Preventing Progression: Can You Avert a Crumbling Foundation?

By Michael Dion, P.E.

Background

More than a decade after Connecticut's crumbling foundations crisis emerged, research and field observations have demonstrated that the presence of pyrrhotite in concrete does not necessarily mean a foundation will fail.

Variations in pyrrhotite concentration, distribution, and prior exposure to environmental conditions can significantly influence to what extent a foundation can deteriorate or even if it will deteriorate.

While these variables make predicting individual foundation outcomes difficult, one critical factor remains consistent: water plays an essential role in the chemical reaction responsible for concrete deterioration. Knowing this fact creates opportunities for homeowners to reduce their risk and potentially slow damage or even prevent it through effective water management.

This paper examines the factors influencing pyrrhotite-related deterioration and provides practical mitigation strategies...from relatively inexpensive drainage improvements and crack sealing...to more comprehensive waterproofing measures. Together, these approaches offer homeowners options, some of them at fairly low cost, for protecting their foundations and potentially avoiding more costly replacements...replacements that may be needed after CFSIC’s sunset date, when the program will no longer be accepting applications.

Pyrrhotite: Understanding the Issue

In 2015, the general public was introduced to the crumbling foundations phenomenon. Initially the cause of crumbling foundations was not publicly known, but a perceived ultimate outcome quickly became common knowledge: a failed foundation.

Sometime after, the public was introduced to the culprit, pyrrhotite, which is hard for homeowners to say, spell, or - when found in their foundations - hear. If you had pyrrhotite in your concrete foundation, it was widely believed that, over time, it would cause the foundation to crack, crumble and likely fail by

collapsing. So, if your foundation had it, major and inevitable problems lay ahead.

Many home foundations showed evidence of pyrrhotite, obtained through laboratory analysis, so this thought process seemed to fit for all. But 10 plus years later, we are still researching and learning and have discovered over time that "one size does not fit all."

What I have found during my 25-year involvement with the crumbling foundations crisis is that the situation is consistently inconsistent.

While this inconsistency is frustrating, it makes complete sense when we consider the geologic factors that lie at the core of this issue. Geologic formations can themselves be very inconsistent.

Consider a drive down a local highway, where we can see tall rock cuts displaying varying colors and layers. Pyrrhotite is within one or more of those layers, and how it ultimately performs within a concrete foundation can vary based on several factors:

- As a pyrrhotite-containing quarry blasts and the rock crushes, the amount of pyrrhotite in the crushed rock can vary. Therefore, the amount of pyrrhotite that ends up in a batch of concrete can also vary.

- Exposed to water and oxygen, pyrrhotite has the potential to oxidize, causing a destructive chemical process that, within concrete, causes crumbling foundations. But when the timing of pyrrhotite reacts can also vary, based on factors like exposure to rain throughout the supply chain; it does not necessarily happen after it is made into concrete. Believe it or not, some pyrrhotite in concrete may have pre-reacted prior to being cast in concrete and, while a lab may find evidence of it, it may have limited destructive capability because it has pre-reacted.

- Pyrrhotite also naturally exists within stone in various configurations. It may occur in what we call a "clustered configuration," where there is a larger quantity of pyrrhotite in a smaller area. When a higher quantity of cluster pyrrhotite in freshly mined stone is used in a concrete batch, the potential exists for moderate to severe reaction within the foundation. Then, there is a possible "disseminated configuration," where pyrrhotite may be scattered broadly within the stone. In this latter

case, the pyrrhotite may have less expansive capability, especially when surrounded by dense, low-permeable elements. It is sometimes referred to as non-reactive aggregate. When a concrete batch with disseminated configuration pyrrhotite is used in a foundation, it may have only a mild or non-existent reaction. The difference is profoundly important.

Prevention Measures: Keeping Water at Bay

While foundation failure outcomes are inconsistent due to the issues we've discussed, the main factor in pyrrhotite causing crumbling foundations, and therefore in mitigating progression, *is* consistent: it's water.

Without water, nothing happens.

To illustrate this, we see 40-year-old concrete foundations that show reactive cracking in outer walls exposed to damp soils, while at the same time the same foundation's internal walls, supporting the garage or dry party walls, show no signs associated with pyrrhotite. Can we conclude that it's possible to prevent a pyrrhotite-containing concrete foundation from reacting and therefore failing?

The evidence seems to show that if we eliminate water, the chances of a chemical reaction may be greatly delayed or even averted.

