The Landers-Big Bear Earthquakes

Opinions

We Already Know - Now Let's Do It!
by David C. Breiholz, President, D.C. Breiholz; Chairman, Hazardous Building Committee, SEAOSC

Most of the damage suffered in the Landers-Big Bear earthquakes of June 28, 1992, was avoidable with a simple and inexpensive bracing or anchoring detail. These earthquakes caused significant damage to single family residences and mobile homes not anchored to their foundations and to chimneys with no reinforcing steel and/or not connected to the wood framing.

Common fireplace damage consisted of toppled or partially collapsed chimneys. The difference between minor architectural damage and significant structural damage was often an inexpensive connection detail such as a chimney tie strap. A pair of off-the-shelf chimney straps installed costs about $30.00. The repair cost for a chimney collapsed through a roof may be a hundred times the cost of the tie straps.

The disturbing fact about the damage to single family residences is that the majority of these structures were issued permits under the Uniform Building Code, which has seismic provisions in Chapters 29 and 37 to prevent, or at least control, this type of earthquake damage. Unfortunately, having information in the code doesn’t guarantee a building will be built per code. In the case of mobile homes, damage would be greatly reduced if there were seismic requirements in the State Code (Title 25) for bracing the piers or otherwise providing lateral support for seismic forces.

We don’t need another earthquake to verify these past lessons. We have all heard “a simple detail could have prevented all this damage.” Obviously the state must require lateral bracing provisions for mobile homes as soon as possible. As for masonry chimney construction and foundation anchor bolts, where the code provisions are already in place, we members of the construction team -- designer, contractor and building departments -- must do a better job to carry out our responsibilities, or we will not benefit from what we have learned from past earthquakes.

Improve the Single Family Code
by Chris Poland, President, H.J. Degenkolb Assoc., and Janiele Maffei, Struct. Eng., H.J. Degenkolb Assoc.

The Landers-Big Bear earthquakes of June 28, 1992, damaged numerous wood-frame, single family residences in the mountainous region surrounding Big Bear Lake. Both the City of Big Bear Lake and the County of San Bernardino each red-tagged over 100 residences. Damage to masonry chimneys and damage to hillside residences on stepped footings accounted for many of the structural failures.

Failure occurred in both old and new chimneys predominantly at the roof line. Some masonry chimneys built integrally with tall, flexible wood stud walls sustained damage at their base. Current standards of construction for chimneys are not compatible with UBC design forces. UBC design provisions define lateral forces that are as much as ten times the allowable resisting load capacity of code-required chimney anchorages. Masonry chimney construction standards should be made compatible with UBC design lateral forces, and should incorporate UBC detailing requirements.

Numerous new, code-complying hillside residences with stepped concrete or masonry footings sustained damage due to direct shear and torsion. The rigidity of the concrete foundation at the uphill wall overshadowed the more flexible downhill plywood walls. Despite the presence of long shear walls at the stepped and downhill walls, the buildings rotated about the stiffer, uphill wall where the floor was supported directly on the foundation. Damage to the side, stepped walls was most severe at the short walls near the top of the slope. These walls appeared to have failed with a zipper-like action, separating from their foundation at the top and then losing anchorage progressively down the stepped wall as the shorter, stiffer walls completely failed before loading the taller walls below. This type of failure was evident in houses of all ages and sizes including buildings with shallow crawl spaces at the downhill wall. The presence of basements with cross walls between the stepped walls appeared to have minimized but not prevented damage to the stepped walls.

The substantial incompatibility of concrete and plywood walls in hillside residences needs to be addressed. The top wall of these structures should be designed to resist the lateral load at that level and torsion should be fully accounted for.
Modify the Alquist-Priolo Act

by Jeff Johnson, President, Jeffrey A. Johnson, Inc.; Jim Slosson, Chief Eng. Geologist, Slosson & Associates; and Cliff Grey, Consulting Geologist

Observations following the Landers-Big Bear earthquakes of June 28, 1992, indicate there is a clear need to upgrade the Alquist-Priolo Special Studies Act. The Alquist-Priolo Act (AP) was developed and signed into law as a means to protect human life from the direct hazards of surface fault rupture. It was believed that structures designed for human occupancy should not be built across an "active" fault. The intent of the law was to locate "active" faults and thereby save lives. However, single-story wood frame structures located directly across a fault rupture or within the shear zone performed their life safety function well (i.e., none of the observed structures experienced catastrophic failure or collapse). Numerous buried lifelines and some above ground utilities, on the other hand, failed as a direct result of fault rupture and/or crustal shorting. As of mid-August, some lifelines in the Landers/Yucca Valley area were still being repaired or repairs were still in the planning stage.

We reviewed approximately six separate structures during recent visits to the earthquake area. At two sites, people who were inside the structures at the time of the earthquake were briefly interviewed. At a third, a relative of the occupants was interviewed. One structure was located in Yucca Valley, the others in Landers. A fault ruptured directly across the residence in Yucca Valley. The horizontal offset was less than one foot. The occupants indicated the shaking was intense. However, they were able to exit the structure safely.

One of the structures in Landers was located on a pressure ridge and was subject to secondary or conjugate faulting. The occupant at the location was able to walk through the house during the intense shaking, find his children and then safely exit the residence unharmed even though the residence experienced intense strong-motion shaking and significant damage. The damage appeared to be more related to shaking than to secondary faulting. It is interesting to note that the type of secondary faulting observed at the pressure ridge would not have been considered as part of a typical AP fault study.

A corner of the other residence in Landers experienced deformation due to surface fault rupture. Horizontal offset was approximately eight feet. Again there was heavy damage but, according to the interviewed relative, the occupants were able to exit the residence safely.

We were unable to locate any evidence of structural collapse and/or loss of life as a direct result of surface fault rupture. We did see, however, that relatively poorly constructed single family residences performed their life safety function rather well. Structures of this type appear to perform better than commonly expected. The same cannot be said of buried and above ground lifelines.

During the course of a several site visits, we observed a large number of ruptured water lines and several distressed water tanks. The actual number of water line failures most likely numbered in the hundreds. The loss of water lines due to surface fault rupture and associated crustal deformation had a significant effect on emergency services, including fire fighting ability due to loss of water pressure. Fortunately, fires were not a major problem, although loss of suitable drinking water was.

It is clear that a similar event in a more populated area could have resulted in significant loss of life due to lifeline failure. It appears that fault rupture can indirectly cause greater loss of life due to failure of water lines and the inability to combat the ensuing fires than the direct collapse of a structure. The AP was designed to save lives. It seems only logical that the act should be expanded to include critical lifelines as well as structures intended for human occupancy. What good is it to have fire trucks sitting outside station houses if there is no water or not enough water pressure to put out the fires? If the efforts of the AP or fault location program were also directed toward identification of zones where buried lifelines and associated critical structures cross "active" faults, lives could be saved in the next major event by improving post earthquake emergency efforts.

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