APPENDIX A - NOTATIONS & ACRONYMS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_b$</td>
<td>Area of individual reinforcing steel bar (in², mm²) (Section 3.8.1)</td>
<td></td>
</tr>
<tr>
<td>$A_e$</td>
<td>Effective shear area (Section 3.6.2)</td>
<td></td>
</tr>
<tr>
<td>$A_g$</td>
<td>Gross cross section area (in², mm²) (Section 3.6.2)</td>
<td></td>
</tr>
<tr>
<td>$A_{jh}$</td>
<td>The effective horizontal area of a moment resisting joint (Section 7.4.4.1)</td>
<td></td>
</tr>
<tr>
<td>$A_{jh}^{fr}$</td>
<td>The effective horizontal area for a moment resisting footing joint (Section 7.7.1.4)</td>
<td></td>
</tr>
<tr>
<td>$A_{jv}$</td>
<td>The effective vertical area for a moment resisting joint (Section 7.4.4.1)</td>
<td></td>
</tr>
<tr>
<td>$A_{jv}^{fr}$</td>
<td>The effective vertical area for a moment resisting footing joint (Section 7.7.1.4)</td>
<td></td>
</tr>
<tr>
<td>$A_s$</td>
<td>Area of supplemental non-prestressed tension reinforcement (Section 4.3.2.2)</td>
<td></td>
</tr>
<tr>
<td>$A_s'$</td>
<td>Area of supplemental compression reinforcement (Section 4.3.2.2)</td>
<td></td>
</tr>
<tr>
<td>$A_{jh}^{s}$</td>
<td>Area of horizontal joint shear reinforcement required at moment resisting joints (Section 7.4.4.3)</td>
<td></td>
</tr>
<tr>
<td>$A_{iv}^{s}$</td>
<td>Area of vertical joint shear reinforcement required at moment resisting joints (Section 7.4.4.3)</td>
<td></td>
</tr>
<tr>
<td>$A_{jv}^{s}$</td>
<td>Area of vertical j-bar reinforcement required at moment resisting joints with a skew angle &gt;20° (Section 7.4.4.3)</td>
<td></td>
</tr>
<tr>
<td>ARS</td>
<td>5% damped elastic Acceleration Response Spectrum, expressed in terms of $g$ (Section 2.1)</td>
<td></td>
</tr>
<tr>
<td>$A_{sf}^{b}$</td>
<td>Area of bent cap side face steel required at moment resisting joints (Section 7.4.4.3)</td>
<td></td>
</tr>
<tr>
<td>$A_{st}$</td>
<td>Area of longitudinal column steel anchored in the joint (Section 7.4.4.3)</td>
<td></td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing Materials</td>
<td></td>
</tr>
<tr>
<td>$A_v$</td>
<td>Area of shear reinforcement perpendicular to flexural tension reinforcement (Section 3.6.3)</td>
<td></td>
</tr>
<tr>
<td>$B_c$</td>
<td>The other cross-sectional dimension of a rectangular column (Section 7.7.1.4)</td>
<td></td>
</tr>
<tr>
<td>$B_{cap}$</td>
<td>Bent cap width (Section 7.3.1.1)</td>
<td></td>
</tr>
<tr>
<td>$B_{eff}$</td>
<td>Effective width of the superstructure for resisting longitudinal seismic moments (Section 7.2.1.1)</td>
<td></td>
</tr>
<tr>
<td>$B_{eff}^{fr}$</td>
<td>Effective width of the footing for calculating average normal stress in the horizontal direction within a footing moment resisting joint (Section 7.7.1.4)</td>
<td></td>
</tr>
<tr>
<td>BDD</td>
<td>Caltrans Bridge Design Details (Section 7.7.1.7)</td>
<td></td>
</tr>
<tr>
<td>BDS</td>
<td>Caltrans Bridge Design Specification (Section 3.2.1)</td>
<td></td>
</tr>
<tr>
<td>$C_{i,j}^{pile}$</td>
<td>Axial compression demand on a pile (Section 7.7.1.1)</td>
<td></td>
</tr>
<tr>
<td>CIDH</td>
<td>Cast-in-drilled-hole pile (Section 1.2)</td>
<td></td>
</tr>
<tr>
<td>CISS</td>
<td>Cast-in-steel-shell pile (Section 1.2)</td>
<td></td>
</tr>
<tr>
<td>$D_c$</td>
<td>Column cross sectional dimension in the direction of interest (Section 3.1.4.1)</td>
<td></td>
</tr>
<tr>
<td>Notation</td>
<td>Definition</td>
