Northridge EarthQuake!

Reinforced Masonry Performs Well

*by John Chrysler**

In the immediate aftermath of the 1994 Northridge Earthquake, masonry received considerable attention, some adverse. Some may think that the performance of masonry was inadequate, but the facts clearly state that masonry performed very well. It is a fact that not one life was lost due to masonry failures in this earthquake.

Immediately following the 6.8 magnitude earthquake, the news media reported the widespread building damage, which included an abundance of damaged brick chimneys and fallen property fence walls. These spectacular scenes grossly misrepresented the overall performance of masonry.

The property fence walls are not regulated by the permit and inspection process of the Uniform Building Code as long as the height does not exceed 6 feet. This may be considered a loophole in the Code, but people generally expect that these property fence walls will be constructed to withstand normal wind and seismic forces.

There was one 40 foot failure in the hundreds of miles of sound barrier walls along the Southern California freeways. There were very few masonry wall failures of public service facilities, such as hospitals, police stations and fire stations, electrical service facilities and in commercial construction. It is interesting that these successfully constructed walls are much taller that the 6 foot property fence walls.

Normally, minimum steel at 48" on center should be expected, with horizontal steel at the top of the wall. To be effective, the cells that contain the steel must be fully grouted. Additionally, the footings that support the property fence walls must be adequate to withstand not only the weight of the wall but also the overturning forces of wind and earthquakes. Generally, these provisions were not met causing wall failures.

*Director of Technical Services
Masonry Institute of America, Los Angeles, CA

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Across the street from Cal State Northridge Parking Structure brick chimney stands tall.

Another common failure was the brick chimney. According to the City of Los Angeles, approximately 15,000 chimney failures were recorded within their jurisdiction. Conservatively, this represents about 2% of the masonry chimneys that were exposed to this earthquake. Field observations showed that over 90% of the observed failures were due to non-compliance with the current Code.

These shortcomings included lack of reinforcement, inadequate grouting of the reinforcement and deficient connections of the chimney to the structure. Failures of nonreinforced old chimneys as expected were abundant.

Many connection failures of metal chimneys were reported after the earthquake. Not visible from the exterior, these failures will allow dangerous, hot gasses to escape inside the chimney chase if not corrected.

One of the most visible failures was the Cal State Northridge Parking Structure, a ductile concrete frame system that collapsed at the East and West ends. Opposite the East end of this parking structure, across Zelzah Avenue, are five houses in a row, all with brick chimneys that suffered no damage due to the earthquake.

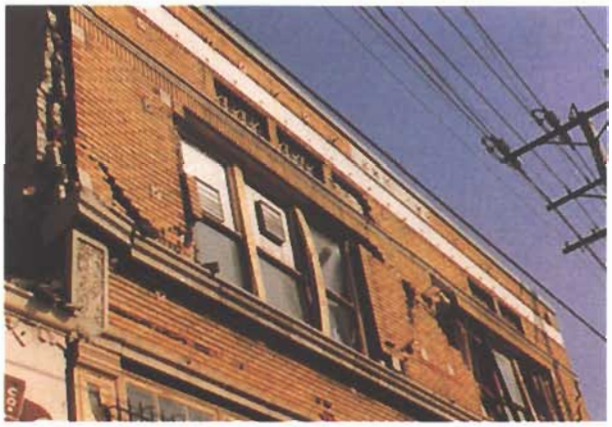
We must not lose sight of the fact that hundreds of thousands of masonry chimneys withstood the Northridge Earthquake without damage.

A large portion of the old unreinforced masonry buildings within the City of Los Angeles fell within the jurisdiction of Division 88. Division 88 is an attempt to secure the masonry of the old pre-1933 buildings to the roof and floor diaphragms to keep the building from total collapse in the event of a major earthquake. It was never intended to prevent damage to the structure.

Most of these old pre-1933 buildings are economically marginal, therefore, the Division 88 fix had to be cost effective. More elaborate recommendations could have been made in the Division 88 ordinance, at an economic hardship to the public.

Since the retrofitted buildings performed better than those that were not retrofitted, it is reasonable to say that Division 88 was effective.

Reinforced masonry constructed over the past 30 years performed very well in this very significant earthquake. According to the current Uniform Building Code , most buildings are designed to withstand a lateral seismic force of 30% (0.3 g) of the weight of the building and there is no direct design criteria for vertical uplift.



Unreinforced, retrofitted building in Los Angeles heavily damaged without collapse.

1.0 2.0 3.0 4.0

Below 3.0 felt by very few people.

3.0 - 3.9 Felt indoors. Vibrations feel like passing light trucks. May not be recognized as an earthquake.

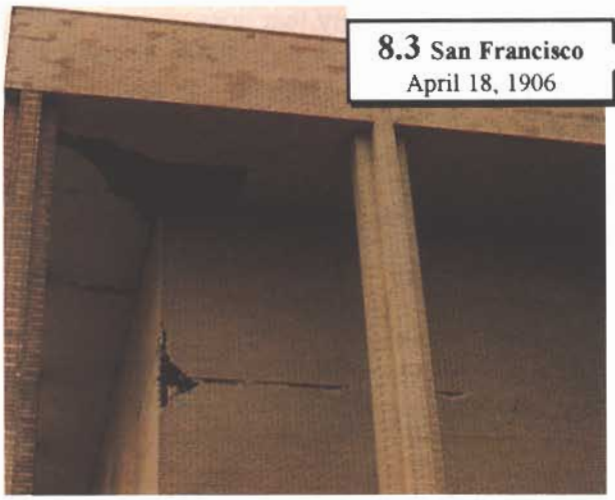
4.0 - 4.9 Felt outdoors by most people. Sleepers awakened. Doors swing. Pictures move. Some plaster breaks.

