

## 8. SEISMIC DETAILING

### 8.1 Splices in Reinforcing Steel

#### 8.1.1 No Splice Regions in Ductile Components

Splicing of flexural reinforcement is not permitted in critical locations of ductile elements. The “no splice” region shall be the greater of: The length of the plastic hinge region as defined in Section 7.6.3 or the portion of the column where the moment demand exceeds  $M_y$ . A “no splice” region shall be clearly identified on the plans for both hinge locations of fixed-fixed columns.

#### 8.1.2 Reinforcement Spliced in Ductile Components & Components Expected to Accept Damage

Reinforcing steel splices in ductile components outside of the “no splice” region shall meet the “ultimate splice” performance requirements identified in Memo to Designers 20-9.

#### 8.1.3 Reinforcement Spliced in Capacity Protected Members

Reinforcing steel splices designed to meet the SDC requirements in capacity protected components shall meet the “service splice” requirements identified in MTD 20-9. The designer in consultation with the Seismic Specialist may choose to upgrade the splice capacity from service level to ultimate level in capacity protected components where the reinforcing steel strains are expected to significantly exceed yield. These locations are usually found in elements that are critical to ductile performance such as bent caps, footings, and enlarged pile shafts.

#### 8.1.4 Hoop and Spiral Reinforcement Splices

Ultimate splices are required for all spiral and hoop reinforcement in ductile components. Splicing of spiral reinforcement is not permitted in the “no splice” regions of ductile components as defined in Section 8.1.1. Spiral splicing outside the “no splice” regions of ductile components shall meet the ultimate splice requirements.

### 8.2 Development of Longitudinal Column Reinforcement

Refer to Chapter 8 in the Bridge Design Specifications for the development requirements for all reinforcement not addressed in this Section.

### 8.2.1 Minimum Development Length of Reinforcing Steel for Seismic Loads

Column longitudinal reinforcement shall be extended into footings and cap beams as close as practically possible to the opposite face of the footing or cap beam.

If the joint shear reinforcement prescribed in Section 7.4.4.2, and the minimum bar spacing requirements in BDS 8.21 are met, the anchorage for longitudinal column bars developed into the cap beam for seismic loads shall not be less than the length specified in equation 8.1[1]:

$$l_{ac} = 24d_{bl} \quad (\text{in, or mm}) \quad (8.1)$$

The anchorage length calculated in equation 8.1 cannot be reduced by adding hooks or mechanical anchorage devices.

The reinforcing development requirements in other Caltrans documents must be met for all load cases other than seismic.

The column reinforcement shall be confined along the development length  $l_{ac}$  by transverse hoops or spirals with the same volumetric ratio as required at the top of the column. If the joint region is not confined by solid adjacent members or prestressing, the volumetric ratio of the confinement along  $l_{ac}$  shall not be less than the value specified by equation 8.2.

$$\rho_s = \frac{0.6 \times \rho_l \times D_c}{l_{ac}} \quad (8.2)$$

### 8.2.2 Anchorage of Bundled Bars in Ductile Components

The anchorage length of individual column bars within a bundle anchored into a cap beam shall be increased by twenty percent for a two-bar bundle and fifty percent for a three-bar bundle. Four-bar bundles are not permitted in ductile elements.

### 8.2.3 Flexural Bond Requirements for Columns

#### 8.2.3.1 Maximum Bar Diameter

The nominal diameter of longitudinal reinforcement in columns shall not exceed the value specified by equation 8.3.

$$d_{bl} = 25 \times \sqrt{f'_c} \times \frac{L_b}{f_{ye}} \quad (\text{in, psi})$$

$$d_{bl} = 2.1 \times \sqrt{f'_c} \times \frac{L_b}{f_{ye}} \quad (\text{mm, MPa}) \quad (8.3)^{16}$$

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<sup>16</sup>  $f'_c$  rather than  $f'_{ce}$  is used in equation 8.3 to ensure conservative results. [7]

$$L_b = L - 0.5 \times D_c \quad (8.4)$$

$L$  = Length of column from the point of maximum moment to the point of contra-flexure

Where longitudinal bars in columns are bundled, equation 8.3 shall apply to the nominal effective diameter  $d_{bb}$  of the bundle, taken as  $1.2 \times d_{bl}$  for two-bar bundles, and  $1.5 \times d_{bl}$  for three-bar bundles.

#### **8.2.4 Development Length for Column Reinforcement Extended Into Enlarged Type II Shafts**

Column longitudinal reinforcement shall be extended into enlarged shafts in a staggered manner with the minimum recommended embedment lengths of  $2 \times D_{c,max}$  and  $3 \times D_{c,max}$ , where  $D_{c,max}$  is the larger cross section dimension of the column. This practice ensures adequate anchorage in case the plastic hinge damage penetrates into the shaft.

#### **8.2.5 Maximum Spacing for Lateral Reinforcement**

The maximum spacing for lateral reinforcement in the plastic end regions shall not exceed the smallest of the following:

- One fifth of the least dimension of the cross-section for columns and one-half of the least cross-section dimension of piers
- Six times the nominal diameter of the longitudinal reinforcement
- 8 inches (220 mm)