<td>Section/Note</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>$D_{c.g.}$</td>
<td>Distance from the top of column the center of gravity of the superstructure (Section 4.3.2.1)</td>
<td></td>
</tr>
<tr>
<td>$D_{c,max}$</td>
<td>Largest cross sectional dimension of the column (Section 8.2.4)</td>
<td></td>
</tr>
<tr>
<td>$D_{ft}$</td>
<td>Depth of footing (Section 7.7.1.1)</td>
<td></td>
</tr>
<tr>
<td>$D_{Rs}$</td>
<td>Depth of resultant soil resistance measured from top of footing (Section 7.7.1.1)</td>
<td></td>
</tr>
<tr>
<td>$D_s$</td>
<td>Depth of superstructure at the bent cap (Section 7.2.1.1)</td>
<td></td>
</tr>
<tr>
<td>$D'$</td>
<td>Cross-sectional dimension of confined concrete core measured between the centerline of the peripheral hoop or spiral. (Section 3.6.3)</td>
<td></td>
</tr>
<tr>
<td>$D^*$</td>
<td>Cross-sectional dimension of pile shaft in the direction of interest (Section 7.6.2)</td>
<td></td>
</tr>
<tr>
<td>$E_c$</td>
<td>Modulus of elasticity of concrete (psi, MPa) (Section 3.2.6)</td>
<td></td>
</tr>
<tr>
<td>$E_s$</td>
<td>Modulus of elasticity of steel (psi, MPa) (Section 3.2.3)</td>
<td></td>
</tr>
<tr>
<td>$E_{da}$</td>
<td>Elastic Dynamic Analysis (Section 2.2.1)</td>
<td></td>
</tr>
<tr>
<td>$E_{sa}$</td>
<td>Equivalent Static Analysis (Section 2.2.1)</td>
<td></td>
</tr>
<tr>
<td>$F_{sk}$</td>
<td>Abutment shear key force capacity (Section 7.8.4)</td>
<td></td>
</tr>
<tr>
<td>$G$</td>
<td>The gap between an isolated flare and the soffit of the bent cap (Section 7.6.2)</td>
<td></td>
</tr>
<tr>
<td>$G_c$</td>
<td>Shear modulus (modulus of rigidity) for concrete (ksi, MPa) (Section 5.6.1)</td>
<td></td>
</tr>
<tr>
<td>$H$</td>
<td>Average height of column supporting bridge deck between expansion joints (Section 7.8.3)</td>
<td></td>
</tr>
<tr>
<td>$H'$</td>
<td>Length of pile shaft/column from ground surface to the point of zero moment above ground (Section 7.6.2)</td>
<td></td>
</tr>
<tr>
<td>$H_{o-max}$</td>
<td>Length of pile shaft/column from point of maximum moment to point of contraflexure above ground considering the base of plastic hinge at the point of maximum moment (Section 7.6.2 (c))</td>
<td></td>
</tr>
<tr>
<td>$H_s$</td>
<td>Length of column/shaft considered for seismic shear demand on Type I pile shafts. (Section 7.7.3.1)</td>
<td></td>
</tr>
<tr>
<td>$I_{c.g.}$</td>
<td>Moment of inertia of the pile group (Section 7.7.1.1)</td>
<td></td>
</tr>
<tr>
<td>$I_{eff}$</td>
<td>Effective moment of inertia for computing member stiffness (Section 5.6.1)</td>
<td></td>
</tr>
<tr>
<td>$I_g$</td>
<td>Moment of inertia about centroidal axis of the gross section of the member (Section 5.6.1)</td>
<td></td>
</tr>
<tr>
<td>$K_{eff}$</td>
<td>Effective abutment backwall stiffness $\frac{kip}{in^3/ft} \quad (\frac{kN/mm}{m})$ (Section 7.8.1)</td>
<td></td>
</tr>
<tr>
<td>$K_i$</td>
<td>Initial abutment backwall stiffness (Section 7.8.1)</td>
<td></td>
</tr>
<tr>
<td>$L$</td>
<td>Member length from the point of maximum moment to the point of contra-flexure (ft, m) (Section 3.1.3)</td>
<td></td>
</tr>
<tr>
<td>$L$</td>
<td>Length of bridge deck between adjacent expansion joints (Section 7.8.3)</td>
<td></td>
</tr>
<tr>
<td>$L_b$</td>
<td>Length used for flexural bond requirements (Section 8.2.3.1)</td>
<td></td>
</tr>
</tbody>
</table>
The moment demand generated in pile $P_i$ will be

