CHAPTER 7
SUBSTRUCTURES

7-1 Bent Caps

General

The guidelines of this section pertain to the cast-in-place concrete caps of all end bents and interior bents.

For substructures at Corrosive Sites, see Section 12-~~13~~12.

Plan Layout

Show the control line for the interior bent or end bent. For interior bents, if the control line is offset from the centerline of the bent due to eccentric loading, place the following note on the bent drawings:

The Contractor's attention is called to the fact that the centerline joint in the deck slab (control line) is offset from the centerline bent.

The control line shall not be offset from the centerline of the bent if the calculated offset is less than 3 inches (75 mm).

Show the work point and workline and provide all bent dimensions as measured from this point or line.

Show all substructure elevations to three decimal places.

Anchor Bolts

The location and the required anchor bolt projection above the bridge seats shall be shown for all substructure units. See Section 6-6 "Anchorage" for anchor bolt projection requirements. Where pipe inserts for anchor bolt adjustment are required, show the location of the swedged anchor bolts and the 4" (102 mm) ϕ pipe inserts, and place the following note on the plans:

For pipe insert details, see Bearings Sheet.

Construction Joints

In general, use a construction joint when the cap length exceeds 90 feet (30 m). Locate this construction joint within 2 - 3 feet (1 m) of a column or pile.

Minimum Cap Clearances

The following guidelines shall be followed in determining the bent cap width:

- For steel superstructures, the distance from the side face or step of a concrete cap to the centerline of the anchor bolt shall not be less than 5 inches

(125 mm), nor shall the distance to any edge or corner of an elastomeric bearing or masonry plate be less than 2 ½ inches (65 mm).

- For prestressed girder superstructures, the distance from the side face or step of a concrete cap to the centerline of the anchor bolt shall not be less than 5 ½ inches (140 mm), nor shall the distance to the elastomeric bearing be less than 2 ½ inches (65 mm).

Increase cap widths if necessary to provide these minimum dimensions. When it becomes necessary to lift rolled beam and prestressed girder spans for repair, Bridge Maintenance must use a hydraulic jack placed under the bent diaphragm. To accommodate this operation on severely skewed bridges, consideration shall be given to providing a minimum edge distance of 2 ½ inches (65 mm) to the edge of the jacking base plate. The jack base plate is usually 12 inches (305 mm) by 9 ½ inches (240 mm). Place the jack so that the 9 ½ inch (240 mm) dimension is normal to the centerline of the cap.

The following guidelines shall be followed in determining the bent cap length:

- For steel superstructures, the length of interior bent caps should provide a minimum of 9 inches (230 mm) from the edge or corner of the bearing plate to the end of the cap.
- For prestressed girder superstructures, the length of interior bent caps should provide a minimum of 9 inches (230 mm) from the anchor bolt to the end of the cap.
- For cored slab structures, both end bent and interior bent caps shall be detailed with a concrete lateral guide at the outside face of the exterior slab units, see Figure 7-1. Provide 1 ½ inch (38 mm) expansion joint material between cored slab and lateral guide.

Bridge Seat Elevations

In the computation of bridge seat elevations where metal plates bear on concrete, a $^{3}/_{16}$ inch (5 mm) thickness shall be included for the preformed pads used between the masonry plate and the concrete. These preformed pads are not used with elastomeric bearings.

If the elevation difference between any two adjacent bridge seats is:

- Less than $^{1}/_{8}$ inch (3 mm), use the lower elevation for both bridge seats.
- $^{1}/_{8}$ inch (3 mm) to less than 1 inch (25 mm), incorporate the difference into the sole plate thickness for elastomeric bearings and use the lower elevation for both bridge seats. For other bearing types, use a fill plate with the masonry plate and allow the Contractor the option to combine the fill plate with the masonry plate and use the lower elevation for both bridge seats.
- 1 inch (25 mm) or greater, detail a step in the bent cap.

Reinforcement

Minimum reinforcement and spacing should be in accordance with the AASHTO LRFD Bridge Design ~~Standard~~ Specifications and the following guidelines.

Main Steel

The minimum number and size of main bars for both top and bottom mats of bent cap reinforcing steel shall be as follows:

Cap Width	Reinforcing Steel
≤ 3'-0" (910 mm)	4 - #9 (#29) bars or equivalent
3'-0" (910 mm) - 4'-0" (1.22 m)	5 - #9 (#29) bars or equivalent
4'-0" (1.22 m) - 5'-0" (1.52 m)	6 - #9 (#29) bars or equivalent
5'-0" (1.52 m) - 5'-8" (1.73 m)	7 - #9 (#29)bars or equivalent

Stirrups

For shrinkage and temperature reinforcement, provide 'U' shaped stirrups in the ends of the cap. Place stirrups 6 inches (150 mm) from the cap faces and space at a maximum of 1'-6" (450 mm) both vertically and horizontally.

For end bents, space #4 (#13) or #5 (#16) stirrups according to the AASHTO LRFD Bridge Design ~~Standard~~ Specifications using one 'U' shaped stirrup and one horizontal stirrup at each location.

For interior bents, invert alternate stirrups. The size and spacing of the stirrups should be according to the AASHTO LRFD Bridge Design ~~Standard~~ Specifications. In addition, place #4 (#13) 'U' shaped stirrups at 6" (150 mm) centers beneath the bearing area of each beam or girder.

