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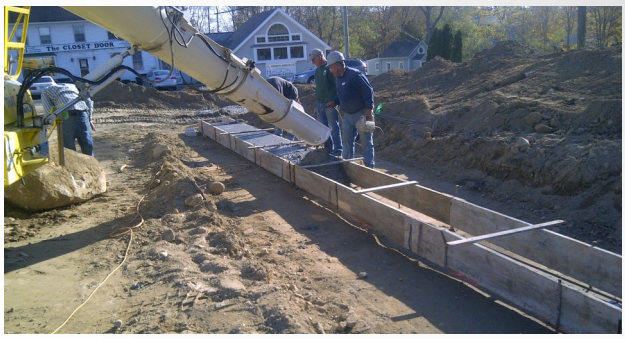


Concrete Basics

By Kevin E Miller

The Importance of Quality Concrete

The content of this newsletter, Concrete Basics, will provide us with the most important fact, not all concrete is the same when placed in the wall of your foundation. Simple forensics of the concrete and being able to determine what took place during the production, delivery and placement of the concrete is valuable information when studying the crumbling concrete crisis in Connecticut.

Water, Water, Water

Let's start with one of the most important facts when handling fresh concrete, Abrams' Law, "The law states the strength of a concrete mix is inversely related to the mass ratio of water to cement. As the water content increases, the strength of concrete decreases". The compressive strength of concrete is stated as *pounds per square inch* or PSI, the requirement for residential foundation walls is 3,000 PSI and design professionals would recommend a water to cement ratio not to exceed 0.58. Therefore a concrete design using 500 lbs. of cement per cubic yard would be allowed 290 lbs. of water to retain the designed strength.

To fully understand the crumbling foundation crisis in Connecticut and Massachusetts requires knowing all the variables associated with concrete construction. The importance of this writing is to establish why the extent of damage on a group of homes is not alike and why predictability is so difficult to plot.

Piece of Cake

To be knowledgeable about the concrete epidemic requires a moderately technical explanation on concrete production. The science of mixing ingredients together to form a finished product is part of our daily life, and the mixing of sand, stone, cement and admixtures to produce concrete is similar to the sequencing, measuring and mixing required for baking the perfect cake or loaf of bread. In comparison the sand, stone and cement would be the dry ingredients, or flour and sugar when baking a cake. The admixtures (chemicals) used for concrete would relate to the eggs and yeast for baking and finally water is water, too much or too little can really have an adverse effect on both baking and concrete production. You might ask, what does baking a cake have to do with crumbling foundations? Would you add 25% more water to your favorite cake recipe? The results would be disastrous, when producing concrete, we call it exceeding the water/cement ratio, resulting in lower compressive strengths and increased permeability. Why would you abuse the concrete that will be supporting your house? It is not just the water that should be our concern. Let us run through a few other scenarios that make concrete vulnerable to severe mineral attack such as re-shipping concrete left over from the previous delivery, excessive mixing or the use of concrete that has gone past an acceptable time limit. Again, would you follow these practices when trying to bake a cake for that special person?

"You might ask, what does baking a cake have to do with crumbling foundations?"

"Tis The Season"

Summer, Winter, Spring or Fall, when is the ideal time to start that concrete foundation?

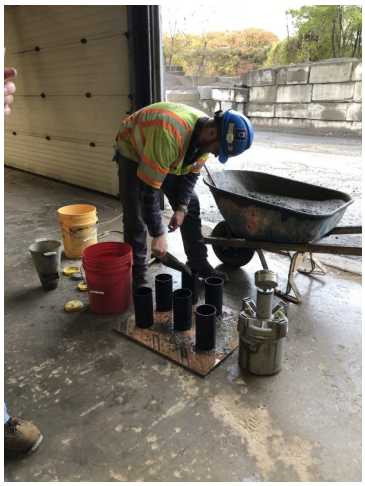
Spring and Fall would always be the choice when handling fresh concrete. The weather during the spring and fall is concrete friendly staying away from extreme heat or freezing cold.

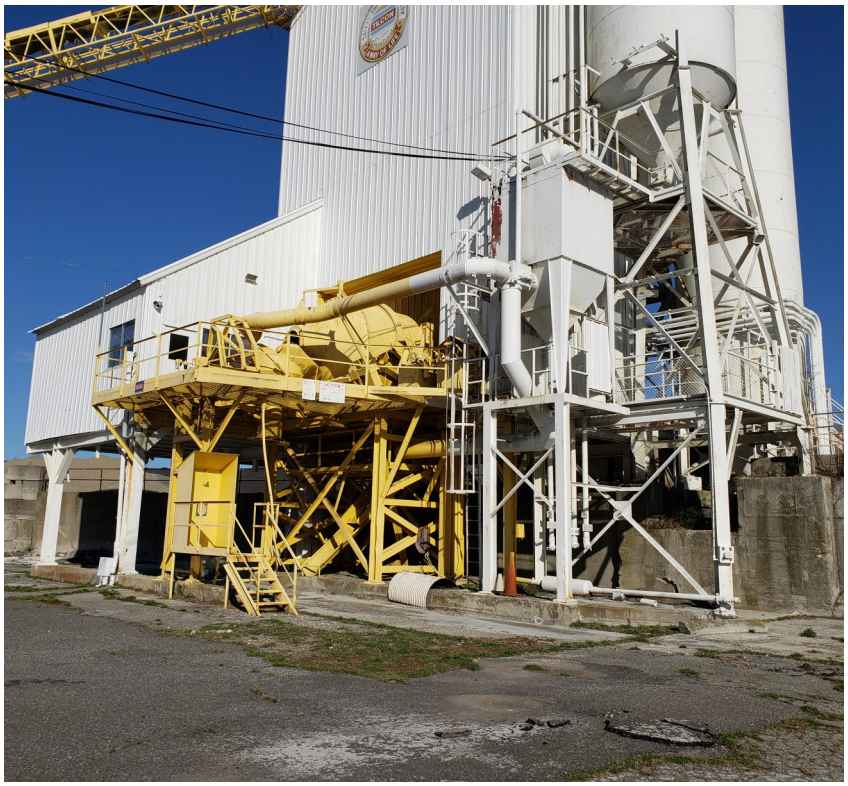
Winter months require special care which is not always in the budget of a typical residential construction project.

