Long Beach 1933 — Coalinga 1983 But With a Difference

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At 4:45 p.m. Monday, May 2, 1983, an earthquake which registered 6.5 on the Richter scale struck the rural oil and farming community of Coalinga, California (Fig. 1).

The earthquake destroyed the central downtown area and seriously damaged 563 of the 2500 homes in the area. This was a disaster that was unexpected and caused devastation throughout this small farming community. There was a miracle; the miracle was that no deaths occurred. It was reported that approximately 45 people were injured, but only one seriously.

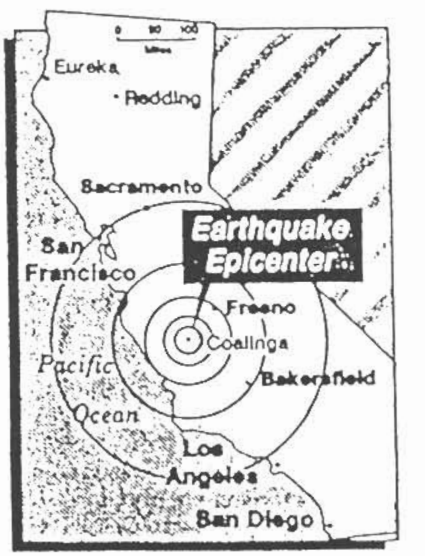

Fig. 1. *The epicenter of the earthquake was approximately five miles northeast of the city of Coalinga.*

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Fig. 2. *Damage to unreinforced masonry buildings in the March 10, 1933, earthquake of Long Beach.*

In surveying this devastating earthquake, it came to mind that here was the 1933 earthquake of Long Beach, California, all over again.

The size of the earthquake, 6.5 on the Richter scale, was approximately the same that hit the city of Long Beach in 1933. The devastation, the collapse of buildings, the falling out of unreinforced masonry walls was seen in Long Beach (Fig. 2) as well as in Coalinga.

The old, unreinforced masonry buildings suffered much damage throughout the downtown area called Coalinga Plaza. These buildings were the viable merchandising center for the community. They were constructed in the early 30s and were built of quality masonry for that time. Face brick, bond patterns, fancy and skilled detail were used in the bricklaying for these walls. However, there was no reinforcing; lime mortar was used and the floor systems and roof diaphragms were not adequately secured to the walls.

The general downtown area suffered major devastation from 4th Street to 7th Street and from Forest Avenue to Durian Avenue. This was the area that was well secured by police and highway patrol (Fig. 3).

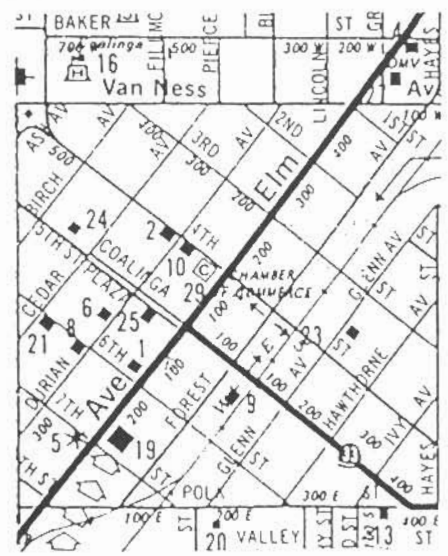

Fig. 3. *Map of downtown central area of Coalinga.*

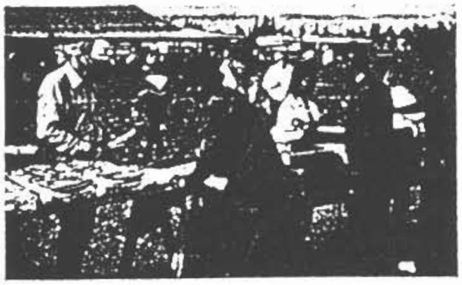

Fig. 4. National Guard distributing food; note dining tent in the rear.

It is to the credit of the community and the law enforcing agencies that order was well maintained and aid was provided for everybody.

The California National Guard came in immediately (Fig. 4) and set up emergency food distribution field kitchens and dining tents. The next day, Tuesday, the National Guard and the Salvation Army were feeding hundreds, and by Thursday they were feeding thousands.

The California Highway Patrol, the Fresno County Sheriff's Department and the City of Coalinga Police Department all cooperated in maintaining law and order throughout the devastated area. They maintained the downtown area in a secure position, keeping everyone out who did not have proper authority or business to be there.