Step-Up Steel

Observe the following procedures when placing steel in the top of bent caps with stepped bridge seats:

- For caps in which the steel is placed horizontally, the top steel should be raised to a position as shown in Figure 7-2 when the distance from the centerline of the bar to the top of the cap exceeds 6 ½ inches (165 mm). If this distance is between 6 ½ inches (165 mm) and 12 inches (305 mm), it may be more appropriate to provide additional #4 (#13) bars, to match the number of top bars, as shown in the Sloped Cap detail of Figure 7-2.
- When the bottom of the bent cap is sloped, the top steel should be placed parallel to the bottom of the cap. The stirrups shall be detailed a clear distance of 2 inches (50 mm) below the critical point along the top of cap so that the stirrups might be of uniform detail throughout. Additional #4

(#13) bars, to match the number of main bars, should then be placed horizontally in the top of the cap where the distance from the centerline of the bar to the top of the cap exceeds 7 inches (180 mm). See Figure 7-2.

Sloped Caps

If the cap depth at opposite ends of both end bents and interior bents differ by more than 15 inches (380 mm), consideration shall be given to sloping the bottom of the cap along its length so that one stirrup height may be detailed throughout. When the bottom of the cap is sloped, slope the top of cap lengthwise as well.

To accommodate the use of plain, level bearing pads on cored slab structures, it may be necessary to slope the bridge seats transversely to account for grade and slab camber. Even for flat grades, note that the camber alone may necessitate the use of sloped seats.

Epoxy Protective Coating

When epoxy protective coating for concrete is used, the following note should be placed on the bent and/or end bent sheet:

The top surface areas of the _____ caps shall be cured in accordance with the Standard Specifications except the Membrane Curing Compound Method shall not be used.

All end bent caps shall receive epoxy protective coating. At an end bent where there is a backwall, the top surface area minus the area of the backwall shall be given the protective coating. The following note shall be placed on the plans:

Backwall shall be placed before applying the Epoxy Protective Coating.

At an end bent where a curtain wall is used, the top surface area of the cap shall be given the protective coating except that the Contractor may, but is not required to, coat the top surface area to be covered by the curtain wall.

Where there is an expansion joint in the bridge deck over the bent, the bent cap shall receive epoxy protective coating on the entire top surface area of the cap. The chamfer area is included in the top surface area as indicated in the Special Provisions.

Where elastomeric bearings are used, the epoxy protective coating shall not be applied to the area under the elastomeric bearings. Where steel bearings are used, the Contractor may, but is not required to, coat the areas under the bearings.

Do not apply epoxy protective coating to the bent caps of prestressed concrete cored slab structures.

7-2 Integral Abutments

General

In order to reduce maintenance problems associated with expansion joints, engineers shall consider eliminating joints on bridges by utilizing integral abutments at the end bents, and employing continuous or continuous for live load girders over interior bents wherever possible.

Girder bridges with the geometric properties listed below shall be detailed with integral abutments~~; see Section 7-2~~.

- Tangent alignment.
- Skews between 70^o and 110^o, i.e. ($70^o \leq$ skew $\leq 110^o$).
- Vertical grade $\leq 5\%$.
- Girder height shall not exceed 6ft. (1.83m)
- Total bridge length shall not exceed:
  - 300ft. (91.44m) for steel girder bridges.
  - 400ft. (121.92m) for prestressed concrete girder bridges.

Some site conditions, such as very high rock lines, may not permit use of integral abutments. For those situations, alternative end bent substructure types should be considered on a case-by-case basis.

Piles

Integral abutment bridges depend on the flexibility of the piles to accommodate longitudinal bridge movements. Utilizing the prescribed bridge lengths above and detailing piles as suggested below will limit the need to analyze and design the piles to resist forces developed from longitudinal movements of the integral abutment. In addition, integral abutment piles should not be less than 10 ft. in length.

For sites with rock, dense material, or cohesive soils, provide prebored holes as necessary to allow for adequate pile lengths. After the piles are installed and fixity is achieved, the prebored hole shall be filled with loose dry sand. In addition, integral abutments shall be designed with a single row of vertical piles oriented such that longitudinal bridge movements shall induce bending about the weak axis, i.e. the pile strong axis shall be parallel to the bridge control line (workline). If bending stresses are excessive, then the piles may be oriented for bending about the strong axis.

Approach Slabs and Wing Walls

Approach slabs shall be supported on a blockout provided in the end bent integral diaphragm, and shall be anchored to the diaphragm so that it moves longitudinally in concert with the bridge.

The roadway end of the approach slab shall be supported on a sleeper slab. Use BAS11 -- "Bridge Approach Slab for Integral Abutment" for preparing plans.
Brace piles for wing walls piles ~~shall~~are not ~~be~~ permitted. Wing walls may be tapered to reduce their resistance to longitudinal bridge movements.

Figures 6-119 through 6-123 show details at the integral end bent for steel girder and concrete girder superstructures.

7-3 End Bents

General

See Figures 7-3 through 7-8 for the end bent cap layout on tangent alignments. These figures should be modified for use on curved or spiral alignments. For cored slab superstructures, use an expansion joint material thickness of 1½ inch (38 mm) in lieu of the 1 inch (25 mm) shown in the above Figures.

All end bent caps shall be sloped on the top surfaces of the cap. See Figure 7-9 for details to include on the plans.