Instrumentation in Santa Monica, 14.3 miles (23 km) from the epicenter, recorded a horizontal acceleration of 0.93 g and a vertical acceleration of 0.25 g. At this significant distance, the ground motion was over three times code design standards. This was a very powerful earthquake! According to seismologists, the ground accelerations were the highest ever recorded.

The Northridge Mall, which is less than 3 miles (4.5 km) from the epicenter, suffered extensive damage. The Bullocks Store, a non-masonry structure, collapsed. Yet only a few yards away, the Broadway Store, a double wythe reinforced brick facade with concrete floors and interior concrete columns stood like a fortress. There was extensive damage to the interior and exterior, but it is repairable. Ironically, the Broadway Store was under construction during the 1971 San Fernando Earthquake.

Fire Stations, which use extensive masonry in their design, withstood the earthquake almost flawlessly. The facilities were in full operation the same day of the earthquake.

Typical Fire Station perimeter wall with no damage.



Broadway, Northridge Mall is double wythe reinforced brick and shows damage from floor pounding while adjacent Bullock's Store (not masonry) collapsed.

The technology in the fields of concrete and structural steel has advanced at a pace never before known to man. On the other hand, masonry has been common for thousands of years, so the design of masonry has evolved empirically, which means that what has worked successfully for thousands of years should work successfully in the future. Masonry construction has been enhanced by the use of reinforcement within the masonry unit, thereby giving masonry additional capability to withstand lateral seismic and wind forces.

5.0 -5.9 Felt by all. People walk unsteadily. Glass breaks. Furniture moves. Objects fall from shelves.

6.0 - 6.9 Difficult to satnd. Serious damage to unreinforced chimneys, stucco and unreinforced masonry walls.

7.0 - 7.9 Some well-built wooden structures and bridges destroyed serious damage to dams, dikes embankments. Large landslides.

8.0 Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.

Any damage to masonry that does occur is highly visible and can be repaired. When a crack appears in masonry, it does not mean that the masonry has failed, but it does mean that the reinforcement had a chance to do its job, namely, hold the masonry together. When a structural engineer verifies the structural integrity of the system, the crack can be filled and the masonry system continues to function as a safe and economic building element.

Mirabella, a 23 story undamaged brick veneer tower near heavily damaged Santa Monica.

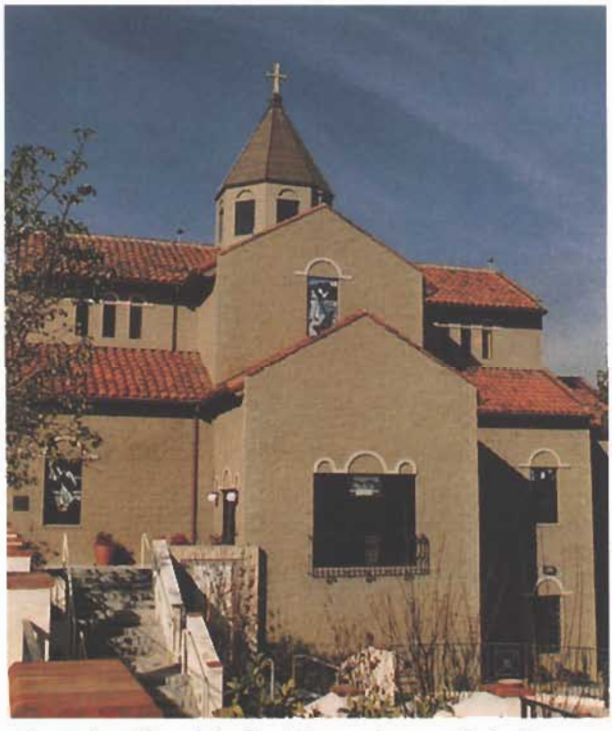
The Northridge Earthquake changed forever the way we think of structural steel as the ideal building material for withstanding seismic activity. In this event, several hundred buildings are suspect of joint failure in the structural steel. The University of Texas, Arlington, has been involved in testing to recommend methods of repair. Several months later, they are still searching for an answer to this problem.

Masonry veneer constructed in accordance with current code and recommended design practices performed very well. Building movement may have caused damage to veneer systems with a solid mortar fill of the cavity between the veneer and the backup system and solid fill directly under the shelf angle. Corrosion resistant ties and horizontal joint reinforcement restrained the collapse of veneer systems subjected to heavy damage.

Veneer corners were subjected to bilateral or torsional building movement, so the need to isolate corners becomes more evident. On buildings that did include isolated corner design, no failures were seen.

There are countless examples of masonry successes. They are not spectacular, they just work. Buildings such as Pledgerville Senior Housing, in Pacoima, a 5-story masonry bearing wall system with full interior shear walls; Northridge Department of Water and Power Pump Station only 2 miles from the epicenter with no structural damage to the masonry; the Northridge Post Office which suffered only non-structural damage and was operational just after the earthquake and the Automobile Club, Van Nuys which had considerable interior damage, with no damage noted to the reinforced concrete masonry and veneer are examples of the success of masonry.

The list is not endless, but it is extensive. With the progress of masonry and the proven reliability of reinforced masonry in particular, there is justification to expand the use of masonry in all markets of construction.



Armenian Church in San Fernando recently built reinforced block with no damage.