOLERANCE ON LOCATION AS IN.

3. DETAIL BAR REINFORCEMENTS TO THE LIMITS OF THE FOOTING.

4. PROVIDE * CLEAR COVER FOR BOTTOM RAYS OR REINFORCING.

5. FOR ALL LEVELING DEVICES REVIEW SHEET A-2.

6. ALL REINFORCING NOT SHOWN IN DRAWING.

7. USE CAST-IN-PLACE EXTENSIONS TO KEEP SIZE AND WEIGHT OF PRECAST FOOTING WITHIN LIMITS.

PRECAST FOOTING ON PIPE PILES

NOTE: REINFORCING STEEL RAYS CAN BE FULLY PLANTED IN THE PILE OR AFTER PILE INSTALLATION.
SECTION A-A1: CANTILEVER ABUTMENT WITH PRESTRESSED CONCRETE GIRDERS

SECTION A-A1: CANTILEVER ABUTMENT WITH STEEL GIRDERS

SECTION C-C1: TYPICAL CANTILEVER ABUTMENT STEM SHEAR KEY

NOTE: REINFORCEMENT NOT SHOWN FOR CLARITY
NOTE:
1. APPROACH SLAB THICKNESS IN ACCORDANCE WITH BD-628M OR A SMALLER THICKNESS MAY BE USED IF CONFIRMED BY DESIGN COMPUTATIONS WHICH TAKE INTO ACCOUNT THE HIGHER CONCRETE STRENGTH OF PRECAST CONCRETE.

CORRECTIONS TO THE SLAB THICKNESS INDICATED WITH YELLOW HIGHLIGHTING MADE BY BRIDGE DESIGN AND TECHNOLOGY DIVISION ON 7-30-14 AFTER COMMUNICATION WITH STANDARD DEVELOPER.
NOTE:
2. APPROACH SLAB THICKNESS IN ACCORDANCE WITH BD-628M OR SMALLER THICKNESS MAY BE USED IF CONFIRMED BY DESIGN COMPUTATIONS WHICH TAKE INTO ACCOUNT THE HIGHER CONCRETE STRENGTH OF PRECAST CONCRETE.

NOTE
2. APPROACH SLAB THICKNESS IN ACCORDANCE WITH BD-628M OR SMALLER THICKNESS MAY BE USED IF CONFIRMED BY DESIGN COMPUTATIONS WHICH TAKE INTO ACCOUNT THE HIGHER CONCRETE STRENGTH OF PRECAST CONCRETE.

NOTE
1. 2 LAYERS OF 4 MIL POLYETHYLENE SHEETING PROVIDE 2'-6" CAP FROM HEAT RISE OF BACKFILL, POLYETHYLENE SHEETING ALONG BACKFILL TO ALLOW FOR DRAINAGE.

FENNEDT DRAWING 12-603-BDDTD 3/18/2013

CORRECTIONS TO THE SLAB THICKNESS INDICATED WITH YELLOW HIGHLIGHTING MADE BY BRIDGE DESIGN AND TECHNOLOGY DIVISION ON 7-30-14 AFTER COMMUNICATION WITH STANDARD DEVELOPER.
5. Approach slab thickness in accordance with BD-628M or a smaller thickness may be used if confirmed by design computations which take into account the higher concrete strength of precast concrete. See Note 5.

Corrections to the slab thickness indicated with yellow highlighting made by Bridge Design and Technology Division on 7-30-14 after communication with standard developer.
5. Approach slab thickness in accordance with BD-628M or a smaller thickness may be used if confirmed by design computations which take into account the higher concrete strength of precast concrete.