For bridges on a moderate to heavy skew (skew ≤ 60° or 120°≤ skew), chamfer cap and wing corners in accordance with Figure 7-10.

~~In order to facilitate drainage, 3" (76 mm) ϕ PVC pipe drains should be located at 10 feet (3 m) maximum centers in the end bents. Pipe drains shall be extended through end bent caps whether or not slope protection is used. See Figure 7-10 for the pipe drain details.~~

Temporary drainage details shall be shown on the plans for all end bents. For details and notes to be shown on the plans, see Figure 7-11. The figure is drawn to show normal crown and should be modified for superelevated structures or other conditions on a project specific basis.

Backwalls

A backwall shall be use on all bridges except cored slab bridges with approach slabs. See Figure 7-12 for backwall details. For deep superstructures, backwalls shall be designed on a project specific basis.

Provide a horizontal construction joint between the backwall and the end bent cap. Extend the construction joint through the wings level with the cap. Run the 'K' bars the entire length of the backwall from wing to wing. Match the 'H' bars in the wing to the 'K' bars in the backwall as applicable. See Figures 7-13 and 7-14 for details.

The elevations on the top of the backwall along the fill face side shall be shown on the plans. Elevations shall be shown at the left side, at the centerline of survey or the grade point, and at the right side. Additional elevations at all crown breaks shall also be indicated on the plans.

When applicable, ~~D~~detail oversized blockouts for water or sewer utilities passing through the backwall. A blockout sized 4" (100 mm) larger than the utility pipe

diameter is to be used with all utility lines. Place t~~T~~he following note ~~shall be placed~~ on the plans:

Center utility in blockout and fill annular space around utility pipe with joint filler in accordance with Standard Specification Article 1028-1.

Turned Back Wings

In general, turned back wings shall be detailed for all end bents.

For bridges over highways and railroads, the wings shall be of a sufficient length to provide a 1'-0" (300 mm) minimum berm 1'-6" (450 mm) above the bottom of the end bent cap as shown in Figure 7-15. For bridges over streams, the wings shall be of a sufficient length to provide berm widths as indicated in Figures 11-1 through 11-3. In no case shall the wing length be less than 2 feet (600 mm) as measured from the fill face. When the length of the wing exceeds 11 feet (3.35 m), detail a brace pile located one-third ($^1/_3$) of the length from the end. See Figure 7-16.

The wings shall be placed at the outside edge of the backwall. The outside edge of the wings shall be located 3 feet (1 m) measured perpendicular from the outside edge of superstructure and shall be parallel to the superstructure. Insure that the wings and cap are adequately reinforced at this junction. For details of wings, see Figure 7-13.

In general, the tops of the wings should follow the grade line. See Figure 7-14 for a suggested method of detailing sloped wings. For bridges with metal rails, set the top of the wings at the outside edge of the approach slab to match the top of the curb or sidewalk. For bridges with concrete barrier rail, the top of the wings at the outside edge of the approach slab should be set level with the top of the approach slab. Detail the bottom of the wings as level or follow the grade using the same criteria for sloping the top of the wings.

~~When metal rails are used,~~ T~~t~~he turned back wings shall have a blockout as shown in Figures 7-17 and 7-18. This blockout ~~allows for saw cutting of joints in the deck and approach slab and also~~ allows for slip forming of the parapet. Reinforcing steel in the blockout may be bent as necessary. The blockout concrete shall be placed ~~after the joint between the deck and approach slab is sawed and, if slip forming is used,~~ after the concrete barrier rail or parapet and end post are cast. ~~A blockout in the wings is not required when concrete barrier rail is used.~~

Use a 1 inch (25 mm) expansion joint material in the vertical joint between the backwall and the approach slab. See Figure 7-14 for details.

When the Foundation Recommendations call for Reinforced Bridge Approach Fill, place the following note on the end bent sheet:

The Contractor shall provide for installation of the 4"** (102 mm) **ϕ drain pipe through the wing wall as required for Reinforced Bridge Approach Fills, see the Roadway plans. Reinforcing steel in the wing wall may be shifted as necessary to clear the drain pipe.

Special Wings

Any wings other than the turned back wings outlined above shall be considered special wings and should only be used when site or design conditions prevent the use of turned back wings. Such conditions may include matching existing wings, tying to an existing structure, a very shallow superstructure, etc. Where special wings are necessary, the Project Engineer shall submit the proposed special wing design and layout to ~~the Assistant State Bridge Design Engineer for approval.~~the Engineering Development group.

~~7-3~~7-4 Pile Bents

General

Unless otherwise specified, the criteria of this section shall apply to both interior pile bents and pile supported end bents.

Pile bents shall be designed as per the AASHTO LRFD Bridge Design ~~Standard~~ Specifications. Buckling due to the unsupported length of the pile should be checked. See Section 7-6.

The minimum amount of embedment for pile heads shall be as indicated in Section 2-1. For sloped caps, the minimum pile embedment shall be detailed from the bottom of the cap at the controlling edge to the top of the pile. A minimum 9 inch (230 mm) clear distance shall be maintained from the exterior pile to the end of cap. For details of pile end bents and interior pile bents, see Figures 7-~~19~~23 through 7-~~23~~28.

