6.3 ARCHITECTURAL COMPONENTS

6.3.9 FREESTANDING WALLS OR FENCES

6.3.9.1 FREESTANDING MASONRY WALL OR FENCE

This category covers freestanding (cantilevered) walls and fences built of either reinforced or unreinforced masonry. Freestanding fences of 6 feet or less are often not covered by code provisions; nevertheless, unreinforced or poorly reinforced masonry walls or fences or those with inadequate foundations are vulnerable to earthquake damage.

TYPICAL CAUSES OF DAMAGE

- Unreinforced masonry elements perform poorly in earthquakes; unreinforced or under-reinforced masonry walls and fences frequently fail out-of-plane and may collapse completely. Walls with inadequate foundations may also fail out-of-plane and tip over.
- Falling masonry walls and fences may injure people and property and block pedestrian walkways, driveways, loading docks, streets and access for emergency vehicles during an emergency.
- When these fences serve as a security perimeter, their failure may result in a security breach following an earthquake resulting in additional property damage due to trespassing or looting.
- The 1994 Northridge Earthquake damaged many miles of poorly constructed concrete masonry unit (CMU) fences and caused collapse of walls with inadequate or absent reinforcing and foundations in Northridge and Sylmar, California, covering sidewalks with debris, as shown in Figure 6.3.9.1-1. After the 2010 Haiti Earthquake, the debris were apparent from aerial photos of the affected areas.

Damage Examples

Figure 6.3.9.1-1 Collapse of freestanding CMU walls covering much of the sidewalk in the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of Robert Reitherman). The rubble reveals that the wall was unreinforced.

Figure 6.3.9.1-2 Freestanding masonry fences with inadequate reinforcement collapsed covering both sides of this street in Port-au-Prince in the 2010 magnitude-7 Haiti Earthquake (Photo courtesy of Yves Montoban). Many miles of such fencing collapsed in the 2010 Haiti Earthquake.

Figure 6.3.9.1-3 Damage to reinforced masonry boundary fence at industrial facility in Southern Peru; out-of-plane movement at construction joint in wall without sufficient reinforcing for the level of shaking experienced at this location in the 2001magnitude-8.4 Peru Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers). Additional boundary steel or reinforced concrete boundary columns located either side of construction joints would improve the performance of this type of fence.

Figure 6.3.9.1-4 Photo at top shows complete collapse of poorly detailed confined masonry fence in foreground; partial collapse of poorly detailed confined masonry fence in distance at left; no damage to well detailed confined masonry fence in distance at right in the 2010 Haiti Earthquake. Close-up view of well-detailed confined masonry fence in bottom photo with concrete columns and bond beam at top (Photos courtesy of Eduardo Fierro, BFP Engineers). Fences in foreground and at right formed the security perimeter at an electric power plant in Port-au-Prince.

SEISMIC MITIGATION CONSIDERATIONS

- Freestanding walls or fences built of concrete masonry units (CMU), brick or stone need to be engineered and constructed to cantilever from the base with appropriate

foundations, adequate reinforcing, good quality mortar, and good workmanship. Seismic loading at the base of tall cantilever walls can be substantial in a major earthquake. Such walls could be constructed using standard seismic detailing for reinforced masonry such as the details shown in Figure 6.3.9.1-6 and 7. Engineered reinforced concrete walls would clearly be another, although more costly, alternative.

- The State of California has published several guidelines that relate to the construction of such fences; see DSA IR 21-1 *Masonry Wall – Non Structural*, DSA IR 21-2 *Concrete Masonry High Lift Grouting Method*, DSA IR 21-3 *Clay Brick Masonry High Lift Grouting Method*, and DSA IR 21-4 *Masonry: Concrete Masonry Unit Standards* (California Department of General Services, 2007a, 2009b, 1999, and 2007b). DSA IR 21-1 describes minimum requirements for a garden wall or screen wall to be used at California schools or essential facilities. Other jurisdictions may have standard details for highway sound walls or short retaining walls that could be adapted for use. Some jurisdictions or homeowner associations may also have zoning restrictions or similar that limit the height, setbacks, or materials used for fencing; check the local jurisdiction. The details shown in Figure 6.3.9.1-5 were adapted from details provided online by the City of San Diego, California for reinforced CMU fences up to 6 feet in height.
- While design and construction of unreinforced masonry walls or fences typically do not come under the purview of the building code, there are many hazardous masonry walls or fences in existence. These could be demolished and replaced with a reinforced masonry fence, wood fence, or cyclone fence. As an alternative, the performance of unreinforced masonry walls with adequate foundations could be substantially improved by using retrofit details for confined masonry. Even though the use of confined masonry is rare in the U.S., it is common in other parts of the world. This system utilizes reinforced concrete boundary members on all four sides of each unreinforced masonry wall panel with a panel size limited to roughly 3 meters in length. The Confined Masonry Network (http://www.confinedmasonry.org/) provides information and details on this subject.
- The International Building Code exempts fences from a building permit if the fence is not over 6 feet in height. The code also states that work must still comply with building code requirements even when a permit is not required.
- Fence heights may also be regulated by the zoning laws of the city. For specific information about the zoning regulations for your fence on your lot, contact the development services and zoning departments for requirements.