$$M_{pile(i)} = \text{The moment demand generated in pile } (i) \text{ (Section 7.7.1.1)}$$

Earthquake moment magnitude (Section 6.1.2.2)

$$M_m = \text{Earthquake moment magnitude (Section 6.1.2.2)}$$

Moment attributed to secondary prestress effects (Section 4.3.2)

$$M_{p/s} = \text{Moment attributed to secondary prestress effects (Section 4.3.2)}$$

Nominal moment capacity based on the nominal concrete and steel strengths when the concrete strain reaches 0.003.

$$M_n = \text{Nominal moment capacity (Section 3.4)}$$

$$M_{n,e} = \text{Nominal moment capacity based on the expected material properties and a concrete strain, } \varepsilon_c = 0.003 \text{ (Section 3.4)}$$

Expected nominal moment capacity of the right and left superstructure spans utilizing expected material properties (Section 4.3.2.1)

$$M_{n,e}^{sup R,L} = \text{Expected nominal moment capacity of the right and left superstructure spans utilizing expected material properties (Section 4.3.2.1)}$$

Expected nominal moment capacity of a type II pile shaft (Section 7.7.3.2)

$$M_{n,e}^{type II} = \text{Expected nominal moment capacity of a type II pile shaft (Section 7.7.3.2)}$$

Column overstrength moment (Section 2.3.1)

$$M_{o}^{col} = \text{Column overstrength moment (Section 2.3.1)}$$

Idealized plastic moment capacity of a column calculated by $M$-$\varphi$ analysis (kip-ft, N-m)

$$M_{p}^{col} = \text{Idealized plastic moment capacity of a column calculated by } M$-$\varphi$ analysis (kip-ft, N-m) \text{ (Section 2.3.1)}$$

Moment capacity of a ductile component corresponding to the first reinforcing bar yielding (Section 5.6.1.1)

$$M_t = \text{Moment capacity of a ductile component corresponding to the first reinforcing bar yielding (Section 5.6.1.1)}$$

Moment curvature analysis (Section 3.1.3)

$$M$-$\varphi = \text{Moment curvature analysis (Section 3.1.3)}$$

Memo to Designers (Section 1.1)

$$\text{MTD = Memo to Designers (Section 1.1)}$$

Blow count per foot (0.3m) for the California Standard Penetration Test (Section 6.1.3)

$$N = \text{Blow count per foot (0.3m) for the California Standard Penetration Test (Section 6.1.3)}$$

Abutment support width normal to centerline of bearing (Section 7.8.3)

$$N_A = \text{Abutment support width normal to centerline of bearing (Section 7.8.3)}$$

