

# PRECAST SUBSTRUCTURE ELEMENTS MANUAL



*Refer to Utah Department of Transportation (UDOT)  
Specification 03131S – Precast Substructure Elements*

PRECAST SUBSTRUCTURES

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## PRECAST SUBSTRUCTURES

### Section 1

#### GENERAL INFORMATION

The purpose of this manual is to provide guidance with the design and detailing of Precast Concrete Substructure Elements according to 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:** Show cover for substructure elements with 3 inch clear cover for bottom mats of reinforcement for footings and 2 inch clear cover for other substructure elements.

**Angles:** Show in degrees, minutes, seconds to the nearest whole second if such precision is available.

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**References:** The Designer will verify that all requirements of the current 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. Use the following general guidelines for sizing precast concrete substructure elements:

Width: Keep the narrowest width of the element and any projecting reinforcing below 14 feet. This is to keep the widths reasonable for shipping.

Weight: Keep the maximum weight of each element to less than 100,000 pounds in order to keep the size of site cranes reasonable.

Height: Keep the maximum height of any element including any projecting reinforcing less than 10 feet so the element can be transported below existing bridges.

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.

Footings: Several different types of precast concrete footings have been developed. Footings can be supported by either soil or by deep foundations. There are no standard footing sizes. Base the size of any particular footing on the requirements listed above. Do not consider these requirements to be limitations. It is possible to build very large footings in an accelerated mode. The typical detail sheets show a partial precast

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footing. The intent of this detail is to use the partial precast footing to support the dead load of the construction. The sequence of construction for his scenario is as follows:

1. Install the footing.
2. Continue construction of the remainder of the substructure and superstructure.
3. Cast the footing extensions at the same time and cure.

This approach will allow for accelerated construction with large footings. Partial precast footings can also be used for large multi column pier bents. The details show a three column bent with three independent footings as an example. These three footings can be connected with closure pours to form one large footing to meet project specific requirements.

Columns: UDOT has decided to use octagonal shaped pier columns. Round columns were considered but present a more complex fabrication process. Round columns required casting in the vertical position and construction can be difficult for tall columns. Columns with flat surfaces can be cast in the horizontal position. An octagonal column 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. The octagonal columns allow for round column seismic performance without the difficulties of casting. Round columns can be used but there may be a cost premium.

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

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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 follow 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 exact beam seat elevations required. The designer can decide whether the stepped abutment tops are required. This will vary from bridge to bridge based on the roadway cross slope, abutment skew, and grade. The abutment top can be kept level and constant on some bridges.

### **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*".

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### Section 3

#### USE OF TYPICAL DETAIL SHEETS

The drawings developed by UDOT 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 Utah. 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.

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### 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.
6. Skew angles.
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

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### 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 UDOT 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.

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### Section 5

#### FOUNDATION TYPES

The typical 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 UDOT Section 03211, Reinforcing Steel and Welded Wire. 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. The end of the embedded bar can be cut without touch-up coating.

#### **Special requirements for columns:**

Refer to ASTM A706 (Weldable Grade 60) for vertical reinforcement in columns. This will improve ductility.

The grouted reinforcing splice 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. Individual hoops with ends connected with resistance butt welds (see specifications). These hoops will need to be ASTM A706. Weld prior to application of epoxy coating
1. 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.

The column end connections may be comprised of both of these options with the spirals in the column and welded hoops in the footing or cap. Another option is to use welded hoops in all locations.

#### **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 4,000 psi. Specify this strength at a higher level with prior UDOT approval here higher strengths are required. Specify the final designed concrete strength required on the plans.

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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 2500 psi

7 Day Strength of 4000 psi

Flowable bedding concrete is used to seat elements on top of the subgrade. UDOT 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:

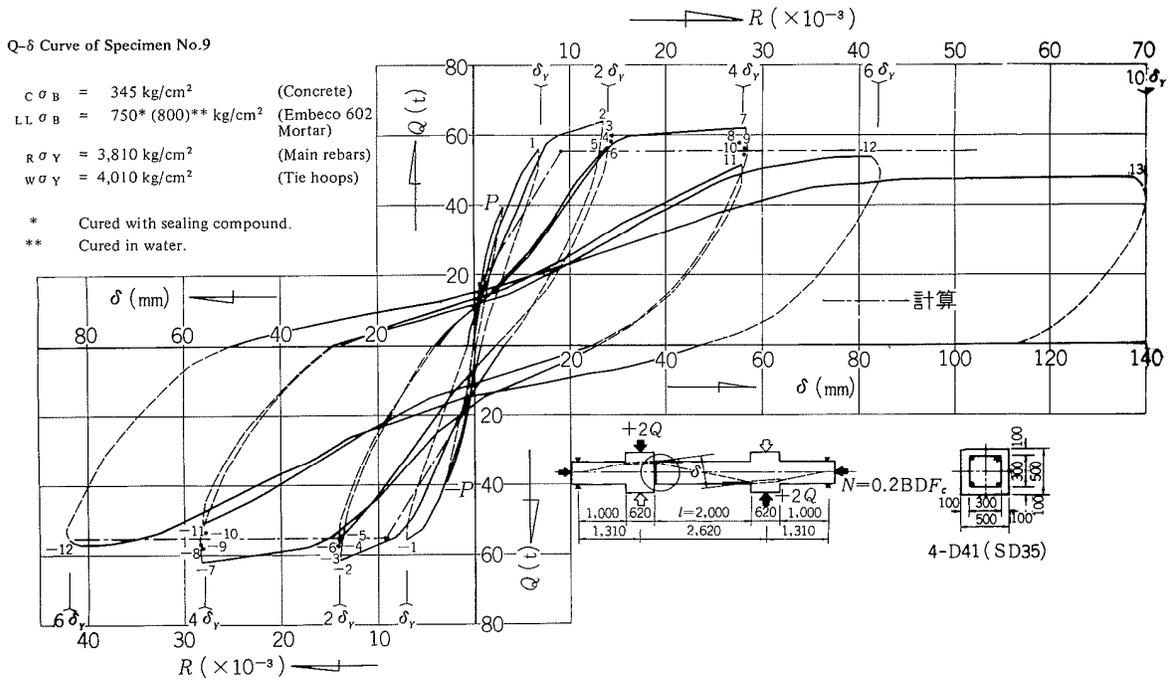
1. Three companies make similar products.
2. The companies have been in the vertical construction market for over 25 years.
3. They can easily meet the AASHTO requirements for mechanical connectors.
4. They can develop the specified tensile strength of the bars.
5. They can easily be cast into precast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

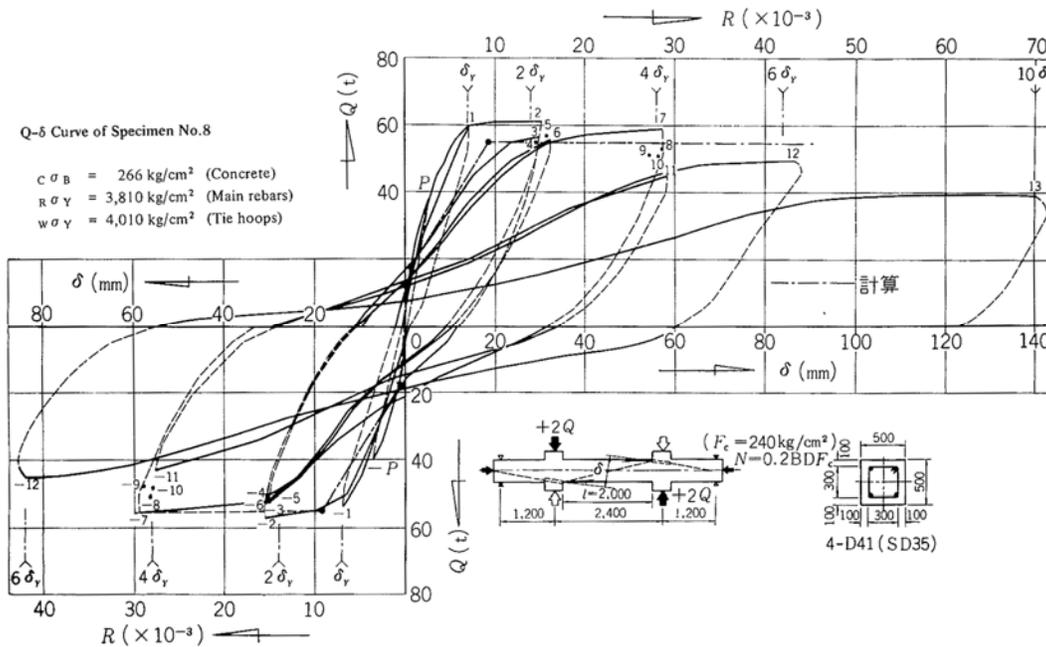
Grouted splice couplers have been researched in Japan. The following tables show the results of two tests. The first plot shows the performance of a column with grouted splice couplers. The second shows a column with continuous mild reinforcement. The testing was done to show the hysteretic behavior of the connectors. An axial load of  $0.2 \cdot BDF_c$  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

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**Table 2**  
 Test data for Continuous Reinforcement in Plastic Hinge Zone



The loading was as follows:

1. One cycle to  $1.0 \cdot \sigma_Y$
2. Five cycles to  $2.0 \cdot \sigma_Y$

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3. Four cycles to  $4.0 \cdot \sigma_y$
4. One cycle to  $6.0 \cdot \sigma_y$
5. One cycle to  $10.0 \cdot \sigma_y$

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.

