THE CONSULTANTS PERSPECTIVE

A SUGAR PUBLICATION

FORENSIC ENGINEERING AND EXPERT WITNESS SERVICES

SPRING 2007 **PROPERTY/CASUALTY EDITION**

IDENTIFICATION OF CRACKS IN CONCRETE AND MASONRY WALLS

by

Jim Robinson, PE, SE

Cracks in concrete and masonry walls are a common source of property claims. FORCON is regularly called upon to determine the cause of these cracks so that a determination of coverage can be made by the claims adjustor. Some of the more common causes of these cracks exhibit distinctive characteristics that can allow the adjustor to make an initial assessment of the probable cause, and a better determination as to whether or not an engineering assessment is in order.

FORCON structural engineering consultant Jim Robinson, PE, SE has examined cracks in numerous concrete and masonry walls during his 30 year career. In the following article he explains how certain common causes of cracking can often be identified by the cracking patterns and location of the cracks.

SHRINKAGE CRACKS

Shrinkage cracks show up in two basic locations in most walls; the approximate mid-point of a long section of wall, and the narrowed section of the wall such as across a door or window head. Shrinkage cracks are virtually uniform in width from top to bottom and typically extend from the top of the wall to within a couple of feet of the foundation.

Shrinkage cracks are usually caused by an inadequate number of control or contraction joints within the constructed wall. A common rule of thumb for the placement of these joints would have them spaced no further apart than three times the height of the wall, or forty feet. There are several conditions under which this spacing would be too great. One of those is an extremely irregular shaped wall. This type of wall will require twice as many control joints as a normal flat, one-directional wall.

Another common cause for shrinkage cracks in concrete walls would be an excessive water content within the concrete. In general terms, a higher water content within a concrete mix will result in a greater amount of shrinkage. This is quite evident in some concrete walls where there are an excessive number of cracks.

A common cause of shrinkage cracks in masonry walls is using uncured masonry units. When green, or uncured units are used to construct a masonry wall, they will continue to cure once placed resulting in excessive shrinkage of the wall. Masonry units experience a significant amount of shrinkage when curing.

If this curing shrinkage is not virtually complete when the unit is placed within the wall, it will result in an increased number of shrinkage cracks within the finished product.

In a concrete wall, a shrinkage crack will typically fall within the middle section of the wall length and run virtually vertical in that wall. In a masonry wall, the shrinkage cracks will usually find a weakened point in the wall such as a location of several penetrations for piping or conduit. From this point, they will run vertically most often in a stair-stepping fashion following the mortar joints. If however, there is an exceptionally good bond between the mortar joints and masonry units, the shrinkage crack may extend through the masonry units themselves thereby making a vertical crack.

SETTLEMENT CRACKS

Settlement cracks, as the name implies, result from a settlement of a support condition. This support condition can either be the soils on which a wall rests and depends for its support, or it could be the crushing of a column or other support element which supports one end of the wall. In either case, settlement cracks are caused by a change in the vertical location of one section of the wall relative to the remainder of the wall.

Settlement cracks typically appear in two different locations. The first and primary location would be at wall corners and wall ends. This type cracking is the result of settlement of the wall corner or wall end and manifests itself as a diagonal crack beginning near the corner or end of the wall at the top and progressing downward away from the corner. This type of cracking is illustrated in Figure #1. Another characteristic of a normal settlement crack in this location is that it will be significantly wider at the top, tapering to closure at the bottom in a uniform fashion.

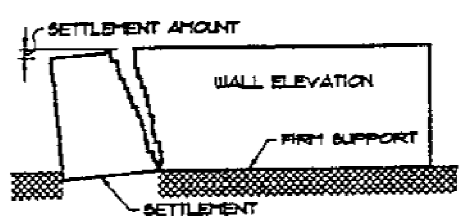

FIGURE #1

There are two types of problems which create the majority of the settlement cracks described above. The first is erosion which seems to occur more quickly at the end of a wall or the corner of a building. This erosion will remove the supporting soils from underneath this corner and allow settlement to occur. The second most common cause is that of a concentrated load being applied to the wall at the corner or wall end. This load can come from a column above or from a beam bearing condition.

When this additional concentrated load is not accounted for in the foundation design, a much higher stress will exist under the footing at the wall end or corner than along the remainder of the wall. This will often result in settlement of the corner related to the remainder of the wall.

Another type of settlement crack which occurs at the corner or end of the wall will have the completely opposite orientation than the one just described. This would be a crack which originates close to the corner at the bottom of the wall, proceeds upward and away from the corner, and would be wider at the bottom than it is at the top. These crack characteristics indicate a condition where the end or corner of the wall has a significantly stronger support condition than the remaining portion of the wall. This allows the central portion of the wall to settle further into the ground or into its support while the corner portion remains supported and held at a rigid location . Such a condition can occur when a wall is supported by a beam and column system if the column is coincident with the end or corner of the wall, and the central portion of the wall is supported by a beam which has inadequate stiffness and deflects enough to allow wall cracking. This cracking pattern is illustrated in Figure #2.