The California Department of Transportation (Caltrans) came in with bulldozers, front end loaders, cranes and trucks to remove debris and pull down walls that were deemed to be in danger of imminent collapse. The rapid deployment of these forces probably prevented many injuries and perhaps saved lives in the removal of dangerous walls and structures.

The building departments from the County of Fresno, the City of Coalinga and adjacent cities rallied together and formed teams to inspect buildings throughout the whole city. Signs were posted on buildings warning people to keep out of them if they were dangerous, or could offer potential collapse or further damage in event of subsequent earthquakes. These teams worked feverishly to provide rapid evaluation of all buildings.

As a result of this activity, certain buildings were designated safe command posts and business centers. Included in these command posts were the Highway Patrol Office, the Elk's Lodge (Fig. 5), and the West Hills College in Coalinga. Other buildings were evaluated and, depending on their conditions, were ruled safe or not. This provided merchants with opportunities to maintain their business or carry on limited business if the buildings could not be entered by the public at that time.

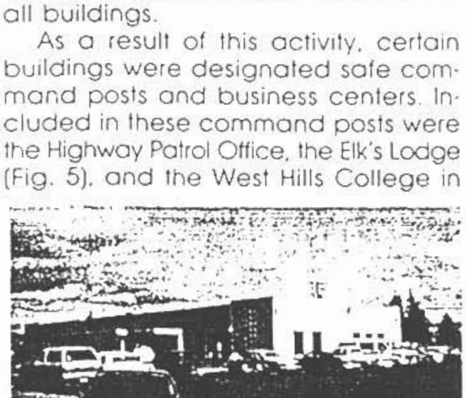

Fig. 5. Elk's Lodge No. 1613 served as central command post for the building inspection services.

Underground water pipes and gas lines were damaged. The National Guard set up distribution points to supply fresh drinking water. Gas lines were secured throughout the area and people were notified to turn off the gas lines in their homes due to potential leaking of gas in ruptured lines.

Old Masonry Buildings Toppled

The similarity between the 1933 Long Beach earthquake and the Coalinga earthquake of 1983 is the severe damage to the old, unreinforced masonry buildings. These multi-wythe brick structures constructed with lime mortar and no reinforcing and only government anchor ties to the roof or floor system suffered damage from the parapets collapsing, wythes of the masonry walls peeling off, arches over windows collapsing, and intersecting corners failing.

Much of the damage to unreinforced masonry buildings was in the Coalinga Plaza, which is the central shopping business district. Other unreinforced masonry buildings that suffered damage were along Forest Avenue: businesses such as a Mexican food restaurant, Poe's Automotive Parts and Garage, and the Youth Center (Fig. 6).

Fig. 6. Building on north side of Forest Ave. (left) Poe's Automotive Parts and Repair Garage; (right) the Youth Center building.

Close inspection of connection details indicated that government anchors, approximately 1" diameter bars going from a joist through the brick walls with a plate on the end, were installed approximately every four to six feet. These government anchors maintained some integrity between the roof system and the wall system.

The State Theater building, an old, unreinforced concrete masonry building constructed in the early 30s, suffered damage to parapets and corners. This was due to major diaphragm movement and distortion. While investigating the earthquake, Caltrans knocked down the high scenery loft and then the front of the building.

Contrast — Old and New

In Coalinga Plaza there was a dress shop in an old, unreinforced masonry store on the west side of the street. Building Official John Wyse of the County of Fresno Building and Safety Division, took us in there and explained, "I want to show you the difference between old masonry and new masonry." Walking through the store, we saw damage throughout and damage on the outside of the building. Then, going into the rear of the store, we entered a new two-story addition of reinforced concrete block masonry, and the building official told us, "This is where the people came to be safe." This was a modern two-story reinforced concrete addition to the old, unreinforced masonry building, and it performed very well (Fig. 7). The building official explained that there were no cracks in the new masonry addition and it came through just like we wished all buildings would.

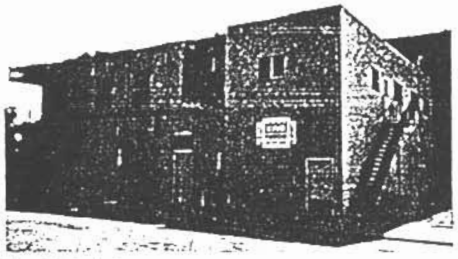

Fig. 7. Building at 5th St. and Durian Ave. (left), unreinforced masonry dress shop; on the right, new 2-story addition.