CORRECTIONS TO THE SLAB THICKNESS INDICATED WITH YELLOW HIGHLIGHTING MADE BY BRIDGE DESIGN AND TECHNOLOGY DIVISION ON 7-30-14 AFTER COMMUNICATION WITH STANDARD DEVELOPER.
NOTE:
1. APPROACH SLAB THICKNESS IN ACCORDANCE WITH BD-628M OR A SMALLER THICKNESS MAY BE USED IF CONFIRMED BY DESIGN COMPUTATIONS WHICH TAKE INTO ACCOUNT THE HIGHER CONCRETE STRENGTH OF PRECAST CONCRETE.

SEE NOTE 1

CORRECTIONS TO THE SLAB THICKNESS INDICATED WITH YELLOW HIGHLIGHTING MADE BY BRIDGE DESIGN AND TECHNOLOGY DIVISION ON 7-30-14 AFTER COMMUNICATION WITH STANDARD DEVELOPER.

NOTE:
1. APPROACH SLAB THICKNESS IN ACCORDANCE WITH BD-628M OR A SMALLER THICKNESS MAY BE USED IF CONFIRMED BY DESIGN COMPUTATIONS WHICH TAKE INTO ACCOUNT THE HIGHER CONCRETE STRENGTH OF PRECAST CONCRETE.
WATERPROOFING DETAIL AT BACKWALL WITH PAVING NOTCH

WATERPROOFING DETAIL AT BACKWALL WITHOUT PAVING NOTCH

PIER WATERPROOFING DETAILS

PIER WATERPROOFING INSTALLATION NOTE:
INSTALL 2'-0" PRE-FAB WATERPROOFING MEMBRANE TO FIT PIER COLUMN AND TOP OF POSTING AS SHOWN. CONCRETE TO BE PLACED DIRECTLY ON TOP OF WATERPROOFING MEMBRANE. POSTING, SECTION 1-1, TO PROVIDE 1'-0" MINIMUM PRE-FAB WATERPROOFING MEMBRANE IN EACH DIRECTION OVER WATERPROOFING MEMBRANE AS PROTECTION.

NOTES
1. FOR ADDITIONAL WATERPROOFING DETAILS, SEE 600-40 AND 600-59.

ABUTMENT, WINGWALL OR RETAINING WALL
WATERPROOFING DETAIL

+ WATERPROOFING MEMBRANE AND 1'-0" THICK PRE-FAB CELLULAR POLYSTYRENE TO BE USED ON FRONT FACE OF ABUTMENT, WINGWALL OR RETAINING WALL. TAPER TO CURVE THE DISTANCE FROM EDGE OF POSTING TO THE FRONT FACE OF THE RETAINING WALL 3'-0" AT 45°.
PRECAST STRUCTURE ELEMENTS
GUIDELINES

Central Atlantic Bridge Associates
TABLE OF CONTENTS

SECTION 1 – GENERAL INFORMATION  3
SECTION 2 – TYPICAL SUBSTRUCTURE ELEMENTS  6
SECTION 3 – USE OF TYPICAL DETAIL SHEETS  9
SECTION 4 – SHEET CHECKLIST  10
SECTION 5 – FOUNDATION TYPES  12
SECTION 6 – MILD REINFORCING AND CONCRETE PROPERTIES  13
SECTION 7 – DESIGN  15
SECTION 8 – LIFTING DEVICES, HANDLING, AND STORAGE  18
SECTION 9 – VERTICAL ADJUSTMENT  19
SECTION 10 – GROUTED SPLICE COUPLERS  20
SECTION 11 – CLOSURE POURS  22
SECTION 12 – TOLERANCES  23
SECTION 13 – ASSEMBLY PLANS  24
Section 1

GENERAL INFORMATION

The purpose of this manual is to provide guidance with the design and detailing of Precast Concrete Structure Elements according to PennDOT Drawing 12-602-BDTD, PennDOT DM-4 and AASHTO LRFD Bridge Design Specifications except as noted otherwise.

