6-5 REINFORCED CONCRETE PIER WALLS

Piers are defined in *Bridge Design Specifications* (BDS) Article 7.5.1.3 and Commentary. Pier walls shall be designed as columns about the weak axis and as piers about the strong axis (BDS Article 7.5.2) with exception as defined below. See Attachment 1 for a summary of BDS reinforcement criteria applicable to pier walls designed as a column (displacement ductility demand > 4.0). Such piers could be reinforced according to tie criteria, or with multi-spirals (assuming the pier as a row of several individual slender columns).

Pier wall thickness must be sufficient to satisfy slenderness criteria of BDS Article 8.16.5. Longitudinal seismic displacements within the wall height should not exceed ⅓ the pier thickness. The longitudinal movements should be based on an engineering evaluation considering joint closures and abutment movement, not on computer generated ARS criteria. The thickness must be adequate to allow insertion of a minimum 4-inch concrete placement tube through the network of cross tie tails. If pier walls are loaded below the lesser of $0.1f'_c$ Ag or $0.4P_b$ for Load Group VII, they can be exempt from the stringent confinement requirements of ACI Appendix A and BDS Article 8.18.2. This exemption will apply only if the pier is designed for a ductility displacement demand of four or less. Pier thickness and width dimensions can be adjusted, or a pier(s) added to reduce the axial load to $0.1f'_c$ Ag or $0.4P_b$. When considering such revisions, they should be cost compared to pier walls designed as columns and requiring the severe tie arrangements or multi-spirals to meet confinement specifications.

If the pier wall satisfies the foregoing criteria, reinforcement provided to meet the group moment and shear loads subject to the following minimums will be considered satisfactory for confinement:

$\rho_h \geq 0.0025$ (horizontal ties, but not cross-ties)

$\rho_n \geq \rho_h$

Spacing of all horizontal bars and ties shall not exceed 12 inches in any direction, except vertical spacing shall not exceed 6 inches in plastic hinge zones.

Refer to Attachment 2 for example detailing of a pier wall designed for a displacement ductility demand ≤ 4.0 about the longitudinal axis.

Supersedes Memo to Designers 6-5 dated August 1993

Cross ties shall have a 135° seismic hook on one end and a 90° hook on the opposite end. Cross ties shall be placed so that 90° and 135° hooks of adjacent ties, horizontally and vertically, shall be alternated.

All piers and their foundations must be analyzed for strength and stability about the strong axis for all load cases, using ARS elastic forces for Group VII. Fusing at the pile/footing interface, sliding, or rocking can be used as an analytical tool to reduce transverse seismic demands in competent soils.

Confinement reinforcement relief allowed in this memo is based partially on test results from U.C. Irvine.

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RDL:(osp)