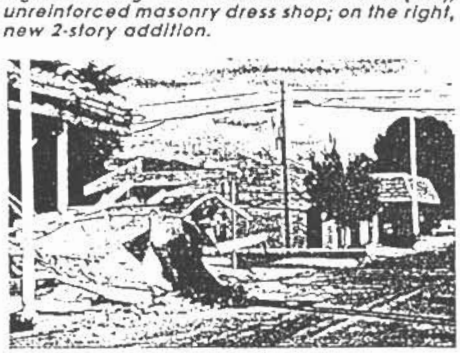

Fig. 8. On 5th St. in Coalinga Plaza looking north, unreinforced masonry building that collapsed; reinforced concrete masonry real estate office building (center) came through without damage.

At the corner of Cedar Street and 5th Avenue there was an old, unreinforced masonry building that was virtually destroyed. Across the street on the northwest corner was a new one-story Vernard & Whitmore real estate building of reinforced slumped block that survived the earthquake with no damage (Fig. 8).

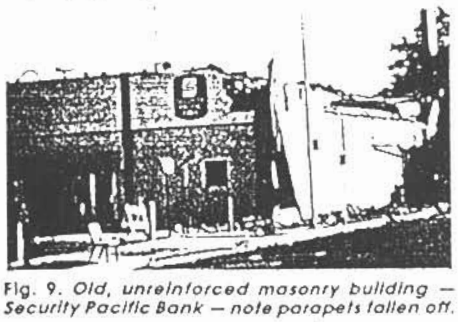

Fig. 9. Old, unreinforced masonry building — Security Pacific Bank — note parapets fallen off.

(Fig. 9) The Security Pacific Bank on the corner of Durian and Coalinga

Plaza suffered significant damage to the parapets and unreinforced masonry walls. Immediately next to this building was McMahan's Furniture store (Fig. 10). This reinforced concrete masonry building performed extremely well with no broken windows and only slight cracks along the base, indicating high shears developing within the system but no damage to the building itself. The masonry walls performed well, including the parapets.

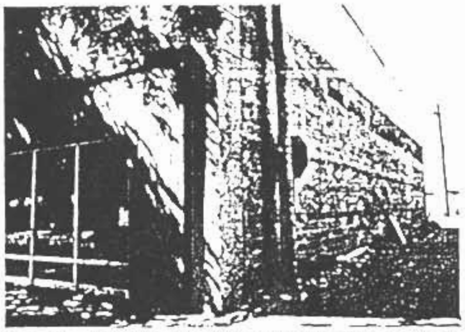

Fig. 10. *Next to the Security Pacific Bank is McMahan's Furniture store of modern reinforced concrete masonry; no damage.*

Modern Masonry Performs

One of the many lessons that was learned from this earthquake is that buildings constructed in accordance with the techniques of present-day design and construction are performing. Modern masonry structures, reinforced and well tied together withstood the vigors of this serious earthquake. It was reported that the ground acceleration was approximately 0.5g and that there were three significant undulating uniform earthquake waves.

Fig. 11. *State Market — reinforced masonry; no damage.*

There were a number of modern masonry buildings that performed extremely well, such as State's Market (Fig. 11). John Kariotis, structural engineer of Pasadena, reported that the equipment on the roof was displaced and moved around, indicating that the building was subjected to very high seismic velocity, but the masonry walls came through unscathed.

The L&M Equipment building, still in operation, performed well, as did the hardware store on Forest and 5th. Whereas the Thrifty Drug Store (Fig. 12) suffered serious damage at the suspended tee bar ceiling, however, the main concrete masonry building performed very well.

Fig. 12. *Thrifty Drug Store — T-bar ceiling with panels displaced and fallen out.*

Government Buildings

The government buildings performed extremely well, such as the Department of Motor Vehicles (Fig. 13) and the Forest Fire Station building of four-inch-high concrete masonry units

Fig. 13. *Department of Motor Vehicles — No damage to the concrete masonry building.*

One of the very fine buildings was the police station. This was in the heart of downtown, and the inquiry to the desk sergeant indicated that they had suffered serious damage of bookcases thrown over, desks moved around, and disruption of equipment; however, there was no damage to the building itself. Personal inspection confirmed this statement (Fig. 14).