Substructures are the portions of the bridge generally located between the superstructure (beams and deck) and the foundation (supporting soil, piles, or drilled shafts). Geotechnical design, pile design, and detailing are not considered substructures and are not covered in this portion of the manual.
The Precast Substructure details sheet will normally contain, but is not limited to, the following listed details:

1. Plan View of each substructure unit
2. Elevation View of each substructure unit
3. Typical Transverse Sections as needed
4. Individual piece plans, elevations, and sections showing
   a. Dimensions
   b. Internal reinforcing details including grouted splice couplers
   c. Lifting points
   d. Approximate shipping weight of the piece
5. Connection details including grouted reinforcing splice couplers
6. Tolerance details for all applicable pieces
7. Bar Details
8. Table of Estimated Quantities

Show the following dimensions on the Precast Substructure Detail Sheet as listed below:

**Structural dimensions:** Draw all views and details in feet and inches to the nearest $\frac{1}{8}$ inch.

**Reinforcing steel:** Show reinforcement dimensions and locations in all views including bar details in feet and inches to the nearest $\frac{1}{4}$ inch. All measurements are to the centerline of the reinforcements.

**Cover:** Provide 2 inch clear cover for reinforcing unless noted otherwise. Provide 3 inch clear cover for top of footings and 4 inch clear cover for bottom of footings.

**Angles:** Show in degrees, minutes, seconds to the nearest whole second if such precision is available.
References: The Designer will verify that all requirements of the current PennDOT Drawing 12-602-BDTD, PennDOT DM-4 and AASHTO LRFD Bridge Design Specifications and current interim provisions are satisfied and properly detailed in any documents intended or provided for construction.
Section 2

TYPICAL SUBSTRUCTURE ELEMENTS

The typical detail show several types of substructure types. They include:

1. Pier Bents
2. Integral Abutments
3. Semi-integral Abutments
4. Cantilever Abutments
5. Cantilever Walls

Other substructure types are not shown. It is possible to use the details depicted to design other structures. For instance, precast wall piers can be developed using the details for cantilever abutments.

Element Sizes:
The size of precast concrete substructure elements can become an issue for elements that need to be shipped long distances. Element transportation and erection should be investigated during the TS&L study. Use the following general guidelines for sizing precast concrete substructure elements:

- **Width:** Keep the narrowest width of the element and any projecting reinforcing below 12 feet. This is to keep the shipping costs reasonable. Widths over 12 feet will require investigation. 14 feet is the maximum width.

- **Weight:** Keep the maximum weight of each element to less than 100,000 pounds in order to keep the size of site cranes reasonable. In some cases the element weight should be limited to the maximum beam weight on the project. Weights above 50 tons will require investigation.

- **Height:** Keep the maximum height of any element including any projecting reinforcing to less than 8 feet so the element can be transported below existing bridges. Element heights above 8 feet will require investigation.

Follow these limits for design-bid-build projects. The limits can be increased for design-build projects. The designer can work with both the fabricator and contractor to size the elements based on the available equipment and the proposed shipping routes.

Typical Elements:
The following sections briefly describe each type of substructure element shown in the typical detail drawings.

- **Columns:** The use of square shaped pier columns is preferred. Columns with flat surfaces can be cast in the horizontal position. Square columns can be formed with one facet left open. The concrete can be poured...
through the open facet and finished along that face. This approach allows fabricators to build long forms and cast multiple columns at one time.

**Pier Caps:** There are several different types of pier cap beams depicted in the typical details. The only architectural treatment shown is for the underside of the cantilever ends. A 1 x 4 foot chamfer is shown. This is not required but it can have a significant effect on the appearance of the pier. Pier caps can be designed with mild reinforcement, prestressed concrete or even horizontal post tensioning.

Show pier bents as single, double, or triple column bents. The intent is to use combinations of these to make up any particular pier. The designer can choose to use two independent double column pier bents if four columns are required in a pier. Detail an open joint between the bents. The designer can detail extended reinforcing with a closure pour to connect the two bent caps if there is a need to connect them. This should not delay construction as long as the connection is not required for dead loads.