ATTACHMENT 1

Percentage and Spacing [1] Requirements for Pier Wall Reinforcement

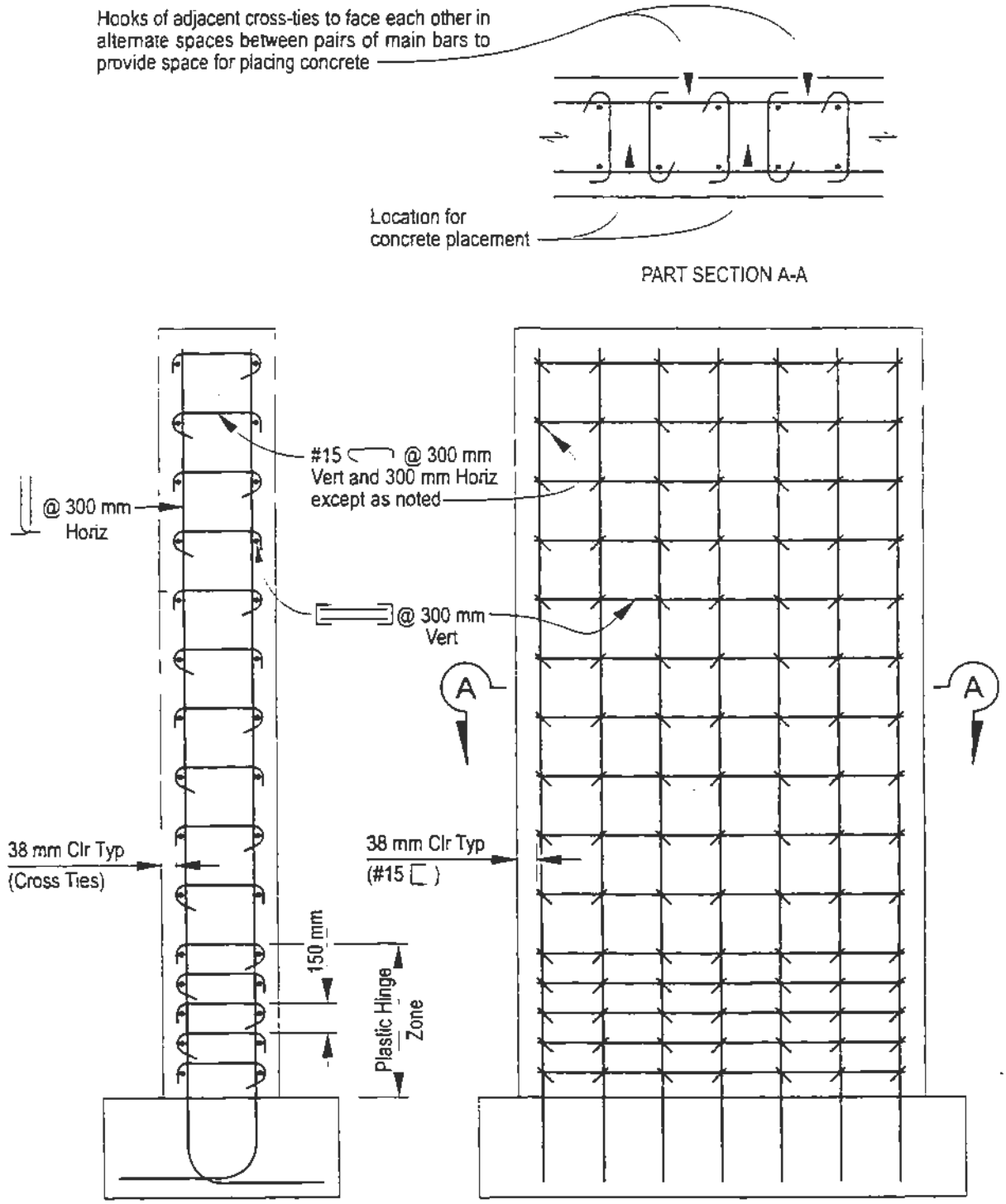
Designed as a Column about Weak Axis (Displacement ductility demand exceeds 4.0)

	Regular Detailing	Ductile Detailing Plastic Hinge Zone
Vertical Reinforcement		
Percentage, ρ_n	$\rho_n > \rho_\ell$; $0.25 \leq \rho_n < 4.00$ (Note 4)	$0.25 \leq \rho_n \leq 4.00$ (Note 4)
Spacing, s_{nh}	$d_n + s_{\min n}$ (Note 5) $\leq s_{nh} < 300$	$d_n + s_{\min n}$ (Note 5) $\leq s_{nr} \leq 200$
Diameter, d_n		
Lateral Ties		
Percentage, ρ_ℓ	$0.25 \leq \rho_\ell$	$0.25 \leq \rho_\ell$
Spacing, $s_{\ell v}$	$d_\ell + s_{\min \ell}$ (Note 6 & 12) $\leq s_{\ell v} \leq 300$	50 (Note 7) $\leq s_{\ell v} \leq 200$ (Note 8)
Diameter, d_ℓ		
Cross Ties		
Percentage, ρ_c (Note 9)	$0.25 \leq \rho_c$	$0.25 \leq \rho_c$
Vertical Spacing, s_{cv}	$d_c + s_{\min \ell}$ (Note 6 & 12) $\leq s_{cv} \leq 300$ (Note 10) or $s_{\ell v}$	50 (Note 7) $\leq s_{cv} \leq 200$ (Note 8)
Horizontal Spacing, s_{ch}	$d_c + s_{\min n}$ (Note 5) $\leq s_{ch} \leq 150$ (Note 11)	$d_c + s_{\min n}$ (Note 5) $\leq s_{ch} \leq 150$ (Note 11)
Diameter, d_c		

Notes:

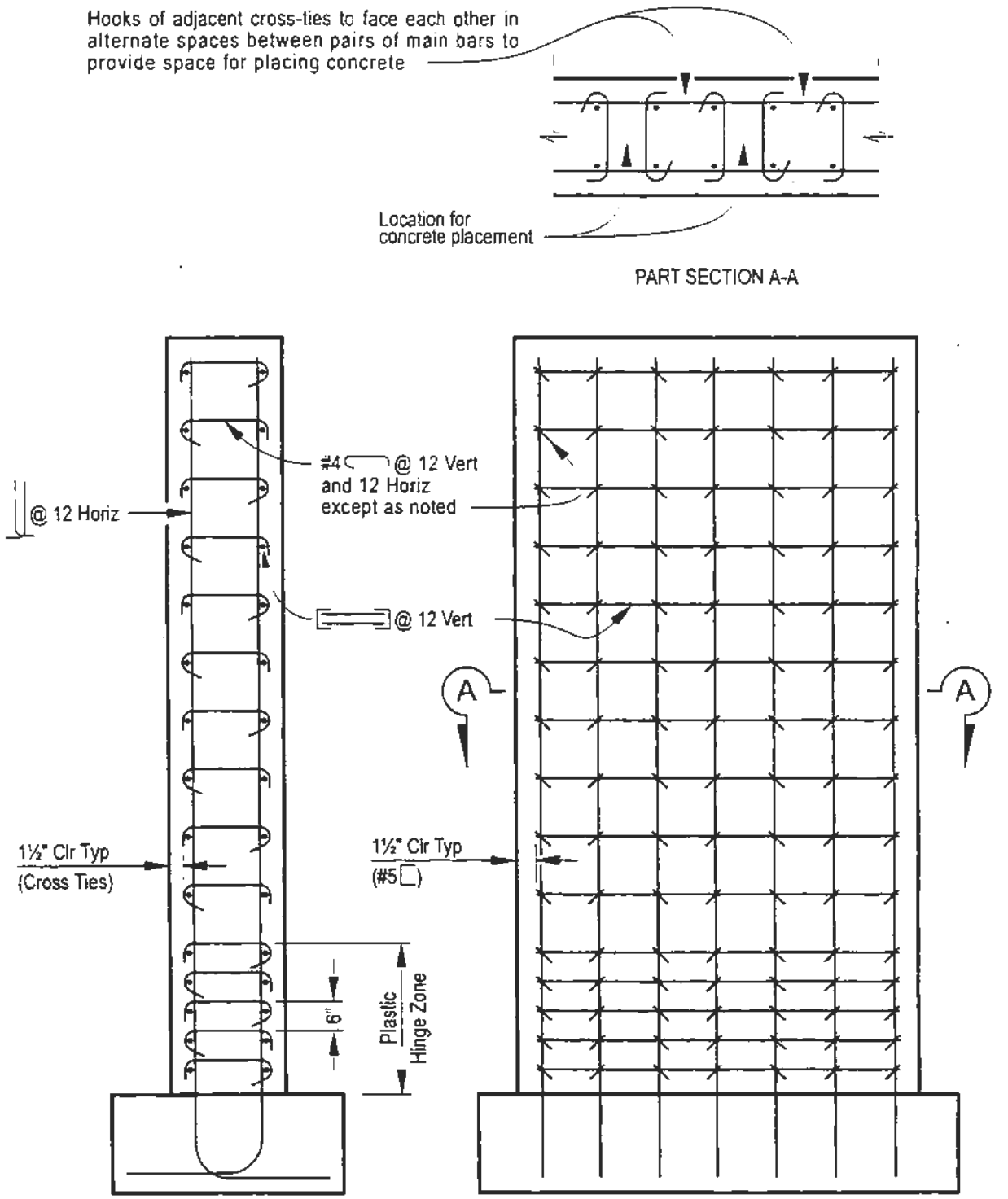
1. All dimensions in millimeters.
4. Maximum vertical reinforcement percentage limited by practical steel placement.
5. $s_{\min n}$ = the largest of {38 mm, $1^1/_2$ × maximum aggregate size, $1^1/_2$ × one vertical bar diameter}.
6. $s_{\min \ell}$ = the larger of {33 mm, $1^1/_3$ × maximum aggregate size}.
7. Based on minimum vertical spacing of lateral tie reinforcement in plastic hinge zone = 50 mm.
8. Maximum lateral tie vertical spacing in plastic hinge zone = 200 mm, but not greater than $6_{d\ell}$ nor $^1/_5$ the least pier dimension.
9. $\rho_c = A_{sc}/(s_{cv}h_{co})$ in which A_{sc} = area of cross tie reinforcing; h_{co} = overall horizontal dimension of pier wall core concrete.
10. Based on maximum vertical spacing of cross ties in pier walls = 300 mm; Assumes that 135° cross tie ends hook over alternate lateral tie/vertical bar joints.
11. Based on maximum horizontal spacing of cross ties in pier walls = 150 mm; Assumes that 135° cross tie ends hook over alternate lateral tie/vertical bar joints.
12. The quantities $d_\ell + s_{\min \ell}$ and $d_c + s_{\min \ell}$ shall not be less than 50 mm.

ATTACHMENT 2



Pier Wall Example Reinforcement for Lightly Loaded Walls
Designed for a Displacement Ductility Demand of 4.0 or Less
(Footing Reinforcement Not Shown)

ATTACHMENT 2



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