Caps

Minimum Width

Type of Pile	Cap Width	
	Single Row	Double Row
~~Timber~~	~~2'-6" (760 mm)~~	~~4'-0" (1.22 m)~~
HP 10x42 (HP 250x26), HP 12x53 (HP 310x79) or 12 inch (305 mm) prestressed concrete	2'-9" (840 mm)	4'-0" (1.22 m)
HP 14x73 (HP 360x108) steel	3'-0" (910 mm)	4'-3" (1.30 m)
16 inch (406 mm) prestressed concrete or 18 inch (457mm) steel pipe pile	3'-3" (990 mm)	5'-0" (1.52 m)

20 inch (508 mm) prestressed concrete	3'-8" (1.12 m)	5'-8" (1.73 m)
24 inch (610 mm) prestressed concrete or steel pipe pile	4'-2" (1.27 m)	
~~24 inch (610 mm) prestressed concrete~~30 in (760mm) -steel pipe pile	~~4'-2" (1.27 m)~~5'-0" (1.52 m)	

Smaller widths may be used for bents with a single row of piles without brace piles; however, reinforcing steel clearance should be checked.

Minimum Depth

Type of Pile	Cap Depth
~~Timber~~	~~2'-3" (690 mm)~~
Single row pile system	2'-6" (760 mm)
Double row pile system	3'-0" (910 mm)

Other Reinforcement

Place 4 or 5 - #4 (#13) 'B' bars longitudinally at equal spaces above each row of piles and #4 (#13) 'B' bars at 4' (1.2 m) ± centers placed normal to the cap.

Provide 2 - #4 (#13) circular 'S' hoops around each pile in a single row system and 3 pairs of #4 (#13) rectangular 'S' bars around each pile in a double row system. See Figures 7-~~19~~23 through 7-~~23~~28.

For interior bents, provide a #9 (#29) 'U' shaped bar in each end of the cap as detailed in Figure 7-~~23~~28.

~~7-4~~7-5 Post and Beam Bents

Caps

The minimum cap size shall be 3'-2" (970 mm) wide by 2'-6" (760 mm) deep for use with 3'-0" (914 mm) ϕ columns. In general, the cap width shall be a minimum of 2 inches (50 mm) wider than the column diameter.

When using drilled piers, the cap width shall be a minimum of 8 inches (200 mm) wider than the column diameter. When the drilled pier extends to the bottom of the cap, the minimum cap width shall be 8 inches (200 mm) wider than the drilled pier diameter.

Use hammerhead or other non-standard bent types on special instructions. Use round noses on hammerhead piers in stream crossings to reduce drift problems.

Columns

When circumstances dictate the use of spread footings, design the column for 1 m (3'-0") of extra height.

In Seismic Performance ~~Category B~~Zone 2, column connections shall be detailed with #4 (#13) or #5 (#16) ties at 3" (75 mm) centers for a minimum of one-half the column diameter into the cap and footings. Use #4 (#13) ties for 4'-0" (1220 mm) diameters or smaller and #5 (#16) ties for 4'-6" (1372 mm) diameters and larger. See Figure 7-~~24~~29.

Minimum Diameter

The minimum size column shall be 3'-0" (914 mm) ϕ. Standard column sizes include 3'-0" (914 mm), 3'-6" (1066 mm), 4'-0" (1220 mm), 4'-6" (1372 mm) and 5'-0" (1524 mm). For column diameters greater than 5'-0" (1524 mm), increase the column diameter in 6 inch (152.4 mm, rounded to the nearest even millimeter) increments.

Spacing

In general, the column spacing should not exceed approximately 20 feet (6 m) center to center of columns. The overhang from the end of the cap to the face of the column should not be greater than 4 feet (1.2 m) and not less than 3 feet (915 mm). Preferably this dimension should be between 3'-3" (1.0 m) and 3'-9" (1.15 m).

In order to minimize the number of drilled piers, consideration shall be given to increasing the center to center spacing of the columns and overhang dimension to achieve a reasonable cap design.

Reinforcing Steel

Columns are to be designed in accordance with the AASHTO LRFD Bridge Design ~~Standard~~ Specifications. Do not detail any bar smaller than a #9 (#29) for 'M' and 'V' bars.

Spiral column reinforcing steel, to be used on all round columns, shall be W20 or D-20 cold drawn wire or a #4 (#13) plain or deformed bar with a pitch of 3 inches (75 mm). The splice of the spiral column reinforcement should be lapped 2 feet (610 mm). For spiral reinforcement details, see Figure 7-~~25~~30.

Place the following note, completed with the applicable spiral designation (SP1, SP2, etc.), directly beneath or near the Bill of Material for each applicable bent. Place a double asterisk (**) in the size column for spiral reinforcing steel in the Bill of Material.

***** The ___ _ spiral reinforcing steel shall be W20 or D-20 cold drawn wire or #4 (#13) plain or deformed bar.***

When epoxy coated spiral column reinforcing steel is required in columns, include a quantity and pay item for "Epoxy Coated Spiral Column Reinforcing Steel".

Batter

For bents of major coastal structures, the exterior columns shall be battered 6% in the lateral direction when the ratio of the height of the column to the center to center distance of the exterior columns is greater than 1.0.

Construction Joints

In general, construction joints shall be used at the top of the footing and the bottom of the cap. A permitted construction joint shall be shown at approximately mid-height for columns 20 feet (6 m) or more in height.