The concrete block fire station garage next to the main cast-in-place concrete building performed very well, as did the local library of reinforced grouted brick masonry.

Fig. 14. *Police headquarters — the reinforced concrete masonry survived without damage.*

The West Hills College of reinforced grouted brick masonry (Fig. 15) was a prime example of first-rate masonry performance. These grouted brick buildings subjected to the same ground acceleration and seismic velocities as other buildings in the area had no damage. There was cracking around the ceilings at the wall lines, and that was all. The performance of reinforced, grouted brick masonry demonstrated well its capability of resisting earthquakes.

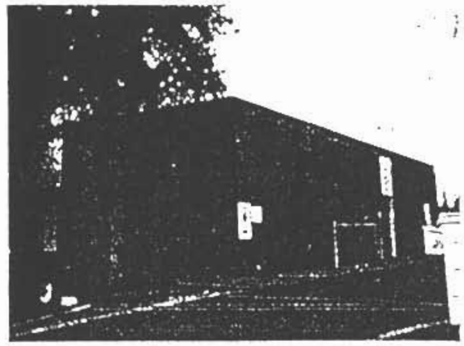

Fig. 15. *West Hills College reinforced grouted brick masonry. This school building was used as the Red Cross headquarters during the disaster. This building performed very well.*

Chimneys and Fireplaces

One of the distressing features of this earthquake was the performance of the unreinforced, unanchored chimneys. These chimneys broke off at the roof line, they failed through the fireboxes, or they peeled away from the buildings themselves (Fig. 16). When the chimney was well anchored and reinforced, it did perform.

Fig. 16. *Unreinforced brick masonry peeled away from the house; no ties.*

The anchored masonry veneer did not perform too well because of the way it was secured. The corrugated tie (Fig. 17) did not anchor the masonry veneer, which pulled away from the wall. Anchored veneer was damaged throughout the area, as shown in Blair's Iron Works on Forest Avenue. At the Blair

Fig. 17. *Corrugated metal ties did not hold the stone veneer in place.*

Iron Works, a heavy machine hacksaw toppled over and a 10,000 pound lathe was displaced 8" on the floor. Also, a rack full of heavy iron parts fell over.

Tanks

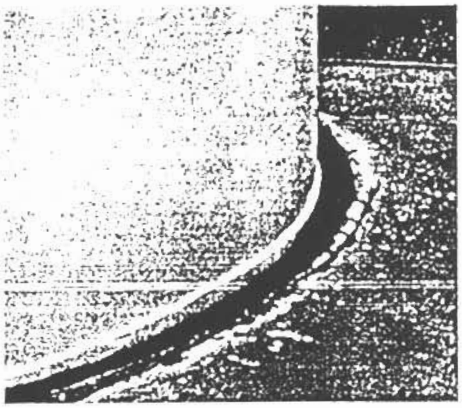

Fig. 18. *Fuel tanks moved approximately eight inches.*

There were two tank frames with three tanks in each. Luckily, they were empty and therefore did not suffer a compression elephant foot failure around the base or collapse due to weight of contents. However, all tanks at each location displaced approximately 8" (Fig. 18) and broke some of the piping attached to them.

An elevated water tank behind the fire station also suffered distress. Approximately three cross-bracing rods were broken and the rest were very slack. It was a benefit that the tank itself was empty and thus was not subjected to as much stress as would be if it were full. The column bases also slid approximately a half-inch under each leg of the elevated tank.

Trailers

The Fairview Mobile Home Park on Thompson Street suffered much damage. The trailers were up on small sheet metal pedestals and these pedestals collapsed or turned over and the trailers dropped approximately 18 inches (Fig. 19).

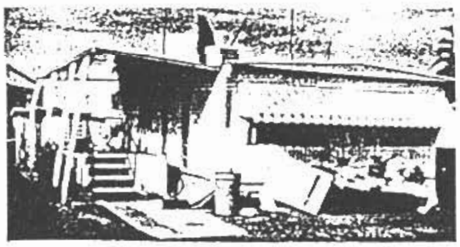

Fig. 19. *Approximately 80% of the trailers were displaced off their light steel piers and collapsed.*

Homes

There were many warning signs posted on residential homes. These homes were built in the 1920s and 1930s and were supported off the foundation on 4" x 4" cripples about 12" high. The ground motion caused the buildings to rock back and forth and collapse just like dominoes. The cripples gave way and the buildings all were displaced

Fig. 20. *Home collapsed in the earthquake.*

(Fig. 20). In addition, many water pipes and gas lines to the homes were broken or disrupted. These homes suffered chimney damage as well as displacement and falling away from the porches.