MITIGATION DETAILS

1. ALL MATERIAL AND WORKMANSHIP SHALL CONFORM TO THE REQUIREMENTS OF THE AUTHORITY HAVING JURISDICTION.

2. CONCRETE SHALL ATTAIN A COMPRESSIVE STRENGTH OF 2,500PSI MINIMUM AT 28 DAYS.

3. CONCRETE BLOCK UNITS SHALL BE MEDIUM OR NORMAL WEIGHT UNITS CONFORMING TO ASTM C90 (LATEST REVISION).

4. MORTAR SHALL BE TYPE S CONFORMING TO ASTM C270 WITH A COMPRESSIVE STRENGTH OF 1,800PSI MINIMUM AT 28 DAYS.

5. GROUT SHALL CONFORM TO ASTM C476 AND BE COMPOSED OF THE FOLLOWING RATIO BY VOLUME: 1 PART PORTLAND CEMENT, 3-PARTS SAND, 2-PARTS PEA GRAVEL, AND SUFFICIENT WATER FOR POURING WITHOUT SEGREGATION OF GROUT CONSTITUENTS (MIN. COMPRESSIVE STRENGTH OF 2,000PSI AT 28 DAYS).

6. ALL REINFORCING STEEL SHALL COMPLY WITH ASTM A615, GRADE 60. VERTICAL STEEL SHALL BE CENTERED IN THE CONCRETE BLOCK CELL IN WHICH IT IS LOCATED, U.O.N.

7. WALL JOINT REINFORCING STEEL SHALL BE DUR-O-WAL WIRE CONFORMING TO ASTM A82 AND ASTM A641 – STANDARD, MILL GALVANIZED MINIMUM LAP SPLICE OF JOINT REINFORCEMENT SHALL BE 12 INCHES.

8. CELLS CONTAINING REINFORCING STEEL SHALL BE SOLID GROUTED.

9. ALL HORIZONTAL WALL REINFORCING BARS SHALL BE PLACED IN BOND BEAM UNITS. ALL JOINT REINFORCING SHALL BE PLACED IN THE MORTARED BED JOINT.

10. ALL GROUT SHALL BE CONSOLIDATED BY VIBRATING IMMEDIATELY. RECONSOLIDATE GROUT AFTER INITIAL WATER LOSS BUT BEFORE PLASTICITY IS LOST TO INSURE ADEQUATE CONSOLIDATION.

11. CONCRETE BLOCK UNITS ARE TO BE STAGGERED (COMMON BOND) AND ARE TO HAVE THE VERTICAL CONTINUITY OF THE CELLS UNOBSTRUCTED.