Total number of piles in a footing (Section 7.7.1.1)

$$N_p = \text{Total number of piles in a footing (Section 7.7.1.1)}$$

Offices Of Structure Design (Section 1.1)

$$OSD = \text{Offices Of Structure Design (Section 1.1)}$$

The effective axial force at the center of the joint including prestress (Section 7.4.4.1)

$$P_b = \text{The effective axial force at the center of the joint including prestress (Section 7.4.4.1)}$$
\[ \begin{align*}
P_c &= \text{The column axial force including the effects of overturning (Section 3.6.2)} \\
P_{di} &= \text{Axial load attributed to dead load (Section 3.5)} \\
P_{\text{sup}}^\text{ax} &= \text{Superstructure axial load resultant at the abutment (Section 7.8.4)} \\
PGR &= \text{Preliminary Geology Report (Section 2.1)} \\
P_{\text{P}} &= \text{Total axial load on the pile group including column axial load (dead load + EQ load due to any overturning effects), footing weight, and overburden soil weight (Section 7.7.1.1)} \\
P/S &= \text{Prestressed Concrete (i.e. P/S concrete, P/S strand) (Section 2.1.4)} \\
R_D &= \text{Displacement reduction factor for damping ratios exceeding 5\% (Section 2.1.5)} \\
R_s &= \text{Total resultant expected soil resistance along the end and sides of a footing (Section 7.7.1.1)} \\
S &= \text{Skew angle of abutment (Section 7.8.2)} \\
SDC &= \text{Seismic Design Criteria (Section 1.1)} \\
SDSEE &= \text{Structure Design Services and Earthquake Engineering} \\
T &= \text{Natural period of vibration, in seconds } T = 2\pi \sqrt{m/k} \text{ (Section 6.1.2.1)} \\
T_{c} &= \text{Total tensile force in column longitudinal reinforcement associated with } M_{o,\text{col}} \text{ (Section 7.4.4.1)} \\
T_{\text{pile}}^{\text{(i)}} &= \text{Axial tension demand on a pile (Section 7.7.1.1)} \\
T_{\text{sv}} &= \text{Net tension force in moment resisting footing joints (Section 7.7.2.2)} \\
V_{c} &= \text{Nominal shear strength provided by concrete (Section 3.6.1)} \\
V_{\text{pile}}^{\text{(i)}} &= \text{Shear demand on a pile (Section 7.7.1.1)} \\
V_{n} &= \text{Nominal shear strength (Section 3.6.1)} \\
V_{\text{pile}} &= \text{Abutment pile shear capacity (Section 7.8.4)} \\
V_{s} &= \text{Nominal shear strength provided by shear reinforcement (Section 3.6.1)} \\
V_{o} &= \text{Overstrength shear associated with the overstrength moment } M_{o} \text{ (Section 3.6.1)} \\
V_{\text{col}}^{\text{o}} &= \text{Column overstrength shear, typically defined as } M_{o,\text{col}}/L \text{ (kips, N) (Section 2.3.1)} \\
V_{\text{col}}^{\text{o}}_{p} &= \text{Column plastic shear, typically defined as } M_{p,\text{col}}/L \text{ (kips, N) (Section 2.3.2.1)} \\
V_{n}^{\text{pw}} &= \text{Nominal shear strength of pier wall in the strong direction (Section 3.6.6.2)} \\
V_{\text{u}}^{\text{pw}} &= \text{Shear demand on a pier wall in the strong direction (Section 3.6.6.2)} \\
c_{(i)} &= \text{Distance from pile } (i) \text{ to the center of gravity of the pile group in the X or Y direction (Section 7.7.1.1)} \\
c &= \text{Damping ratio (Section 2.1.5)} \\
d_{bl} &= \text{Nominal bar diameter of longitudinal column reinforcement (Section 7.6.2)}
\end{align*} \]
SEISMIC DESIGN CRITERIA