~~7-5~~7-6 Piles

General

The capacity to which piles are to be driven, as recommended by the Geotechnical Engineering Unit ~~Soils and Foundation Section~~, shall be indicated on the General Drawing. Where pile loads for various bents on a structure are computed to require different capacities, group the bents together and call for the maximum capacity required if the loads are within 4 - 5 tons (35 - 45 kN) of each other rather than calling for several different capacities on one structure.

For fender system piles, place the following note on the plan sheet showing the top of pile and pile tip elevations:

The Contractor shall determine the pile length such that the final top and tip elevations will be as indicated.

Piles shall not be designated with a pile length in instances where the Contractor is responsible for determining the pile lengths.

When indicated on the Foundation Recommendations, the Contractor shall have the option to use 12 inch (305 mm) prestressed concrete piles with steel pile tips in lieu of HP steel piles. For the note to be placed on the General Drawing, see Section 5-2 "Piles".

When indicated on the Foundation Recommendations, the Contractor shall have the option to use HP 12x53 (HP 310x79) steel piles in lieu of 12 inch (305 mm) prestressed concrete piles with steel pile tips. For the note to be placed on the General Drawing, see Section 5-2 "Piles".

When HP 10x42 (HP 250x62) steel piles are used, the Contractor shall have the option to use HP 12x53 (HP 310x79) steel piles. For the note to be placed on the General Drawing, see Section 5-2 "Piles".

~~Minimum~~ Design Loads

For preliminary design of end bents, use the ~~following minimum~~ design load values shown in the table below. The compressive resistance shown is for piles that are entirely embedded in the ground.

Type of Pile	Minimum Design Load
HP 10x42 (HP 250x62)	50 tons (450 kN)
HP 12x53 (HP 310x79)	60 tons (530 kN) * ∇
HP 14x73 (HP 360x108)	75 tons (670 kN) *
12 inch (305 mm) prestressed concrete	50 tons (450 kN)
16 inch (406 mm) prestressed concrete	75 tons (670 kN)
18 inch (457 mm) steel pipe pile	70 tons (620 kN)
20 inch (508 mm) prestressed concrete	100 tons (890 kN)
24 inch (610 mm) prestressed concrete	125 tons (1110 kN)

* ~~Due to the unsupported pile length of interior pile bents, the preliminary design load shall be 45 tons (400 kN) for HP 12x53 (HP 310x79) and 60 tons (530 kN) for HP 14x73 (HP 360x108).~~

∇ ~~For bridge replacement projects, use 50 tons (450kN).~~

Pile Type	P_r, Compressive Resistance (w/ Pile Tip) (kips)	P_r, Compressive Resistance (w/o Pile Tip) (kips)
HP 10x42	310	37~~2~~0
HP 12x53	385~~8~~	465
HP 14x73	535	64~~2~~0
14" SPP	63~~6~~5	74~~2~~0
16" SPP	730	85~~2~~0
18" SPP	825	96~~2~~0
24" SPP	110~~7~~5	129~~2~~0
30" SPP	1390	162~~2~~0
12" PCP		
16" PCP		

20" PCP		
24" PCP		

Brace Piles

Brace piles shall be used in all end bents where the distance from the crown of roadway to the natural ground line exceeds 10 feet (3 m). Consideration shall also be given to using brace piles where little pile penetration is anticipated, mucky conditions exist and for other special conditions which might warrant their use.

The spacing of brace piles shall not exceed 25 feet (8 m) center to center.

For single and double row of piles, see Figures 7-~~19~~ 23 and 7-~~20~~ 24 for end bent details and Figures 7-26~~21~~ and 7-27~~22~~ for interior bent brace piles details.

For end bents, batter brace piles 3 inches per foot (250 mm per 1000 mm). For interior bents, batter brace piles 1 ½ inches per foot (125 mm per 1000 mm).

Pile Spacings and Clearances

For minimum pile embedment, see Section 2-1.

For end bents, the pile maximum spacing shall be 10'-0".

Use a minimum of five~~four~~ piles in end bent and ~~-~~interior pile bents.

Both brace and vertical piles shall be spaced uniformly about the cap centerline.

~~**Load Tests**~~

~~When a Pile Load Test is to be included in the contract, show the following information on the plans: (Ask GEU if we still do pile load tests??)~~

- ~~The location of the test pile noted on the Foundation Layout Sketch.~~
- ~~The lump sum pay item "Pile Load Test" in the Total Bill of Material.~~
- ~~The reaction frame and jacking arrangement.~~
- ~~The following note on the General Drawing:~~

~~***For Pile Load Test, see Special Provisions. No SP***~~

~~When two pile types or sizes are used in the same bridge and only one test pile is detailed, declare whether the test pile data applies to only one type or both types. Place the proper note on the General Drawing as shown in Section 5-2 "Piles".~~

Steel Piles

The standard splice detail should be placed on at least one bent drawing for each bridge on which HP steel piles are used. Reference should be made to this detail on the plans for all other bents in which HP steel piles are used. See Figure 7-

3126.

When steel piles are used in pile bents on grade separations, encase the piles with a square concrete jacket from the bottom of the cap to 3'-0" (920 mm) below the proposed ground line. The jackets for HP 12x53 (HP 310x79 piles) shall be 1'-8" (510 mm) by 1'-8" (510 mm). The jackets for HP 14x73 (HP 360x108) piles shall be 1'-10" (560 mm) by 1'-10" (560 mm). All jackets shall be reinforced with wire mesh.