The pier cap details show the top of the cap in the transverse direction. This facilitates the connection of the column to the cap. It is best to keep this connection perpendicular in order to simplify the fabrication and avoid fit-up problems in the field. The top of the bents can be stepped at the joint if the pier is wide and made up of multiple un-connected bent caps. Slope the bent cap for severe cross slopes or aesthetic considerations but avoid doing so if possible.

**Wall Stems:** There are several different types of wall stems shown in the typical detail drawings. These include:

1. Cantilever abutment wall stems
2. Cantilever retaining wall stems
3. Integral abutment stems
4. Backwalls and cheekwalls

All of these elements are similar in that they are rectangular. Precast concrete wall stems can get very heavy, especially abutment stems. Several of the elements show voids cast into them. This is done in the case of the integral abutment to allow for a simple connection to the deep foundation. This is done in the case of the cantilever abutment to reduce shipping and handling weight. The concrete in the void area is placed after the element is erected. This concrete is not normally required for strength. It can be cured in place as the erection of the remainder of the bridge progresses.

The abutment details depict a top surface that follows the cross slope of the roadway in a series of steps. These stepped seats are shown with variable height precast beam seats to provide the beam seat elevations required. Beam seats can be cast high, allowing the contactor to grind to
Aesthetic Treatment:
The details depicted in the typical detail sheets do not depict aesthetic treatments. Accelerated construction is not limited to typical bridge elements. It is possible to build aesthetic designs in an accelerated manner. Precast elements can enhance esthetic treatment options. The high quality of precast elements can produce high quality aesthetic treatments. Designers are encouraged to investigate architectural treatments in the PCI manual entitled Architectural Precast Concrete.
Section 3

USE OF TYPICAL DETAIL SHEETS

The PennDOT drawings 12-602-BDTD represent typical details for the design of precast concrete substructures. The details are not standards that can be inserted into project plans. The designer is responsible for the design and detailing of the specific substructure unit using the typical detail sheets for guidance on general concepts and consistent detailing practices.

These sheets were developed to provide an example of the drafting layout of typical precast substructure units. Several different substructure unit types are shown. There are only a few dimensions shown as suggestions for typical detailing. Reinforcing shown is also not standard. The designers will develop reinforcing size, spacing, and patterns for each bridge.

The details will cover the majority of typical substructures used in Pennsylvania. Complex bridges may require different substructure types. Designers are encouraged to use the typical details as a basis for the design of these complex substructures.
Section 4

SHEET CHECKLIST

Plan View
Accurate, measurable detail, with exceptions to enhance clarity

1. Label and locate the control line at each substructure unit. Match the terminology on the layout, such as reference line, centerline, or profile grade line.
2. Show abutment numbers, bent number, or both.
3. Reference control dimensions at all working points. These are usually the intersection of the control line and the centerlines of bents and abutments.
4. Overall dimensions of each substructure unit.
5. Beam lines located and numbered.
7. Label joint locations and type.
8. Design data.

Elevation View
Accurate, measurable detail, with exceptions to enhance clarity

1. Elevations necessary to establish the grade of the substructure.
2. Elevations of all beam seats to the nearest $\frac{1}{16}$ inch.
3. Joint spacing
4. Joint types

Typical Transverse Sections
Accurate, measurable detail, with exceptions to enhance clarity

1. Piece width dimensioned
2. Control line or centerline of bearing (if applicable)
3. Typical section reinforcing.
4. Reinforcing cover.

