

### Decoding Wall Cracks: Lessons Learned from Last Summer's Earthquake By Christopher W. Carlson, Engineering and Technical Consultants, Inc.

Where were you last August when an 5.8 magnitude earthquake hit the national capital region? Having originated in Virginia, it rattled Washington, DC, and sent waves all the way to New York. Many of us in the District thought a passing truck or some other commonplace occurrence was causing our buildings to shake and shutter. Others probably suspected something more sinister. When the media confirmed that an earthquake had struck, their worst suspicions turned to be truths. We have seen the cracks in the Washington Monument and the toppled spires and gargoyles on the National Cathedral. Headline-grabbing indeed. However, what about the damage to the ordinary buildings that PMA members manage? Why were they not newsworthy?

ETC began receiving calls within a few hours of the event. Over the next few weeks, we

visited about one hundred buildings and parking garages. The vast majority of the damage we saw was cosmetic cracking in drywall and plaster interior finishes. In many cases, building owners, managers and occupants were not sure if the cracks were new, resulting from ground motion, or if they predated the quake. In fact, some were new, but many contained dust, grime, spider webs, paint and other signs of age.

We still continue to receive calls from property managers worried that the wall cracks they have noticed in their buildings are the consequence of last summer's earthquake. At the recent PMEXPO, quite a few attendees asked us about earthquake evaluations. They want to make sure that no serious structural damage had occurred that could jeopardize the safety of their buildings' occupants. This might or might not be a legitimate concern, but is certainly one worth discussing with a building engineer.

#### What About Those Cracks?

Cracks in buildings are neither uncommon nor necessarily a cause for concern. We walk by the same

cracks so often that we fail to notice them. We simply become conditioned to seeing them. When the need arises to know

whether a crack is new and relates to some destructive event or suspected defect, evaluation is often complicated by the lack of a reference point. The more we know about what is new and old, the easier it is to place cracks in context. This is one of the reasons to repair cracks in a timely fashion.

The 2011 earthquake did sufficient damage to a number of buildings and parking garages that required structural repairs. In general, we found that well-constructed buildings were left unscathed, but some others revealed construction defects that had gone undetected for decades.

Earthquake shock is propagated in waves radiating away from the epicenter, which generally translates to greater ground movement in the direction of the wave. One of the properties that we inspected for quake damage had rows of three-story buildings parallel to the shock waves and others were perpendicular. Only the buildings in the perpendicular rows sustained visible damage, while the others were essentially unaffected.

The most severe damage was



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*Photo 1: Masonry dislodged from a pitched roof truss.*

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done to masonry gable walls between and on the ends of buildings. Large sections of masonry dislodged from pitched roof trusses and either crashed through the roof or stood precariously out of plumb (by as much as four inches). The masonry wall did not have any ties back to the structure above the adjoining roofline. As a result, the concrete masonry unit (CMU) backup wall and brick facing comprised a cantilever sticking up (unsupported) about seven feet. These buildings had weathered many storms over the years, but no event was strong enough to reveal this original construction defect (see photos 1 and 2).

A hundred year old, three-story row house structure with thick brick walls had large sections of the front façade rotated out of plumb by nearly three inches. The greatest displacement was where abutting and reinforcing masonry walls had become disconnected from the façade. Those cracks were not new, but they widened significantly after being shaken. The cracks had been filled with spackling over the years, but were never properly repaired (see photo 3). Consequently, to repair the building, large portions of the façade will need to be removed and reconstructed.

Another example is a low-rise condominium complex, which experienced cracking and displacement at the connection between the masonry columns of a porch and the end wall. Prior to the earthquake, minor staircase cracking was observed. After the earthquake, the cracks were much wider and the masonry columns had pulled away from the end wall (see photo 4).

ETC determined that there were no footings below the porch columns, which jeopardized the structural integrity of the building from the day it was built. The minor cracking observed prior to the earthquake should have been a telltale sign that there was something wrong. If this problem had been investigated further and subsequently repaired, major damage could have been averted and the structure could have been salvaged.

Unfortunately, the cost of repairs was too high. The owners opted instead to remove the porch.

Our team was also asked to inspect a multilevel, precast concrete parking garage located at a shopping mall. It turned out that the garage had structural defects that the earthquake exposed. We found damage to the interior stairwells formed with CMUs. The rigid stairwell towers, used to stabilize the structure, cracked in shear, as they could not resist the lateral load induced by the ground motion (see photo 5). In other parts of the stairwells, finished drywall exhibited horizontal cracking. From this, we concluded that the stairwell walls lacked adequate detailing and/or reinforcement, which was a preexisting design flaw.

## Raising Red Flags

The ground motion during the earthquake significantly worsened damage to all the structures mentioned in this article. There were no visible signs of defects in the stairwells of the multilevel parking garage prior to the earthquake. When the ground shook, problems were exposed for the first time. If at any time, you think that



**Photo 2: Masonry crashes through the roof following earthquake.**



**Photo 4: Masonry columns pulled away from an end wall.**



**Photo 5: Rigid stairwell towers, used to stabilize the structure, cracked in sheer because they could not withstand the quake's lateral loads.**

the cracks on your walls might signal a bigger problem, taking action might save your building

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**Photo 3: Cracks filled with spackle could not withstand last summer's earthquake. Temporary supports applied.**

big money and your building's occupants stress and, perhaps, their lives. One of the major lessons of last summer's earthquake is that it's better not to wait until an earthquake strikes to inspect your building and make necessary repairs.

In fact, managers who invest in making sure their buildings are free of structural damage help to assure that those buildings are likely to perform much better and sustain less damage if a natural disaster strikes.

In the case of the parking structure, we found concrete had fallen from the underside of the floor above. Clearly, it was a life-threatening situation. Upon investigation, we also discovered that the overhead concrete had already been loosened due to corroding steel reinforcement, which had resulted from water infiltrating the slab. The heavy shaking caused the already deteriorated concrete to fall, but was not the sole cause of the damage.

This type of delaminated concrete is fairly easy to identify with inexpensive, simple testing methods. Had the damaged concrete at the parking structure been repaired prior to the earthquake, chunks of debris would not have fallen and a potential life-safety issue could have been avoided.

## FEMA Guidelines

The Federal Emergency Management Agency (FEMA) published a guideline to help property owners and managers spot more common earthquake damage. FEMA suggests looking for signs of foundation movement, out-of-plumb exterior walls,

bulges in basement walls and cracks in drywall, stucco and plaster, etc.

Did you spot any of the items on FEMA's list where you work or live before the earthquake? You probably did! The issues listed in FEMA's guidelines are not specific to earthquake damage, which makes it nearly impossible for most people to distinguish between damage from earthquake or unrelated causes. It is up to trained professionals to know the difference.

Our post-earthquake experience working on different properties indicates that the majority of suspected earthquake damage we observed was not actually caused by the unusual ground movement. Rather, it revealed previous defects. Improper initial installation of building components and deterioration that had begun well before the ground motion of the earthquake exacerbated preexisting faults. Having said that, is it fair to say that the earthquake did some of us a favor? In a way, it did!

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