## 12.0 RETAINING STRUCTURES

The seismic design of retaining structures is an area of ongoing discussion with the active development of the latest generation of codes and hence the performance of retaining structures in the February 27th event was of great immediate interest. Many different types of retaining structures, ranging from modern mechanically stabilized walls and bridge abutment to older cantilever and gravity concrete structures were subjected to strong ground motions during the M 8.8 event. Their performance was uniformly good, if not excellent, and no significant problems have been reported or observed during the reconnaissance. Similarly, no basement wall damage of any kind has been reported. The rare failures or damage when noted appeared to be due to construction defects. The purpose of this section of the report is to thus show examples of various types of structures observed during the reconnaissance in order to provide baseline documentation for possible future detailed analyses.

**Mechanically Stabilized Retaining Walls –** Mechanically stabilized earth embankment walls, specifically Reinforced Earth walls, have been used in Chile quite extensively for highway embankments, particularly for overpasses and bridge abutments. In the greater Santiago metropolitan area there are numerous underpasses, overpasses and sidehill fills retained with Reinforced Earth walls. Their performance was excellent even when bridges supported by the abutments failed by sliding off their seats as happened in a number of instances as shown in Figure 12.1. The same level of performance occurred along the major north-south freeway, Route 5. Figure 12.2 shows a Reinforced Earth abutment of a collapsed bridge across a rail line. In this case, the approach embankment to the North of this failed railroad overpass had a major failure as well (see Section 9.15), however, the abutments themselves showed no signs of appreciable deformation. In this case, the adjacent older bridge with multiple supports also performed very well and showed no evidence of damage.

Figure 12.1. Intersection of Americo Vespucio Norte and Independencia. Abutment of a collapsed bridge. (33°21'57.83"S, 70°41'17.71"W)

Similarly, block faced mechanically stabilized wall performed very well. Figure 12.3 shows a block faced mechanically stabilized bridge approach which lost the top most row of blocks but otherwise remained intact.


Figure 12.2. Reinforced Earth bridge abutments at a collapsed rail crossing on Route 5 north of Parral (36.0803°S, 71.788°W)

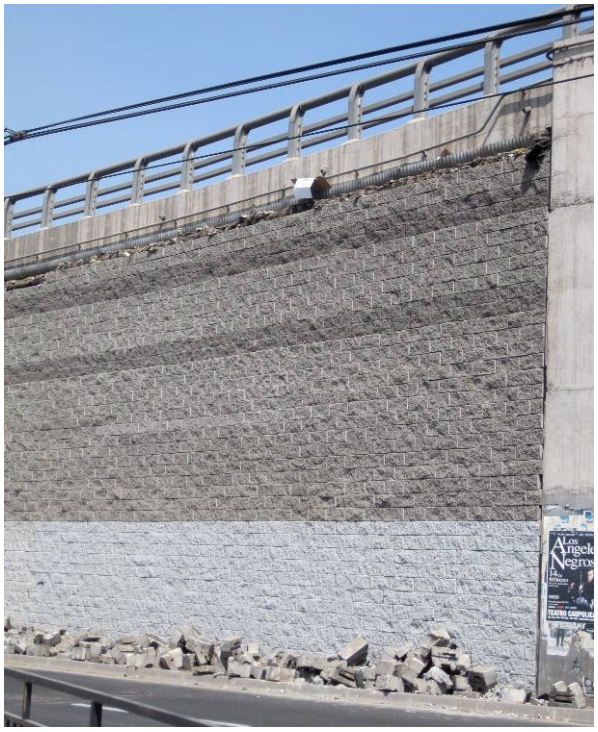

Figure 12.3. Block faced mechanically stabilized embakment, Intersection of Americo Vespucio Norte and Lo Echevers. (33°22'34.54"S, 70°44'52.83"W)

Figure 12.4 shows a photograph of yet another typical MSE retaining structure. This wall, located west of Chillan, was approximately 6 m high and exhibited no damage despite surficial slope instability in the adjacent approach fill slope.


Figure 12.4 Undamaged MSE wingwall on overpass structure over highway 152 west of Chillan despite sliding of adjacent fill slope (S36.6588, W72.2776).

**Conventional, Concrete Gravity and Cantilever Structures –** Conventional concrete gravity and retaining structures similarly performed very well in many different settings. Figure 12.5 shows an overpass structure on the coastal highway just south of Coronel, about 140 km south of the epicenter in an area which experienced significant shaking. The structure experienced no distress and the bridge structures were fully functional after the event.

Figure 12.5. Multiple retaining structures for highway overpass structures south end of Coronel (37.0455°S, 73.1421°W)

Most importantly, there were numerous bridge approach embankments that were shaken with sufficient intensity to experience surficial slumping, yet the abutment forming retaining walls performed very well and showed no evidence of damage. The bridge decks on the other hand were often offset and the concrete seats were spalled or completely fractured. Figure 12.5 shows one such bridge approach embankment and abutment wall on Route 5 north of Chillan. The bridge deck had temporary scaffolding supporting it at the other abutment as it was close to sliding off.

Figure 12.6. Surficial sloughing on a bridge approach embankment, with the abotment showing no evidence of damage, Route 5, north of Chillan.

A rare failure of the uppermost section of a reinforced concrete retaining structure was observed in San Pedro, about 110 km south of the epicenter. The wall (Figure 12.7) was located within 3 km of the south approach to the Llacolen Bridge (the middle bridge across the River Bio Bio connecting Concepcion and San Pedro). The 16-inch thick wall was reinforced vertically with No. 3 or No. 4 bars on 12 inch centers (Figure 12.8). Failure occurred at the uppermost joint as the top wall toppled to the east apparently due to inertial forces. The granular backfill is clearly self supporting (Figure 12.9). Figures 12.9 and 12.10 show water seepage behind the intact portion of the wall and corrosion of the horizontal reinforcing along the joint.

Figure 12.7. Failed reinforced concrete retaining structure in San Pedro.

Figure 12.8. Toppled portion of 16-inch thick wall showing bent compression bars and snapped tension bars.

Figure 12.9. Granular fill soils and water seepage evident behind failed portion of wall.

Figure 12.10. Corrosion of horizontal reinforcing steel where water entered the joint.

**Temporary Retaining Structures** – Temporary retaining structures were not widely observed; however, those observed performed well. Figure 12.11 shows a temporary shoring system in Santiago that appears to have been constructed some months before the earthquake given the vegetative growth on the wall face. The vertical members and single row of tieback anchors appeared undamaged while the exposed gravels between the vertical members did experience some raveling.

Figure 12.11. Undamaged temporary retaining structure in Santiago.