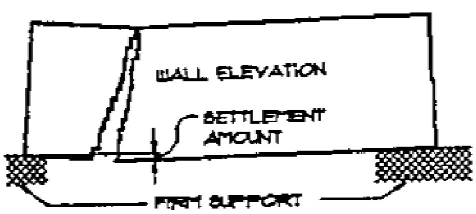

FIGURE #2

Another location of commonly seen settlement cracking is within the central portion of a length of a wall. This crack will normally appear as a vertical crack in a concrete wall and a stair-stepping diagonal crack in a masonry wall. The width of this crack will be much larger at the base of the wall than it is near the top when it reaches closure. This type of cracking will most often occur when the central section of the wall is supported on a flexible element such as interior floor framing which will allow too much flexing of the support thereby generating a settlement type condition for the central portion of the wall resulting in the cracks. See Figure #3 for an illustration of this type of cracking.

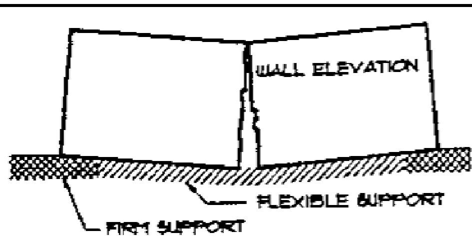

FIGURE #3

LOADING CRACKS

A loading crack is a result of the loading to which the wall is subjected. A properly designed wall would not exhibit these cracks, but an improperly designed wall is very susceptible to this damage. A loading crack is found more often in residential structures than in commercial or industrial structures primarily due to the design effort that is put forth in commercial and industrial projects. There are three basic types of loading cracks that occur repeatedly; vertical cracking at the end of a wall; vertical cracking in the center of the wall and horizontal cracking in the center of the wall.

Vertical cracking at the end of a wall is typically due to a concentrated force being applied at the top of a wall which exceeds the shear capacity within the end section of the wall. This results in a minute amount of compression occurring within this end section which does not occur within the adjacent section of the wall thus causing a vertical crack at the interface between the two segments. This type crack typically maintains a tight appearance at the top and at the bottom but may show a wider gap at approximately mid-height of the wall. This would tend to indicate a bulging effect of the end segment of the wall away from the remainder of the wall. This crack is illustrated in Figure #4.

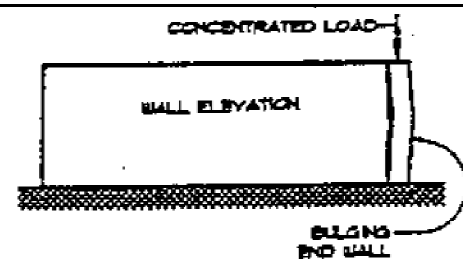

FIGURE #4

Horizontal cracking within the center portion of the wall is typically caused by lateral pressures on the wall which exceed the flexural capacity of the wall. These pressures are normally generated by saturated soil conditions being applied to a basement type wall. When the pressures exerted by the soils retained behind this wall exceed the flexural capacity of the wall, a crack is generated. Observing within the crack, one will note that the crack on the exposed face of the wall is considerably wider than the crack on the concealed face of the wall. Accompanying this crack, one will find a measurable amount of bowing within the wall. This will exhibit itself as a bulge at mid-height into the basement area. This type cracking is illustrated in Figure #5.

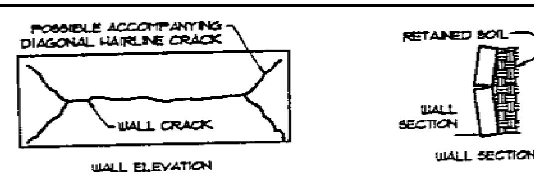

FIGURE #5

A vertical loading crack within the center section of a wall is again, typically the result of lateral pressures exceeding the flexural capacity of the wall. However, in this case the wall typically has insufficient support at the top as compared to the wall discussed above. This condition generates a bowing inward of the wall near the top of the wall. When the pressures exerted by the material retained behind the wall generate stresses within the wall that are in excess of the capacity of the wall, the vertical crack results. This crack will be much wider near the top than it is near the bottom of the wall. Accompanying this crack will be the noticeable bowing of the upper section of the wall inward at the location of the crack.

- CLOSING THOUGHTS -

While shrinkage cracks and settlement cracks may or may not be associated with significant structural problems for the facility, loading cracks most definitely are. These cracks have resulted from excessive internal stresses from loads which the structure should have been designed to resist. Cracks of this type are a cause for immediate concern and should be investigated for cause and repair.