Individual Piece Details
Accurate, measurable details, with exceptions to enhance clarity

1. Overall dimensions
2. Locations and sizes of blockouts and voids
3. Locations of inserts
4. Internal reinforcing details including locations of grouted splice couplers
5. Lifting Points
6. Approximate shipping weight of each piece
Other Details
Accurate, measurable details, with exceptions to enhance clarity

1. Connection details including grouted splice couplers
2. Joint details
3. Installation notes
4. Tolerance details for all applicable pieces
5. Bar Details
6. Table of Estimated Quantities
7. General notes including but not limited to, design criteria, loading, class of concrete, epoxy coating or galvanization, and cross references to various standard sheets
8. Title block, information block, and Engineer’s seal

Final Checks
1. Comply with PennDOT CADD Detailing Standards.
2. Check all details and dimensions against substructure to ensure the details are not in conflict.
3. Double check bars in various details against the bars shown in the bar table.
4. Check that the name and number of the bridge is same on all detail sheets, including layout.
5. Initial the sheet after back-checking corrected details.
Section 5

FOUNDATION TYPES

PennDOT requires foundations up to 5 feet above the normal ground to be cast in place. Never-the-less, for local bridges, typical precast details were developed for several different foundations types. They are as follows:

1. Spread footing on soil
   Place footings on soil with a nominal gap between the underside of the footing and the substrate. Place the footing on temporary leveling devices and set to grade. Fill the void between the precast footing and the substrate with flowable bedding concrete.

2. Spread footing on bedrock
   Place footings on rock with a nominal gap between the underside of the footing and the bedrock. Blasted bedrock is often a very rough surface. Add notes to the plans to allow for installation of a bedding concrete sub-footing. This concrete only needs to be strong enough to support the anticipated soil bearing pressures. Place the footing on temporary leveling devices and set to grade. Fill the footing gap with flowable bedding concrete to make the connection to the substrate.

3. Footings on drilled shafts or pipe piles
   Drilled shafts and pipe piles both have reinforcing extending from the pile or shaft into the footing. Details have been developed from work done in other states. Use a corrugated metal pipe to form voids in the substructure element. The corrugations transfer the pile load into the substructure elements.

4. Footings on driven H-piles
   The details for driven H piles are similar to the pipe piles. Install welded shear connectors on the webs of the pile in order to improve the transfer of force from the pile to the cap.
Section 6

MILD REINFORCING AND CONCRETE PROPERTIES

Mild Reinforcement:
Coat all mild reinforcement according to PennDOT specifications. Coat all grouted splice couplers with epoxy coating. The coating on the bars within the couplers does not need to be removed to make the connection.

Special requirements for columns:

The grouted reinforcing slice coupler is the only connector allowed between the column and adjacent elements. Couplers will develop the minimum specified tensile strength of the attached reinforcing bars. See Section 8 for more information on grouted splice couplers.

Reinforcement will not have lap splices within the column. Specify and detail grouted reinforcing splice coupler within the element on the plans if splicing is required.

Shear reinforcement for columns can be either of the following:

1. Closed loop stirrups as shown on BD 629 sheet 4 of 15 Section A-A for Seismic Zone 1.
2. Spiral reinforcing at the ends of columns. Properly anchor the spiral end to the column core as specified in the AASHTO LRFD Bridge Design Specifications.

Other precast elements:
Allow lap splices in closure pours between elements that are not columns. Use threaded mechanical couples for bars that extend beyond the edges of the precast element, except for columns. Do not weld reinforcement.

Concrete Properties:
Nominal 28-day concrete strength (f’c) for precast substructure elements is 5,000 psi. Specify this strength at a higher level with prior PennDOT approval where higher strengths are required. Specify the final designed concrete strength required on the plans.
Closure pour concrete is a high early strength mix that is developed and submitted by the contractor. The mix will be air entrained and have shrinkage compensating admixtures to prevent cracking and separation of the closure pour concrete from the adjacent precast concrete. The properties are as follows:

- 6 Hour strength of 2,500 psi
- 7 Day Strength of 5,000 psi

Flowable bedding concrete is used to seat elements on top of the subgrade. PennDOT standard flowable fill is used for this purpose.
Section 7

DESIGN

Design of Precast Elements:

The details for precast substructure elements are based on a design process called emulative detailing. This is a process developed by joint committee of the American Concrete Institute (ACI) and the American Society of Civil Engineers (ASCE). The process is documented in the publication entitled “ACI 550.1 - Emulating Cast-in-place detailing in Precast Concrete Structures”.