In conjunction with other high seismic states, Utah is currently pursuing research funding to perform additional seismic testing of these couplers. The goals will be to verify the behavior of the couplers in the plastic hinge zones and to develop AASHTO code provisions for their use. UDOT will allow the use of these couplers in the plastic hinge zone according to the provisions of the ACI 318 code until this research is completed.

### **Substructure Design:**

One of the benefits of emulative detailing is that the design of the substructure element can be similar to a cast-in-place concrete structure. The only design change is the cover requirements for the reinforcing steel. The size of the coupler will dictate the depth of the reinforcing cage.

The design of the individual elements will typically be a standard reinforced concrete design. Special elements such as pier caps can be designed with post-tensioning if desired.

### **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.

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Welded Ties: Pre-welded ties are commonly used in high seismic zones. The welds are resistance butt welds made using special equipment in the fabrication shop. Field welding by lapping bars is not 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.

### **Corrugated Pipe Voids:**

Corrugated steel pipe can be an effective way of providing a void for making connections in precast elements. Several details have been developed that incorporate pipes as void forms. The key feature of these pipes is the corrugations in the pipe. These corrugations are necessary to transfer the forces between the concrete cast within the pipe and the surrounding precast concrete.

It is important to specify that the pipe that has continuous and uniform corrugations along the entire length of the pipe so that the full concrete section can be engaged for shear transfer. Some pipe manufacturers produce pipes with low friction walls that are designed to convey water more efficiently. These pipes are not recommended since the transfer of shear between the interior concrete and the surrounding concrete will be reduced.

Corrugated aluminum pipes should not be used. Aluminum can become reactive with the surrounding concrete, which would lead to degradation of the pipe over time and damage to the concrete. Corrugated plastic pipe should only be used for non structural voids. An example would be a void that is used to simply reduce shipping weights.

The following table includes typical corrugations sizes for corrugated steel pipes:

Inside Diameter Range	Corrugation Pattern
4" to 18"	1.5" x 0.25"
12" to 84"	2.66" x 0.5"
36" to 144"	3" x 1" and 5" x 1"

**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 following general criteria:

1. Use two point picks for columns, pier caps, and wall panels, similar to prestressed beams.
2. Use four point picks for footings. Assume that only two diagonal lift points are engaged at any one time.
3. 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.
4. Use a dynamic load allowance of 15 percent.
5. 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.
6. Specify that any lifting hardware left in place must have 2½ inch top cover and 1 inch bottom cover after installation.

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.

Lifting devices will be removable below the top surface of the panel after placement. Any divot or void at the lifting devices will have a heavy broom finish. Fill divots or voids in with structural non-shrink grout after final position panel placement. Place grout high and ground to final elevation.

**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.

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The following general criteria will be cause for rejection:

1. Broken corners that cannot be properly repaired in the Engineer's opinion.
2. Full depth cracking in a prestressed element.
3. Significant dimensional deformities.
4. Panels that are fabricated outside of the specified tolerances.

### 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 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.

Special requirements for Footings: If a leveling device is used on soil, design the load distribution plate based on the geotechnical constraints at the site. Show the size and thickness of the plate on the plans. The allowable bearing capacity of the soil should not be based on long-term settlement. A higher short-term load should be allowable.

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.

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### 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.  $1.33 \times$  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 3

Bar Size	Outside Diameter (inches)	Length of Sleeve (inches)
4	2.625	14.125
5	3.000	14.125
6	3.000	14.125
7	3.000	18.75
8	3.500	18.75
9	3.500	18.75
10	3.500	23.5
11	4.000	23.5
14	4.000	28.375
18	4.500	39.625

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### 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 4000 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 UDOT 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.

Include a requirement in the project specifications that all connections be dry fit in the fabrication yard prior to installation of the elements at the bridge site. This is especially true for grouted splice couplers. Verify the spacing of the couplers as well as their orientation within the element. The splice reinforcement is often left longer than required in the fabrication yard so that the bars can be cut the exact length in the field as the construction progresses. The dry fit can still be done in this case with the longer bars.

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### 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 pours