Steel pipe piles shall be used in accordance with the standard drawings. When pipe piles are used in pile bents on grade separations, the depth of the concrete plug shall extend a minimum of 5'-0" (1.5 m) below the top of the pile. When pipe piles are used in end bents or pile footings, the embedment length of the pile into the footing shall be filled with concrete as detailed in Figure 7-2520a.

When steel piles are used at Corrosive Sites, see Section 12-13 "Painted Steel".

Exposed steel piles over streams or railroads shall be galvanized. Place the following note on the plans:

The steel piles shall be galvanized in accordance with Section 1076 of the Standard Specifications. ~~***For Galvanizing Steel Piles, see Special Provisions.***~~

Prestressed Concrete Piles

Prestressed concrete piles shall be in accordance with the standard drawings for Prestressed Concrete Piles. When prestressing cables are to be released by burning, the cables shall be burned in opposite pairs and follow the pattern shown on the Standards.

When prestressed concrete piles are used at Corrosive Sites, see Section 12-13 "Corrosion Protection Measures".

When the Contractor is allowed to substitute HP 12x53 (HP 310x79) steel piles in lieu of 12 inch (305 mm) prestressed concrete piles, the substructure should be designed as though the concrete piles will be used. Add the necessary details to the plans to cover both steel and concrete piles. The pay item shall be for "12 inch (305 mm) Prestressed Concrete Piles".

When the Foundation Recommendations require steel pile tips for prestressed concrete piles, see Section 5-2 "Piles" for the plan note to be placed on the General Drawing. For 20 inch (508 mm) prestressed concrete piles that require the use of steel pile tips, add the pile tip details as shown in Figure 7-~~27~~ 32 to the Standard PCP2.

Composite Piles

When the Foundation Recommendations require prestressed concrete piles composite with steel piles, a steel pile splicer shall be used to connect the steel

pile tip to the driven steel pile. See Figure 7-~~27a~~33. Place the following notes on the plans:

For Steel Pile Splicer, See Special Provisions
For Steel Pile Tips, See Special Provisions

~~**Timber Piles**~~

~~Timber piles shall be treated with Chromated Copper Arsenate (CCA). See Section 3-5 for required retention of CCA in timber piles.~~

~~7-6~~7-7 Footings

General

The minimum footing thickness in Seismic Performance ~~Category A~~Zone 1 is 2'-0" (610 mm) without piles and 2'-9" (840 mm) with piles. Seismic Performance ~~Category B~~Zone 2 requires an increased footing thickness. The top of footings shall have 1'-6" (460 mm) minimum earth cover.

Provide minimum reinforcement consisting of #6 (#19) bars at 1'-0" (300 mm) centers located 2 inches (50 mm) clear from the top of the footing. In single column bents, use #6 (#19) bars at 1'-0" (300 mm) centers or 50% of the area of bottom reinforcement, whichever is greater. These bars are to be used in both the transverse and longitudinal directions.

For stream crossings, study each pier location to determine the elevations of the pier footings that might pose hazards to navigation. Specify on the plans a maximum top of footing elevation if deemed necessary.

Stream Crossings

The Foundation Recommendations will consider the scour potential of the site for stream crossings. Subsurface and hydraulic investigations will be made to determine the probable depth of scour or floatation of material. Foundation and structural analysis will determine the required lateral support of the pile. The bottom of footing and pile tip elevations should be determined such that scour will not endanger the structure.

The Soils and Foundations Section will provide bottom of footing elevations and scour critical elevations for all stream crossing structures. For notes to be placed on the plans, see Section 5-2 “Footings”.

The Soils and Foundations Section will determine when footings shall be protected against scour. For details to be shown on the plans, see Figures 7-~~28~~34 through 7-~~30~~36. Place the following note on the plans:

No separate payment will be made for pier scour protection. The entire cost of same shall be included in the lump sum price for “Foundation Excavation.”

Spread Footings

The minimum length for spread footings shall be 20% of the overall distance from the bottom of the footing to the crown of the roadway, rounded up to the next 6 inches (150 mm).

The splice length for spread footing 'M' bars shall be detailed 3 feet (1 m) longer than required to accommodate possible adjustments in the footing elevation.

Pile Footings

The minimum distance centerline to centerline of exterior piles for each pile footing shall be 15% of the overall distance from the bottom of the footing to the crown of the roadway, rounded up to the next 3 inches (75 mm).

For minimum pile embedment, see Section 2-1.

The minimum center-to-center spacing for piles shall be the larger of 2'-6" (760 mm) for ~~timber or~~ steel, or 2'-9" (840 mm) for concrete, and 2.5 pile diameters/widths. The distance from the edge of any pile to the nearest face of the pile footing shall not be less than 9 inches (230 mm).

When concrete piles with steel pile tips are offered as an option to steel piles in the footing, the footing shall be designed based on the minimum spacing for concrete piles.

A minimum of four piles shall be used in each footing. If fewer than six piles are used, all piles shall be vertical. If six or more piles are used per footing, brace piles shall be used in accordance with the detail for foundation piles in bents. See Figure 7-~~31~~37.

When foundation piles are used with laterally battered columns, detail a strut between the footings.