- $d_{bb}$ = Effective diameter of bundled reinforcement (Section 8.2.3.1)
- $f_h$ = Average normal stress in the horizontal direction within a moment resisting joint (Section 7.4.4.1)
- $f_{ps}$ = Tensile stress for 270 ksi (1900 MPa) 7 wire low relaxation prestress strand (ksi, MPa) (Section 3.2.4)
- $f_u$ = Specified minimum tensile strength for A706 reinforcement (ksi, MPa) (Section 3.2.3)
- $f_{ue}$ = Expected minimum tensile strength for A706 reinforcement (ksi, MPa) (Section 3.2.3)
- $f_{yh}$ = Nominal yield stress of transverse column reinforcement (hoops/spirals) (ksi, Mpa) (Section 3.6.2)
- $f_y$ = Nominal yield stress for A706 reinforcement (ksi, MPa) (Section 3.2.1)
- $f_{ye}$ = Expected yield stress for A706 reinforcement (ksi, MPa) (Section 3.2.1)
- $f'c$ = Compressive strength of unconfined concrete, (Section 3.2.6)
- $f'cc$ = Confined compression strength of concrete (Section 3.2.5)
- $f'ce$ = Expected compressive strength of unconfined concrete, (psi, MPa) (Section 3.2.1)
- $\sqrt{f'_c}$ = Square root of the specified compressive strength of concrete, (psi, MPa) (Section 3.2.6)
- $g$ = Acceleration due to gravity, $32.2 \ \text{ft/} \sec^2$ ($9.81 \ \text{m/} \sec^2$) (Section 1.1)
- $h_{bw}$ = Abutment backwall height (Section 7.8.1)
- $k_{(i)e}$ = Effective stiffness of bent or column $(i)$ (Section 7.1.1)
- $l_{ac}$ = Length of column reinforcement embedded into bent cap (Section 7.4.4.1)
- $l_b$ = Length used for flexural bond requirements (Section 8.2.2.1)
- $m_{(i)}$ = Tributary mass associated with column or bent $(i)$, $m = W/g$ (kip-sec²/ft, kg) (Section 7.1.1)
- $n$ = The total number of piles at distance $c_{(i)}$ from the center of gravity of the pile group (Section 7.7.1.1)
- $p_{bw}$ = Maximum abutment backwall soil pressure (Section 7.8.1)
- $p_c$ = Nominal principal compression stress in a joint (psi, MPa) (Section 7.4.2)
- $p_t$ = Nominal principal tension stress in a joint (psi, MPa) (Section 7.4.2)
- $s$ = Spacing of shear/transverse reinforcement measured along the longitudinal axis of the structural member (in, mm) (Section 3.6.3)
- $s_u$ = Undrained shear strength (psf, KPa) (Section 6.1.3)
- $t$ = Top or bottom slab thickness (Section 7.3.1.1)
- $v_{jv}$ = Nominal vertical shear stress in a moment resisting joint (psi, MPa) (Section 7.4.4.1)
- $v_c$ = Permissible shear stress carried by concrete (psi, MPa) (Section 3.6.2)
- $v_s$ = Shear wave velocity (ft/sec, m/sec) (Section 6.1.3)
- $\varepsilon_c$ = Specified concrete compressive strain for essentially elastic members (Section 3.4.1)
- $\varepsilon_{cc}$ = Concrete compressive strain at maximum compressive stress of confined concrete (Section 3.2.6)
- $\varepsilon_{co}$ = Concrete compressive strain at maximum compressive stress of unconfined concrete (Section 3.2.6)
\( \varepsilon_{op} \) = Ultimate compressive strain (spalling strain) of unconfined concrete (Section 3.2.5)
\( \varepsilon_{cu} \) = Ultimate compression strain for confined concrete (Section 3.2.6)
\( \varepsilon_{ps} \) = Tensile strain for 7-wire low relaxation prestress strand (Section 3.2.4)
\( \varepsilon_{ps,EE} \) = Tensile strain in prestress steel at the essentially elastic limit state (Section 3.2.4)