Since field evidence has shown that pyrrhotite does not react if water (or oxygen) isn't available, this opens the opportunity for homeowners to prevent the progression of a crumbling foundation. While not easy to restrict, water *can* be managed and minimized around a home using some basic techniques of water management, for example:

- The most common water management tools are readily apparent. They are gutters and roof leaders. Maintaining gutters and making sure that leader discharges are sending water away from the foundation is absolutely critical. Adding leader extensions to get water even 3 to 5 feet further away from the foundation can improve your chances.

- The ground surface around the perimeter of the foundation should be sloped to make sure water drains away. It is important that the actual *ground surface slopes*...mulch or stone may give the perception of

grade where no real grade exists. We know that water generally flows on the surface of soil but will seep through mulch or stone. We want water to leave, not infiltrate down where it can, over time, set off the reaction that causes a crumbling foundation. We need to take all the steps necessary to encourage surface water to flow away.

- Here's the truth: most cracking in a concrete foundation is caused by shrinkage, not by pyrrhotite. Sealing foundation wall cracks unrelated to reactive pyrrhotite, which let water in, is a key tool in the homeowner's toolbox. Shrinkage stress can cause a crack along the length of a wall, or where a wall changes in direction such as around a corner, or at "geometric changes" such as at windows, beam pockets, and wall height changes. What is common to all shrinkage stress cracking is that it generally occurs in the upper portion of the walls, and likely above ground. Those cracks then become an artery that allows water to enter the wall from above or at ground level. So even if the wall has a form of damp proofing or waterproofing, these cracks allow water to "jump the fence" so to speak. Now, compare that to homes showing signs of reactive cracking, where the crack manifestations are often found in the middle third of the wall's height. With water entering from the upper third it makes way into the wall and activates a reaction. Sealing <u>all</u> cracks on the outside of the home, from the siding down to the top of the water proofing, is a recommended preventative procedure. This damp proofing procedure should be within a foot of grade, though there can be variations in its depth.

- The next tool in our toolbox may be to consider the sealing of the entire outside of the foundation wall. Concrete is not waterproof. Its permeability is a direct function of its strength. Residential concrete is generally at the lower end of concrete strength and has the ability to allow moisture to travel through it. That is why the walls get waterproofed below grade, which is the area subject to sustained moisture. Above grade, the wall has the ability to air dry, but there are times of year, especially during winter, when even the above-grade wall has long-term moisture exposure. Therefore, sealing the above-grade surface and extending it 8 to 12 inches below grade can reduce moisture penetration. For the full basement portion of the home, extend the sealer to the existing waterproofing. Buried frost walls, like those in a typical garage, 8 to 12 inches deep into the ground, may be enough,

since anything deeper generally lacks oxygen. So even if wet, the lack of oxygen can hinder the pyrrhotite chemical reaction.

What's the takeaway? Many of these water management items are low in cost. Homeowners can many times take on some of these measures themselves to further reduce their risk.

Another tool, but one coming at a higher cost, would be to unearth the foundation, exposing its outside face and allowing application of a more comprehensive waterproofing system from the top surface of the footing to the siding. Foam insulation can then be installed to avoid direct contact with soil, and drains can be enhanced or installed if not present. Roof leaders can then be piped, and free-draining soil backfill installed. Using this approach, the concrete wall is sealed from water, separated from direct contact with damp soil, with piping, and with free draining soil used to give water a clear and fast path to leave. This process may be costly, but of course not nearly at a cost associated with a full foundation replacement, which may not only have a homeowner assessment above and beyond what CFSIC will pay for, but will require 12 to 14 weeks (or more) of alternative living expense.

Conclusion

The crumbling foundations phenomenon will likely never have a finite conclusion, with clear answers for all our questions...such as how much pyrrhotite it takes or how long it takes before a foundation starts to react or ultimately fail. Even lab testing techniques are different, making it difficult to compare results at times. But here's the universal truth: science tells us that pyrrhotite oxidizes when water and oxygen are available and field evidence clearly shows concrete can weather this storm if protected, first and foremost, from water.

We've learned that the evidence of pyrrhotite alone in a positive lab analysis isn't automatically a death knell for a concrete foundation.

Ultimately, concrete foundations can survive. The average residential foundation is overbuilt and can handle mild to moderate degradation and still serve its purpose. As discussed above, some foundations that test positive for pyrrhotite may not have a visual pyrrhotite-related reaction even after 40 years.

To the question I've been asked many times, let me state the answer categorically: by implementing and maintaining water management procedures and systems, we may even provide the concrete foundation of a home located in the epicenter of the crumbling foundations crisis, an opportunity to survive...even if a lab report indicates the presence of pyrrhotite.

By protecting concrete from the "Ultimate Activator" - the villain of our story, water - homeowners can reduce the chances of a crumbling foundation ever happening.

A Word from CFSIC

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