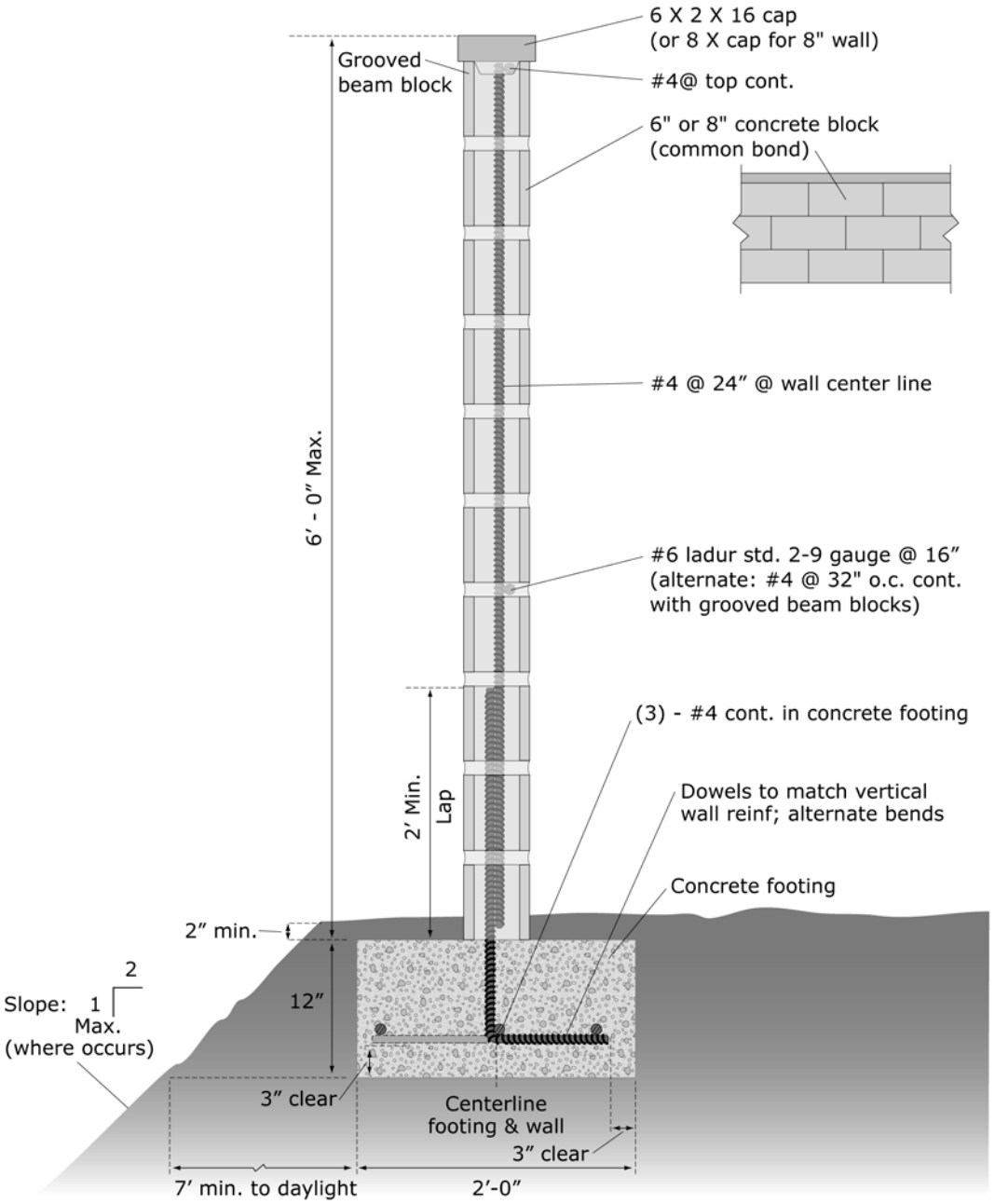
12. ALL FOOTINGS MUST EXTEND INTO FIRM UNDISTURBED NATURAL SOIL OR SOIL WHICH HAS BEEN COMPACTED TO AT LEAST 90 PERCENT MAXIMUM DENSITY.

13. THESE WALLS SHALL NOT BE CONSTRUCTED ON EXPANSIVE SOIL (EXPANSION INDEX GREATER THAN 20), LIQUEFIABLE SOILS OR OTHER QUESTIONABLE SOILS, UNLESS THE SOIL HAS BEEN SPECIALLY PREPARED IN ACCORDANCE WITH RECOMMENDATIONS OF A CIVIL OR GEOTECHNICAL ENGINEER.

14. PROVIDE VERTICAL CONTROL JOINTS AT 25'-0" ON CENTER MAXIMUM.

15. FENCE WALL DESIGN INCLUDES ½" OF PLASTER (OR VENEER) ON EACH SID OF THE WALL. NO FINISHES WITH A TOTAL WEIGHT GREATER THAN 13PSF (SUMMATION OF BOTH SIDES OF WALL) ARE ALLOWED.

Figure 6.3.9.1-5 6ft maximum height concrete masonry unit (CMU) wall (PR) [1 of 2].



Design Criteria
1. Allowable soil bearing pressure = 1500 PSF
2. Allowable lateral bearing pressure = 100 PSF
3. Seismic load based on site class D w/ mapped spectral acceleration, S_S = 2.03
4. Wind load based on 85 MPH basic wind speed, Exposure Category C
5. See Sheet 1 of 2 for construction specs

Figure 6.3.9.1-5 6ft maximum height concrete masonry unit (CMU) wall (PR) [2 of 2].