This process emulates cast-in-place connections with precast elements. Conventional cast-in-place (CIP) construction is not monolithic. Construction joints are common. CIP construction joints are typically detailed with dowels and lap splices with the exception of column connections. Emulation design replaces the traditional lap splice with a mechanical coupler. These couplers are allowed by the AASHTO LRFD Design Specifications. AASHTO requires that the couplers develop 125 percent of the specified yield strength of the connected bar. This is more than adequate in most cases for use in connection emulation such as abutments and walls. The one exception is column connections in high seismic zones.

Use grouted splice couplers in connection emulation details for accelerated bridge construction based on the following:

1. Three companies make similar products.
2. The companies have been in the vertical construction market for over 25 years.
3. They can easily meet the AASHTO requirements for mechanical connectors.
4. They can develop the specified tensile strength of the bars.
5. They can easily be cast into precast elements

The design of column connections is especially difficult for high seismic zones. These connections develop plastic hinges to dissipate the seismic forces on the structure. There are no prefabricated bridge connections tested in the United States for plastic hinging to date.

Grouted splice couplers have been researched in Japan. The following tables show the results of two tests. The first plot shows the performance of a column with grouted splice couplers. The second shows a column with continuous mild reinforcement. The testing was done to show the hysteretic behavior of the connectors. An axial load of 0.2*BDF’c was applied and the column was loaded laterally to various levels and repeated to develop the hysteresis plots.
Table 1
Test data for Grouted Splice Couplers in Plastic Hinge Zone

Table 2
Test data for Continuous Reinforcement in Plastic Hinge Zone

The loading was as follows:
1. One cycle to $1.0\sigma_y$
2. Five cycles to $2.0\sigma_y$
3. Four cycles to $4.0^*\sigma_y$
4. One cycle to $6.0^*\sigma_y$
5. One cycle to $10.0^*\sigma_y$

A review of the plots shows that the behavior of the grouted splice couplers is almost identical to the behavior of a continuous mild reinforcing column. The coupler showed slightly lower drop off-of moment capacity at the higher ductility ratios.

These connections are currently allowed in high seismic zones in the United States for vertical construction such as buildings. The Seismic section of the current ACI 318 code classifies these connections as “Type 2” Mechanical Connectors. The ACI code specifies that these connectors are required to develop 100 percent of the specified tensile strength of the connected bar. Designers are encouraged to review the ACI code provisions.

**Column Confinement:**
Confinement of column reinforcing is possible with precast concrete elements. The AASHTO design specifications do not mandate the confinement reinforcing bars be continuous from the column into the adjacent members footing or cap. The confinement reinforcing can be ended in the column and separate confinement reinforcement can be added to the adjacent element. The following types of confinement reinforcement can be used in precast construction:

- **Spirals:** Spiral reinforcement can be used. It is important to anchor the spiral into the column core at the base of the column. Refer to the AASHTO Guide Specification for Seismic Design provisions for anchoring spirals.

- **Closed loop stirrups:** Closed loop stirrups are permitted.

The commentary in the AASHTO LRFD specifications offers some guidance on the use of individual hoops or ties when compared to spirals. The AASHTO LRFD commentary includes the following information about advantages of seismic hoops over spirals:

1. Improved constructability when the transverse reinforcement cage must extend up into a bent cap or down into a footing. Seismic hoops can be used at the top and bottom of the column in combination with spirals or full height of the column in place of spirals.
2. Ability to sample and perform destructive testing of in-situ splices prior to assembly.
3. Breakage at a single location versus potential unwinding and plastic hinge failure.
Section 8