There were several very old concrete block houses with heavy concrete block. These suffered severe damage. Luckily, no one was killed, and the houses had to be torn down later.

P.G.&E. Power Station

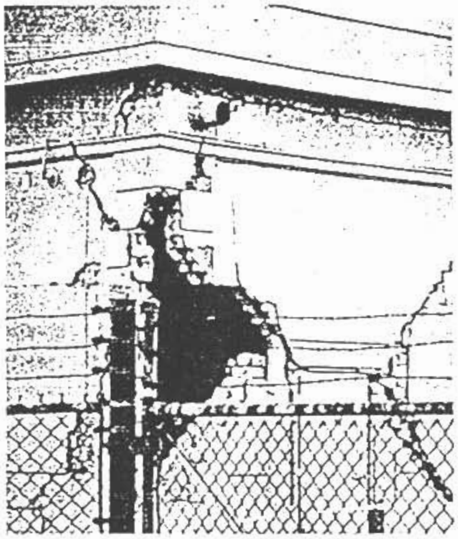

Fig. 21. *P.G.&E. Substation & Warehouse — unreinforced concrete masonry power station showing diagonal cracks of in-plane failure.*

On the outskirts of town at Merced and Jayne Avenue, the P.G.&E. Substation & Warehouse was located. This old, small unreinforced masonry building was significantly damaged (Fig. 21). Inplane forces were acting, causing high diagonal tension stresses on the unreinforced wall. The significant ground acceleration imposed high loads upon this building.

Lessons We Have Learned

We have progressed a long way from the construction of the 1920s and the 1930s of unreinforced masonry buildings and should not be too critical, for they have performed well for over 50 years. Even now with the damage that they suffered, no one was killed. The buildings will be taken down and replaced with modern masonry, which proved to perform very well.

As we evaluate these buildings, it is evident that reinforcing steel is required to both resist the forces for overturning and out-of-plane bending and also for in-plane horizontal shear forces. Buildings that are well reinforced horizontally performed very well while those that did not have horizontal reinforcing were subjected to damage.

We have also seen that veneer anchorages must be improved. Corrugated metal ties do not hold the masonry. Adequate anchorage to the supporting wall is required. Adhered veneer performed well as it is light and, with adequate adhesion, did not cause any problems.

One thing that is continually stressed is connections. Adequate connections between the roof diaphragm, the floors, and the walls are important. Where connections are weak, diaphragms give way and walls fail. Tieing diaphragms to walls not only gives integrity and continuity to a building, but it also keeps the building from being distorted and being damaged.

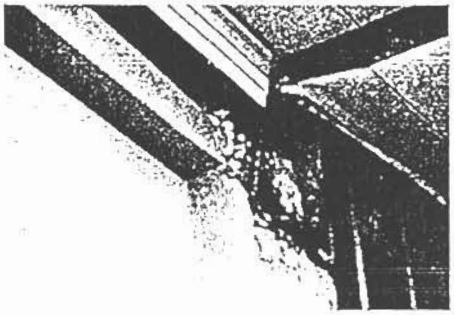

Fig. 22. *J.C. Penney building — anchor bolts pulled free from cast-in-place conrete pilaster column.*

Ties around anchor bolts are important, as shown in the J.C. Penney building (Fig. 22), where large anchor bolts were pulled out of the cast concrete pilasters. Current requirements call for #3 or #4 ties to be imbedded and to tie the anchor bolts to the main reinforcing.

Connections of siding to frames must be improved. This is shown where the corrugated asbestos was torn off the unbraced steel frame in the Union 76 warehouse (Fig. 23). Better details, either flexible or rigid, are needed to insure that the siding does not fall off.

Conclusion

We have learned much from this earthquake and it gives us confidence that the design and construction that is currently required is in the right direction. We have improved the design and construction of our buildings to the point that, in a serious earthquake like this, there were no fatalities and very few people were seriously hurt.

It now behooves us to consider improving our design and construction to reduce the damage to the buildings. However, this is similar to buying insurance; the amount of reduction in damage is proportional to the cost of construction. Under major earthquakes survival is all that is demanded, under small or medium earthquakes, not only survival, but minimal damage is desired.