DSA
BU 09-06

BULLETIN: MINIMUM REINFORCEMENT OF CONCRETE PIERS AND CAISSONS EMBEDDED WITH STEEL POLES

Purpose: This bulletin amends requirements for the review and update up of Pre-Check (PC) documents previously announced. These requirements relate to the reinforcement requirements for concrete piers and caissons embedded with steel poles.

Discussion: The issue being addressed is whether or not additional longitudinal bars and transverse reinforcement are required if the steel area of the high strength steel pole embedded in the pier, when counted as reinforcement, exceeds the minimum reinforcement ratio required by the code.

An initial finding resulted in prescriptive requirements for new and existing PC designs. These designs were required to be reviewed for compliance with technical provisions contained in DSA Bulletin 09-06 (as issued 7-1-09 and revised on 9-29-09). Per the previous version of this Bulletin, approval of PC documents could be made void if not revised by January 1, 2010.

Subsequent review of Bulletin 09-06 has shown that, under some conditions, the prescriptive reinforcing requirements may be waived, provided it is shown that the footing has adequate capacity.

1.   Decision: The original Bulletin 09-06 deadline for revisions to PC documents has been waived. Instead, PC designs should be reviewed for compliance with design specifications summarized in Section 3, below, before a project utilizing the PC component is presented at Back Check or OTC review. If it is determined that the PC design needs revision, the PC design must be revised and approved before the installation project can be approved.

If the PC design has elements requiring revision that are independent of site soil conditions, PC design owners are encouraged to resubmit the PC design for DSA approval, as waiting until Back Check or OTC review can delay approval of school projects.

2.   Update Procedure:

2.1   Over-the-Counter (OTC) Update: If the review of the existing PC documents consists solely of checking for additional footing reinforcement, this check can be done during the OTC appointment (see DSA Policy PL 07-02). Update the PC, if necessary, as part of the site adapt project.

2.2   Pre-Check (PC) Plan Update: If the changes are not site specific and will affect all the designs, then contact the DSA Regional Office that approved the original PC and follow the regular PC review procedure and fee schedule (see DSA Procedure PR 07-01).

3.   Revised Structural Requirements – Concrete Piers and Caissons Embedded with Steel

3.1   Scope: These requirements apply to footings for ordinary cantilever structures and poles embedded in earth (for the full depth of the footing), which shall be designed to resist wind and seismic forces, per ACSE 7-05, Section 12.2.5.2, including use of overstrength factor for the design of the foundation or other elements used to provide overturning resistance. Foundation designs incorporating transfer of moment from the column to the foundation through base plates, anchor bolts or other means, shall comply with CBC Section 1808A.

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3.2 **Requirements:** Where the column is embedded in the earth or a footing, the requirements of Section 1805A.7.3 of the 2007 California Building Code (CBC) apply. The lateral capacity of the embedded column may be based on the diameter or diagonal dimension of the column, or the diameter or diagonal dimension of the footing, subject to the following requirements:

3.2.1 **Design based on the diameter or diagonal dimension of the column**: The lateral capacity of embedded columns may be based on "b", the diameter or diagonal dimension of the column. To protect steel columns from corrosion, the backfill material should be concrete and the annular space should be sufficient to provide 4 inches of cover between the steel surface and the earth. The backfill need not be reinforced. The dimension "b" used in the lateral capacity computations of CBC Section 1805A.7.2 shall be that of column, not that of the backfill in the annular space surrounding the column.

3.2.2. **Design based on the diameter or diagonal dimension of the footing**: For cantilever column systems utilizing ordinary steel moment frame detailing, the lateral capacity of embedded steel columns may be based on the diameter or diagonal dimension of the footing, subject to the following requirements:

  a. The column is embedded the entire depth of the footing.

  b. Minimum diameter or dimension of the concrete footing provides a minimum of 4 inches of cover all around.

  c. The dimension "b" used in the lateral capacity computations of CBC Section 1805A.7.2 may be that of the concrete footing.

  d. A minimum longitudinal reinforcement ratio of 0.0025 (vertical steel) shall be provided throughout the vertical depth of the footing. The area of the steel column may be included as part of the longitudinal reinforcement area. If reinforcing in addition to the column is provided, there shall be a minimum of four vertical bars the full length of the footing, and ties or spiral shall be provided complying with Item 2.f, below.

  e. The strength design level overturning moment shall be resolved as a couple produced by the column bearing laterally on the concrete footing, assuming a linear distribution of stress over the embedded length of the column. The strength design level lateral force associated with the design overturning moment shall be combined with the moment resisting couple force at the top of the foundation. Assuming a failure surface projecting 45 degrees from each side of the embedded column, the maximum shear stress in the concrete shall not exceed 2 times φ times the square root of f'c, where φ=0.55.

  f. If the concrete capacity in shear is exceeded, a minimum of four vertical reinforcing bars and shear reinforcing adequate to resist the design loads shall be provided. The shear reinforcing shall be in the form of closed ties (or equivalent spirals) of a minimum 3/8 inch (9 mm) diameter provided at 16-longitudinal-bar diameter maximum spacing over the depth of the footing.

  g. If the diameter of concrete pier exceeds 6 times the steel column least width or 3'-0", whichever is less, reinforcement complying with Item 2.f above shall be provided.

3.3 **Rationale:** Footings for ordinary cantilever structures employing posts and poles as columns embedded in earth present a special design case.

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The distinctive design characteristics of these structures are:

1. The use of a low R value (1.25).

2. Low axial loads (less than 15 percent of the design strength of the column per ASCE 7-05 Section 12.2.5.2).

3. Use of the overstrength factor ($\Omega_0 = 1.25$) for the foundation and other elements used to provide overturning resistance (ASCE 7-05 Section 12.2.5.2, 2nd paragraph).

Designs employing lateral bearing are subject to the requirements of CBC Section 1805A.7. CBC Section 1805A.7.1 provides limitations of the design approach. CBC Section 1805A.7.2 provides general design criteria for determining the depth of embedment required to develop lateral loads. CBC Section 1805A.7.3 covers backfill of the annular space. CBC Section 1805A.7 does not cover footing reinforcement requirements for designs utilizing lateral bearing.

While the embedded column foundation shares geometric similarities to a deep foundation systems such as drilled piers or piles, their loading and failure mechanisms are fundamentally different. Deep foundation systems apply structure loads to the soil primarily in the vertical direction. Lateral loads induce significant bending in the pier at the foundation-to-pier interface. Deep foundation systems are designed to provide adequate axial and flexural capacity and to maintain confinement of the concrete under plastic hinging.

Embedded column foundations for ordinary cantilever systems are typically non-constrained at the top, and have very low ductility demands since the effective R for the footing design (R/Ω_0) is 1.00. These footings are controlled by the ability of the foundation to resist the horizontal reaction generated by the lateral force and the couple resisting the column moment.

The approach described above provides a simplified approach to verify that the shear capacity of the footing is sufficient to resist the horizontal reaction, when the steel area of the column is sufficient to meet the minimum vertical reinforcement ratio. Since distributed reinforcement is not provided, the value of phi for plain concrete is used for the shear check. Where the shear capacity is inadequate or the column/footing is large, reinforcement is required to resist the horizontal reaction of the column against the concrete footing.

The approach described is suitable only for cantilever column systems utilizing ordinary detailing. For systems using special detailing, footing reinforcing must be provided that is sufficient to develop the flexural strength of the steel column at the footing to foundation connection, utilizing the expected yield stress, R_yF_y per AISC 341-05, Section 6.2.