According to the story, the little pig who built his house with bricks was rewarded when the big bad wolf couldn't blow the house down. The other houses made from straw and sticks blew down because of the lack of a proper foundation and tie down straps. It's a sure bet that the brick house didn't have any steel reinforcement, but it was able the resist the wolf's attack, simply because of the weight of the bricks and mortar. Years ago, masonry buildings were built without steel reinforcement. They were limited in height, had thicker walls and generally did not have balconies. The development of high strength steel changed all of that.

The Need For Ongoing Repairs In Concrete Buildings Is Inevitable

by Donald Chalaire, P.E.

First, there were the steel framed skyscrapers in the cities. The massive steel beams and columns could be seen as the workers hoisted them up using cranes to set each one in place. Then came the concrete high rise buildings. The only thing that made the concrete tall buildings possible was the steel reinforcement placed within the concrete. The big bad wolf wouldn't have a chance. Today, most tall condominiums buildings are concrete, and if located in coastal or scenic areas, usually include balconies on every floor. Now with the more recent development of post tensioned cables, the balconies are thinner than ever.

In the last 5-10 years, there have been many articles and much publicity regarding repairs of concrete buildings. Many condominium buildings in coastal areas aged 20 years or more have performed major repair projects at least once or twice. Unfortunately, because of the original construction for most of these buildings, the deterioration of the steel reinforcement is inevitable, and continues on an ongoing basis even after completion of repairs. There is still much confusion about what causes the problem, and what options there are to help reduce the future costs for these repairs.

Myth: The concrete columns and beams holding the building up have massive steel I-beams hidden inside. The rust bleeding from the spalls and cracks is minor because there is a lot of steel inside.

Fact: The concrete columns and beams have many relatively thin steel bars strategically placed near the concrete surfaces in high stress locations. These relatively thin bars carry all of the tension loads like steel rope. The concrete that spalls away from the steel is carrying compressive and shear loads in high load areas. A significant amount of good steel is lost by being converted to rust before enough internal pressure is built up inside the concrete to cause a spall. Thinning of the steel bars occurs, resulting in a reduction of load carrying capacity.

Myth: The building is not falling down. These repairs don't need to be done now.

Fact: The ongoing rust consumption causes the steel bars to get thinner over time. The cumulative effect of the steel bars getting thinner over time causes weakening of the structural elements. When slabs and beams get weaker, they sag increasingly, and eventually cause secondary cracks in adjacent areas due to flexure and torsion. When columns get weaker, they slowly squash, and eventually cause settling damage in above areas supported by the column. The result is secondary cracks in above areas, essentially the same as would be caused by the foundation settling. The building will not suddenly collapse, but will simply get more and more cracks over time. The cracks will start to appear in new areas where there were no signs of problems before.

Myth: The problems were caused by construction defects from the original construction.

Fact: The corrosion attack against the steel bars is caused by exposure to the elements. It's true that areas with less than the specified concrete cover will be affected sooner than other areas. However, the thickness of concrete over the steel only increases the time for the

contamination to get to the steel bars. Eventually, the contamination does get to the steel bars and the corrosion attack begins.

On the other hand, while not a construction defect, one could point a finger at the original design specifications. Typically, original design specifications only provide for watertight membranes over areas such as the roof, top floor of the garage, and the canopy over the front entrance. The building's interior areas have been protected from the very beginning. The interior dry areas will not need spall repairs for a long time, not in our lifetimes. Unfortunately, rarely was a watertight membrane specified for exterior balconies, walkways or stairways. Ironically, the codes allow for this because exterior balconies and walkways do not cover living areas.

Myth: After the current repair project, the repairs will last for the next 20 years. More repairs won't be needed until then.