LIFTING DEVICES, HANDLING, AND STORAGE

Lifting devices:
Create design plans that show recommended lifting locations based on the
design of the element. The Engineer is responsible for checking the handling
stresses in the element for the lifting locations shown on the plans. Design the
elements using the criteria of Chapter 8 of the PCI Design Handbook – MNL-
120:

1. Use two point picks for columns, pier caps, and wall panels, similar
to prestressed beams.
2. Use an eight-point pick if element stresses are excessive with a
four-point pick. Add notes to the plan requiring specialized rigging
that includes pulleys.
3. Use a dynamic load allowance of 15 percent.
4. Do not show specific lifting hardware on the drawings. The
Engineer will verify that at least one lifting hardware manufacturer
can provide a device that can resist the anticipated loads. The
Engineer will consider reducing the size of the panel or switch to a
more sophisticated lifting system if no manufacturer can meet the
required resistance. The Engineer will consult with fabricators for
these situations.

The Contractor may choose alternate lifting locations with approval from the
Engineer. The Contractor will provide the spacing and location of the lifting
devices and submit plan and handling stress calculations to the Engineer for
approval prior to construction of panel.

Handling and Storage:
The Contractor is responsible for the handling and storage of substructure
elements in such a manner that does not cause undue stress on the element.
Submit a handling and storage plan to the Engineer for review prior to the
construction of any element.

The Engineer will inspect all elements and reject any defective elements. The
rejected elements will be replaced at the Contractor’s expense. The Contractor is
responsible for any schedule delays due to rejected elements.
Section 9

VERTICAL ADJUSTMENT

Vertical Adjustment Devices:
Use vertical adjustment devices to provide grade adjustment to meet the elevation tolerances shown on the substructure elevation plans. Pier columns and pier cap elevations can be adjusted with shim stacks contained in the grouted joints.

The plans show typical devices and alternate devices that may be used with Engineer’s approval.

Leveling bolts will be pre-adjusted to approximate required final elevation for the element. Each adjustment device will have a capacity of at least 100 percent more than the tributary weight on the device. Designer will detail the type and locations of the devices.

Significant torque may be required to adjust the leveling bolts for substructure elements. The following is a recommended procedure for adjusting the grade of large footings:

1. Pre-adjust the device to provide the specified elevation.
2. Set the element on the leveling devices but do not fully release the element from the crane. This will greatly limit the amount of force on the leveling bolts.
3. Adjust the element grade while it is still partially supported by the crane.
4. Release the element from the crane once the grade is established.
Section 10

GROUTED SPLICE COUPLERS

Design requirements:
The design of precast elements is based on emulative detailing as described in Section 7. Grouted splice couplers are designed to emulate a reinforced concrete construction joint. The coupler replaces the typical lap splice. The only effect this approach has on the design of the element is the location of the reinforcing steel. The coupler is larger than the connected bar so the reinforcing cage must be set deeper into the element in order to provide the proper cover at the couplers. This may require more reinforcement due to the reduced effective depth of the section.

Use grouted splice couplers as part of a 90-degree hook end. The coupler can be attached to the hooked bar end for example, if the coupler is used in a pier cap. The length of the coupler can be used as part of the hook bar dimension if this is done.

Seismic Detailing:
Grouted splice couplers can be used in plastic hinging zones. The standard requirements for column confinement still apply around the couplers. The diameter of the spiral will need to change at the coupler location if spiral confinement reinforcement is used due to the increased outside diameter of the coupler group. The diameter of the ties will also need to be increased at the couplers if individual ties are used.

Coupler Locations:
Grouted splice couplers can be used in different configurations. The typical detail sheets show two different configurations for vertical bar splices. The preferred configuration is to have the coupler located above the joint. This preference is based on the following:

1. There is less opportunity for the coupler to become contaminated with debris. Couplers located below the joint need to be sealed during fabrication and shipping.
2. Bar extensions at the bottom of element is required for the coupler located below the joint. This may make handling more difficult.