\( \varepsilon_{ps,u}^R \) = Reduced ultimate tensile strain in prestress steel (Section 3.2.4)
\( \varepsilon_{sth} \) = Tensile strain at the onset of strain hardening for A706 reinforcement (Section 3.2.3)
\( \varepsilon_{su} \) = Ultimate tensile strain for A706 reinforcement (Section 3.2.3)
\( \varepsilon_{s,u}^R \) = Reduced ultimate tensile strain for A706 reinforcement (Section 3.2.3)
\( \varepsilon_{y} \) = Nominal yield tensile strain for A706 reinforcement (Section 3.2.3)
\( \varepsilon_{ye} \) = Expected yield tensile strain for A706 reinforcement (Section 3.2.3)
\( \Delta_b \) = Displacement due to beam flexibility (Section 2.2.2)
\( \Delta_c \) = Local member displacement capacity (Section 3.1.2)
\( \Delta_{col} \) = Displacement attributed to the elastic and plastic deformation of the column (Section 2.2.4)
\( \Delta_C \) = Global displacement capacity (Section 3.1.2)
\( \Delta_{cr+sh} \) = Displacement due to creep and shrinkage (Section 7.2.5.5)
\( \Delta_d \) = Local member displacement demand (Section 2.2.2)
\( \Delta_D \) = Global system displacement (Section 2.2.1)
\( \Delta_{eq} \) = The average displacement at an expansion joint due to earthquake (Section 7.2.5.5)
\( \Delta_f \) = Displacement due to foundation flexibility (Section 2.2.2)
\( \Delta_p \) = Local member plastic displacement capacity (in, mm) (Section 3.1.3)
\( \Delta_{pl,s} \) = Displacement due to prestress shortening (Section 7.2.5.5)
\( \Delta_r \) = The relative lateral offset between the point of contra-flexure and the base of the plastic hinge (Section 4.2)
\( \Delta_s \) = The displacement in Type I shafts at the point of maximum moment (Section 4.2)
\( \Delta_{temp} \) = The displacement due to temperature variation (Section 7.2.5.5)
\( \Delta_{col}^y \) = Idealized yield displacement of the column (Section 2.2.4)
\( \Delta_y \) = Idealized yield displacement of the subsystem at the formation of the plastic hinge (in, mm) (Section 2.2.3)
\( \theta_p \) = Plastic rotation capacity (radians) (Section 3.1.3)
\( \rho \) = Ratio of non-prestressed tension reinforcement (Section 4.4)
\( \rho_{li} \) = Area ratio of longitudinal column reinforcement (Section 8.2.1)
\[ \rho_s = \text{Ratio of volume of spiral or hoop reinforcement to the core volume confined by the spiral or hoop reinforcement (measured out-to-out), } \rho_s = 4 \times A_b / (D' \times s) \text{ for circular cross sections (Section 3.6.2)} \]

\[ \rho_{fs} = \text{Area ratio of transverse reinforcement in column flare (Section 7.6.5.3)} \]

\[ \phi = \text{Strength reduction factor (Section 3.6.1)} \]

\[ \phi_p = \text{Idealized plastic curvature } 1/\text{in} (1/\text{mm}) \text{ (Section 3.1.3)} \]

\[ \phi_u = \text{Ultimate curvature capacity (Section 3.1.3)} \]

\[ \phi_y = \text{yield curvature corresponding to the yield of the first tension reinforcement in a ductile component (Section 5.6.1.1)} \]

\[ \phi_Y = \text{Idealized yield curvature (Section 3.1.3)} \]

\[ \mu_d = \text{Local displacement ductility demand (Section 3.6.2)} \]

\[ \mu_D = \text{Global displacement ductility demand (Section 2.2.3)} \]

\[ \mu_c = \text{Local displacement ductility capacity (Section 3.1.4)} \]