Pile Caps

For pile or drilled pier caps supporting post and beam or hammerhead type substructures, use the following criteria to set the bottom of cap elevation:

- At Corrosive Sites subject to tidal fluctuations, set the bottom of the cap at the mean low tide elevation.
- For constructability in river crossings, set the bottom of the cap 1 foot (300 mm) above the normal water surface elevation.

Foundation Excavation

Foundation excavation for all spread and pile footings shall be paid for on a lump sum basis.

For post and beam end bent substructures, specify the measurement and payment for foundation excavation on a cubic yard (cubic meter) basis. For computing the plan quantity, see Figure 7-~~32~~38.

The benefits of designing a seal for interior bents vary. As a general guideline, seals shall be used when the water depth is 20 feet (6 m) or more. Foundation seals shall be detailed to provide 2 feet (610 mm) minimum clearance from each side of the footing to the edge of the footing to the edge of the foundation seal. If there is any doubt regarding the use of a seal, the Project Engineer should consult with Soils and Foundation, Hydraulics and Construction personnel for their recommendations. When a seal is required, the following note should be shown on the plans:

Cofferdams shall not be dewatered when the water elevation is above El._____ .

Complete the note with the water elevation to which the seal depth is designed.

~~7-7~~7-8 Drilled Piers

General

Drilled piers shall be terminated 1 foot (300 mm) ± above the normal water surface elevation for shafts located in water and 1 foot (300 mm) ± below the ground line for grade separations, railroad overheads, or piers located in the banks of streams. Always provide a construction joint at the drilled pier termination and proceed with a column into the cap. When there is insufficient distance to detail a lap splice between the top of the drilled pier and the bottom of the cap, use a column with the same diameter as the drilled pier.

The payment for drilled piers shall be on the basis of length per linear foot (meter) of "_____ Dia. Drilled Piers Not in Soil" and "_____ Dia. Drilled Piers in Soil". ~~Soils and Foundation Section~~Geotechnical Engineering Unit will provide the breakdowns for these quantities to be shown on the plans. Provide a separate quantity for the "Drilled Pier Concrete" in the concrete breakdown. All reinforcing steel in the drilled pier shall be included in the pay items for "Reinforcing Steel" and "Spiral Column Reinforcing Steel" or "Epoxy Coated Spiral Column Reinforcing Steel".

When instructed by the ~~Soils and Foundation Section~~Geotechnical Engineering Unit, permanent casing for drilled piers shall be provided. The payment shall be on the basis of length per linear foot (meter) of "Permanent Steel Casing for _____ Dia. Drilled Pier". The Foundation Recommendations will provide the bottom of casing elevation to be used for computing the pay length for the permanent steel casing. Detail the casing termination at the construction joint between the drilled pier and the column and use this elevation as the top elevation when computing the pay length. The Foundation Recommendations will also provide notes to be placed on the plans.

When instructed by the ~~Soils and Foundation Section~~Geotechnical Engineering Unit, a special pay item for "SID Inspection" will be required and paid for per each. For all projects using drilled piers, pay items for "Crosshole Sonic Logging" and "CSL Tubes" shall be included and paid for per each and per linear foot (meter), respectively.

Reinforcement

Longitudinal reinforcement shall be as required by design. Detail a lap splice at the construction joint when sufficient distance is available between the construction joint and the bent cap. Always detail the longitudinal steel with 3 feet (1 m) of extra length.

When there is insufficient distance to detail a lap splice between the top of the drilled pier and the bottom of the cap, detail the drilled pier reinforcing steel to extend 3 feet (1 m) above the construction joint. Detail column reinforcing steel from 2 feet (700 mm) above the construction joint to the proper embedment in the cap. Maintain constant bar size and spacing between the column and the drilled pier. Detail the couplers to be staggered as shown in Figure 7-~~32a~~39.

Spiral reinforcement shall be detailed as W31 or D-31 cold drawn wire or a #5 (#16) plain or deformed bar with a 5 inch (125 mm) pitch and 4 inches (100 mm) minimum clearance to the spiral. At the construction joint between the drilled pier and the column, detail a spiral splice and provide a standard size and pitch spiral in the column. Do not detail the spiral with the 3 feet (1 m) of extra length.

Notes

Place the following notes on the plans where applicable:

For Drilled Piers, see Special Provisions.

The Contractor's attention is called to the fact that the longitudinal reinforcement for the drilled piers is detailed with 3 feet *(one meter)* ***of extra length.***

All steel in the drilled piers is included in the pay items for "Reinforcing Steel" and "Spiral Column Reinforcing Steel" or "Epoxy Coated Spiral Column Reinforcing Steel".

Place the following note, completed with the applicable spiral designation (SP1, SP2, etc.), directly beneath or near the Bill of Material for each applicable bent. Place a double asterisk (**) in the size column for spiral reinforcing steel in the Bill of Material.

***** The ___ _ spiral reinforcing steel shall be W31 or D-31 cold drawn wire or #5*** *(#16)* ***plain or deformed bar.***

When there is not room to detail a lap splice in the longitudinal steel,

Splicing of the longitudinal bars in the drilled pier will not be permitted.

Mechanical couplers shall be used to join the longitudinal drilled pier reinforcing steel to the column reinforcing steel. The height of the couplers shall be staggered on alternating bars by 1 foot** (300 mm) **and the drilled pier and column steel shall be cut accordingly. See Special Provisions for Mechanical Butt Splicing for Reinforcing Steel.