Fact: The repairs, if done properly, should certainly last more than 20 years. However, for most repair projects, the repairs are only performed in areas showing damages. The repairs are only performed where damages can be detected and then into adjacent areas only as required according to the steel bars. In most projects, very little of the total floor areas are excavated. These non repaired areas continue to be exposed to contaminates, and in turn will be damaged by rusting of the steel bars. Unless the entire floor is replaced all at once (not common), more repairs will be needed in the future and on a regular basis. The need for ongoing repairs in different areas is inevitable.

Myth: Carpet and floor tile protects balconies. Tile grout lines can be sealed.

Fact: Carpet and floor tile are bad for non waterproofed balconies. Floor tile is installed using a square notched trowel to allow pushing down of the tile during the final height adjustment without squeezing the thin set mortar out. The square notched trowel produces voids under the tile that act as passageways to pass and store water. All it takes is one or two places for water to get in. Often wind driven rain enters from the edge or sides and easily passes through the entire sub tile area. The thin set mortar and the tile grout are porous, typically more than the concrete slab. Watch a tiled floor sometime in a drenching rain sometime, under an umbrella of course. Look for air bubbles coming up from the grout lines.

Protection Strategies

After the current repairs, what can be done to protect the concrete, and reduce and delay the future need for repairs? There are protection options available.

The "dry" option is removing all tile, carpet and coatings, and installing a bonded watertight membrane over the entire floor surface. Essentially the same as if it was a roof, the thinking is better late than not at all. The new watertight membrane will prevent additional contaminates from entering the concrete floor surfaces, and over time allow the concrete to dry out as much as possible. This option only delays and reduces future repairs. A reasonable delay estimate would be at least 2-4 times longer than would otherwise occur without waterproofing protection. When future repairs are performed, the watertight membrane will be opened, and local repair of the membrane will be needed. Although installation of floor tile over the watertight membrane is acceptable, future repairs will always be needed that will require partial removal of the tile.

The "wet" option, called cathodic protection, is removing all coatings on at least one side of the slab floor or ceiling, and installing a bonded metallic coating or conductive grid coating.

The coating or grid is connected to the steel reinforcing bars and electrically active with a very low voltage that runs the corrosion process in reverse. The corrosion of the steel bars is stopped, and they do not rust any further from that point in time. The technology is not new. This type of protection has been used on marine structures for years. At this point, there are two different types of cathodic protection offered for residential installations. (See "Gulf Front Condominium Controls Corrosion With Cathodic Protection Systems," on page 10; and "The Reef Condominium Won The 1998 ICRI Award," on page 54.)

The passive system is thin zinc sheets applied to the surfaces that when connected provide a low voltage due to dissimilar metals. The active system is a grid of conductors applied to the surfaces that are connected to a low voltage power supply. In both systems, the wires and connections are hidden by finish coatings. Cathodic protection requires wetness to work, and if too dry will not be activated. This should not be much of a problem, because the corrosion process itself requires wetness to proceed. Cathodic protection is relatively high priced compared to waterproofing, but significantly less than concrete repair costs. There are options available for installation in cost significant locations such as post tension slab edges and along sliding glass door bottom tracks.

The "penetrating additives" option is application of clear penetrating fluids to existing concrete surfaces for the purposes of changing the concrete chemistry or coating the buried steel bars. Some products claim to remove contaminates. Some products claim to convert contaminates to benign non corrosive forms. Some products appear to reduce corrosion by gelling up and reducing the porosity of the concrete. Some products claim to penetrate all around the steel bars placing a protective coating on the steel bars. In all cases, the degree to which they penetrate is directly affected by the porosity of the concrete. Long term evaluation of these products is underway. Installation of these products typically requires removal of tile, carpet and coatings. Following treatments, it is often recommended that a watertight membrane be placed over the entire floor surface.

Conclusions

For older concrete buildings, plan on the need for concrete repairs on a regular basis. A reasonable estimate would be major repair projects every 5 years, or minor repair projects every 2 years. Future repairs can be delayed and future costs can be reduced if corrosion protection is provided. Concrete repair costs and protection strategies should be carefully planned to reduce overall costs over time. Stay tuned . . .

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