The benefit of having the couplers located at the top of a footing is that they are located outside the column hinge zone. They still need to develop the tensile strength of the bars. There is concern that coupler stiffness will shift the plastic hinge farther into the column. This can result in an increase in column shear. The testing results depicted in Table 1 and Table 2 do not indicate that this is an issue. The force required to develop the yield moments in a coupler connection is within 1 percent of the control sample without the couplers.
Size and Spacing of Couplers:
The grouted couplers are larger than the connected reinforcing. This can lead to problems with detailing in congested areas such as pier caps. Design the reinforcing bar size and couplers to allow for crossing reinforcing bar patterns.

**Maximum Spacing:** Detail for spacing that is close to the maximum bar spacing requirements in the AASHTO LRFD Bridge Design Specifications. Base the spacing on the connected bar.

**Minimum Spacing:** The AASHTO requirements for minimum bar spacing are, in part, based on the ability to place concrete properly between the bars. Do not use the diameter of the couplers in the calculations. Check the clear spacing between the couplers. Use the following approach:

Detail the minimum gap between the couplers to be the greatest of the following:
1. 1 inch
2. 1.33 * maximum aggregate size of the course aggregate
3. The nominal diameter of the connected bars

**Clear Cover:** The clear cover for the element is based on the cover over the coupler and the connected reinforcing. This requires the connected reinforcing to be placed slightly deeper into the element in order to obtain the cover over the couplers. Use the following dimensional guidelines for detailing of element with grouted splice couplers based on a review of the three manufacturers’ that are currently supplying product:

<table>
<thead>
<tr>
<th>Bar Size</th>
<th>Outside Diameter (inches)</th>
<th>Length of Sleeve (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2.625</td>
<td>14.125</td>
</tr>
<tr>
<td>5</td>
<td>3.000</td>
<td>14.125</td>
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<tr>
<td>8</td>
<td>3.500</td>
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</tr>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
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</tr>
<tr>
<td>18</td>
<td>4.500</td>
<td>39.625</td>
</tr>
</tbody>
</table>
Section 11

CLOSURE POURS

Use closure pours where needed as directed, designed, and detailed by the designer. Concrete compressive strength in the closure pour will be equal or greater than the precast elements (typically 5,000 psi). Designer will design and detail closure pours.

Designer will specify wet curing for at least 7 days to increase the durability of the closure pours.

Use mechanical couplers in conjunction with the continuous reinforcement in the connected elements when required. All mechanical couplers will conform to AASHTO 5.11.5.2.2 and ACI 318 12.15.3 and meet all PennDOT requirements. Precast the couplers, if used, into the panel after securely attaching them to the continuous reinforcement.
Section 12

TOLERANCES

The tolerance of casting elements is critical to a successful installation. One of the most important tolerances is the location of the grouted splice couplers. Variation in coupler locations will lead to unacceptable misalignments at the coupler locations.

Make the tolerance measurements from a common working point or line in order to specify tolerances of critical elements. Center to center measurements can lead to a build-up of tolerance errors.

The typical detail drawings include details of recommended tolerances. Include these details in all precast substructure projects.

Dry fitting the elements is not necessary provided QA/QC procedures are followed. In the event that a grouted splice coupler is misaligned out of tolerance, and as-built computer models or templates or full scale models do not provide conclusive evidence that the members will join properly, PennDOT can request a dry fit for approval.
Section 13

ASSEMBLY PLANS

Most bridge construction projects require contractors to submit erection plans for bridge girders. Prefabricated substructures also require a level of pre-construction planning. Write project specifications to require that the contractor submit an assembly plan for the construction of the entire structure including the precast substructure.

Include as a minimum the following in the assembly plan:

1. Size and weights of all elements
2. Picking points of all elements
3. Sequence of erection
4. Temporary shoring and bracing
5. Grouting procedures
6. Location and types of cranes
7. A detailed timeline for the construction including time for curing grouts and closure pans