For grade separations, railroad overheads, or shafts located in banks of streams,

The location of the construction joint in the drilled piers is based on an approximate ground line elevation. If the construction joint is above the actual ground elevation, the Contractor shall place the construction joint 1 foot** (300 mm) **below the ground line.

When a pay item for permanent steel casing is required by the Foundation Recommendations,

For permanent steel casing, see Special Provision for Drilled Piers.

~~When drilled piers are detailed on lump sum project,~~

~~***No separate payment shall be make for any additional steel required in construction of the drilled pier as this is considered incidental to the linear foot** (meter) **price for drilled pier.***~~

~~7 8~~7-9 Abutments

~~Reinforced Concrete~~

~~Abutment breastwalls and wings should be designed by the "Trial Wedge" method as specified by AREMA.~~

~~Provide for bridge seats by detailing a minimum width of 15 inches (380 mm) for the top 18 inches (460 mm) of the wall. Locate the dowels or anchor bolts so as to center the bearing over the breastwall.~~

~~Provide a 1 inch (25 mm) expansion joint between the wings and the bridge seats if the length of the abutment exceeds 90 feet (27 m). Consideration shall be given to using such an expansion joint for abutments of any length. Except for those abutments adjacent to streams, detail plastic waterstops in the expansion joints.~~

~~Place a note on the plans requiring anchor bolts to be set by drilling and grouting holes after the breastwall has been backfilled to an elevation 1 foot (300 mm) ± below the bridge seat. Careful attention shall be given to the anticipated movement of the breastwall during the backfilling operation to ensure that conflicts between the reinforcing steel and anchor bolt holes do not occur.~~

MSE Walls

When mechanically stabilized ~~embankment~~ earth structures are used as walls or abutment supports (e.g., reinforced earth, retained earth, tiedback wall, Hilfiker,

etc.), see Section 12-14.

~~7-9~~7-10 Rock Embankment

Generally, the Hydraulics Unit will recommend rock embankment when the proposed fill is to be constructed within the limits of a lake or stream. Rock embankment is used to reduce the siltation of lakes and streams and provides a stable embankment resistant to scouring. The Hydraulics Unit will furnish the following information:

- Water surface elevations
- Elevation and limits of proposed rock embankment
- Proposed core for bridge piles
- Typical section of rock embankment

When requesting the Foundation Recommendations, the Project Engineer shall advise the ~~Soils and Foundation Section~~Geotechnical Engineering Unit that rock embankment will be required.

The proposed rock embankment, core material and elevation of rock embankment shall be shown in the plan and section views of the General Drawing, with a note to see the Roadway plans. For the note to be placed on the General Drawing, see Section 5-2 “General”.

The Project Engineer shall check with the Roadway Design Engineer to verify that the Roadway plans contain the required details and pay items for “Rock Embankment” and “Core Material” for the structure.

~~7-10~~7-11 Pier Crashwalls for Railroad Overheads

Piers supporting bridges over railways and located within 25 feet (7.62 m) of the centerline of a railroad track are required by AREMA Specifications to be protected by a reinforced concrete crashwall. The top of the crashwall shall be located at least 6 feet (1.83 m) above the top of the higher rail for CSX Railroad and 10 feet (3.05 m) for Norfolk Southern Railroad.

Crashwalls adjacent to Norfolk Southern rails shall be a minimum of 2'-6" (760 mm) thick. For CSX rails, the adjacent crashwall thickness shall match the column diameter but shall not be less than 2'-6" (760 mm). For multi-column bents, a crashwall shall connect the columns and extend at least 2'-6" (760 mm) beyond the exterior columns. These extensions shall be measured parallel to the track. When a pier consists of a single column, the crashwall shall extend for a minimum distance of 6 feet (1.83 m) from both sides of the column. The face of all crashwalls shall extend a minimum distance of 6 inches (150 mm) beyond the

face of the column on the side nearest to the track and shall be anchored to the column and footings with adequate steel reinforcement. The crashwall shall extend to at least 4 feet (1.2 m) below the surrounding grade. For general crashwall details, see Figure 7-~~33~~40.

Where a crashwall is used, show a permitted construction joint at the top of the crashwall. Splice the 'V' bars at the permitted construction joint for crashwalls. If a construction joint is required in the cap, a construction joint should be detailed at a comparable position in the crashwall.

~~7-11~~7-12 Median Pier Protection

Guardrail shall be placed in those medians containing piers less than 30 feet (9.14 m) from the edge of pavement and the pier columns shall be protected with a concrete barrier. Special consideration shall be given when barrier shape protection is justified. When barrier shaped protection is required, use Class A concrete reinforced similarly to the barrier rail used on the bridge deck. "Reinforcing Steel" and "Class A Concrete" quantities are included in the bent Bill of Material. No separate pay item is required. See Figure 7-~~34~~41 for details.

If the pier offset is between 30 feet (9.14 m) and 40 feet (12.19 m), then an earth berm shall be placed. When such berms are used, the pier footing shall be designed accordingly and the slope protection placed according to the applicable standard. The top of the footing shall be located 1'-6" (460 mm) below the theoretical ditch line.

Piers with an offset over 40 feet (12.19 m) require no impact protection.

There are several different end treatments for median pier protection, such as attachments for impact attenuators, steel guardrail or concrete median barriers. When median pier protection is called for on the Structure Recommendations, the Structure Design Unit must work closely with the Roadway Design Unit during the plan development stage.