Jim Robinson, PE, SE

ABOUT THE AUTHOR

Jim Robinson has over 30 years experience in the design and analysis of new structures as well as the forensic review of failed, damaged, or distressed structures. He is a registered professional engineer in 40 states, the District of Columbia, and Puerto Rico. Among his many professional affiliations are serving as a Member of the Structural Committee for the International Building Code and previously as a Member of the Wind Load Committee for the Southern Building Code Congress International. Mr. Robinson has also testified extensively as an expert witness. He can be reached through FORCON's Atlanta office or directly at 770-734-0097.

FORCON International Offices

Amherst, VA	(804) 946-0855	**Atlanta, GA**	(770) 390-0980
Pentwater, MI	(231) 869-2017	**Richmond, VA**	(804) 285-7870
Tampa, FL	(813) 684-7686	**Red Hill, PA**	(215) 541-1450

PROPERTY / CASUALTY ASSIGNMENT HOTLINE
1-800-390-0980
OR ASSIGN IT ON LINE AT
www.forcon.com/pcwrf.htm

ACCIDENT RECONSTRUCTION ASSIGNMENT HOTLINE
1-800-877-3260

FORCON's Areas of Expertise

Accident Reconstruction	Architecture
Automotive Fires, Failures & Theft	Biomechanics
Boat Accident Reconstruction	Catastrophe Engineering
Chemical Engineering	Chemistry
Civil Engineering	Codes & Standards
Construction	Electrical Engineering
Electronics	Environmental Engineering
Fire Protection Engineering	Geohydrology
Geology	Geotechnical Engineering
Highway Engineering	Industrial Hygiene
Injury Causation	Materials Engineering
Marine Engineering	Mechanical Engineering
Metallurgy	Roofing
Safety/OSHA	Soils Science
Structural Engineering	Toxic Torts
and more!	

"To Schedule In-House Educational Seminars, Contact Bob Dwyre at 1-800-436-7266

PORTABLE GENERATORS AND SURGE PROTECTORS CAN MAKE A FIERY COMBINATION

Curtis E. Falany, P.E.

Small, portable generators often become the mainstay of hurricane victims. This is a caution to the users of those portable generators regarding their use with 'surge' strips.

During the last two hurricane seasons, I have had the opportunity to observe the heat related failure of several surge strips. The strips failed when they were used with small portable electric generator sets. The failure mode was most often melting but some strips also failed with the discharge of smoke and sparks.

You are probably familiar with these surge strips. They consist of a short power cord, an 'On-Off' switch and several 120 volt receptacles. Sometime the strips include a power light or a status light. The strips I observed fail were all sold under major brand names.

The generator sets involved were consistently inexpensive sets with what is described as an electronic generator or electronic alternator. All of the sets involved generated at 120/240 volts, 60 Hertz, single phase, with capacities of less than 9 KW. Their country of origin was consistently China.

After I observed a few failures, I became curious and conducted my own brief informal investigation of the phenomenon. Several generator sets were obtained from stores or associates. Surge strips were obtained from my office spare parts. A test configuration was developed which included a generator, surge strip, and load. An adaptor was also built to provide a neutral to ground bond.

Each surge strip and load combination was first tested with the normal domestic electric supply. No failures or significant heating was detected.

Generators, adaptors, strips, and loads were tested in different combinations. The load in no case exceeded the rated capacity of the strip. The generators involved ranged in output from 1350 watts to 8550 watts.

In all, we destroyed four power strips using unrecognized brands of inexpensive generators originating in China. No strips were destroyed using generators bearing easily recognized US or Japanese brands regardless of their country of origin.

Where possible, the output voltage of each generator was measured under three conditions; without load, while in test, and with a resistive load. All tested generators measured in the range of 120 to 130 volts using a standard RMS voltmeter.

An attempt was made to observe the output voltage waveform under the test load. Some of the generators destroyed the surge strip before the waveform could be checked. Those generators subsequently had their waveform checked with no load and with a resistive load of approximately one-half their rated output. The output voltage waveform of the offending generators was found to be very badly formed.

My conclusion, based on this informal study, is that the surge strips were not at fault and the generator sets were the cause of the failure. The output waveform of the offending generators contained voltage spikes that frequently or continuously exceed the threshold or clamp level of the surge suppressors in the strip. Further, there were enough of these spikes, or they were of sufficient duration, that they contained enough energy to overheat the strips causing elevated temperatures, melting, and heat related failures.

Curtis E. Falany is a Professional Engineer and Master Electrician with over thirty years of experience. He can be contacted through Forcon's Tampa Office.

FORCON INTERNATIONAL CORPORATION

PRESENTS

THE CONSULTANTS PERSPECTIVE

IN THIS ISSUE ! - AN ARTICLE ON

IDENTIFICATION OF CRACKS IN CONCRETE AND MASONRY WALLS

&

PORTABLE GENERATORS AND SURGE PROTECTORS CAN MAKE A FIERY COMBINATION

FORCON INTERNATIONAL CORP.
1216 Oakfield Drive
Brandon, Florida 33511