Summer placements are also challenging with elevated concrete temperatures followed by the demand for increased water to be added and rapid moisture loss after placement.

High Porosity Equals Shortened Life

We know that the oxidation of pyrrhotite in concrete requires the presence of moisture and oxygen so it would hold true that the greater the porosity of the concrete, the quicker the passage of moisture and oxygen will take place. Porosity is defined as the ratio of voids in relation to the material, and permeability is the ease of which liquids can pass through a material. Excessive mix water combined with the lower cement content of a residential concrete mix can lead to a high porosity mix that is very permeable, in comparison to a well designed concrete mixed used in commercial construction or on transportation projects, which often requires a third party inspector to conduct a series of tests as a basis for acceptance or rejection of the concrete being placed.





Typical Central Mix Concrete Plant

Turning The Heat Up, Summer Concrete

Summer concrete placement can be challenging and disastrous due to elevated temperatures and the effects the heat has on fresh concrete.

Perhaps the most important factor for successful placement is being totally prepared to discharge the concrete truck as soon as possible, avoid delays at all costs. Elevated concrete temperatures can lead to rapid loss of workability usually resulting in the addition of water far exceeding the designed water/cement ratio. Reduced strengths and increased permeability can be attributed to the excessive water addition.

The Connecticut foundation failures generated numerous news articles including interviews with past employees of the concrete supplier in question. The ex-drivers spoke of re-shipping concrete and the practice of using any leftover concrete from the previous delivery. From a quality standpoint the normal delivery time would doubled or worse and the heat created by the hydration process combined with elevated ambient temperatures would spell disaster for the concrete.

How We Look at Concrete

We look at concrete as a gray colored hard as a rock, building material. Hopefully as you read my articles you will have a better understanding of how concrete is produced, delivered and placed in the forms.

Concrete failures are an everyday occurrence and take place well beyond the boundaries of Connecticut's Crumbling Foundations.

Communities all over the world have been plagued with reactive aggregates, mica, pyrite, pyrrhotite, expansive soils and many other natural occurrences. Knowing the basics of concrete and understanding that it is more than a gray rock-like material can be helpful when we start to look at concrete structures.

Future articles will get into more detailed information regarding long term durability and choosing the right concrete for your next project. Also important is examining current structures, what causes concrete cracks and other surface defects.

Placing Concrete in Northern Climates

When discussing concrete in colder climates we should not fail to mention the extra precautions needed to produce a quality concrete mixture with the ability to withstand freeze/thaw cycles and reach initial set in a shorter period of time.

The freeze/thaw protection is achieved by the addition of an admixture used to entrain small air bubbles in the concrete to act like a shock absorber against the expansion and contraction of the concrete during the numerous cycles of freezing and thawing. The average exterior concrete exposed to freeze/thaw should have an air content in the range of 4% to 8% as tested with the proper equipment.

Equally important during the colder months is the use of hot water in the concrete and the addition of an accelerating admixture to speed up the initial set time of the concrete and offering additional protection such as insulated blankets or straw to retain the heat produced by the hydration of the cement.

Unfortunately the lack of inspection on residential construction prevents monitoring these important placement details.

Terminology Defined

- Admixtures—Chemicals or minerals added to the concrete for a specific purpose, generally to improve the placement and long term durability of the concrete.
- Air Entrainment— The concrete is required to have an air content of 6% +/- to withstand freezing and thawing in northern climates. Air Entraining admixtures are dosed into the concrete to provide the proper results when tested in the field.
- Compressive Strength—The strength of the concrete usually stated as PSI, pounds per square inch. The average residential foundation would be 3,000 PSI.
- Permeability—Is a measure of the porosity of the hardened concrete and is important for overall durability, the more permeable, the more porous the concrete.
- Slump—A measure of the fluidity or flowable characteristic of the fresh concrete, High slump refers to concrete that would flow easily.
- Water/Cement ratio—Is the ratio of the amount of water compared to the amount of cement. A 0.50 w/c would be 1/2 pound of water for every pound of cement.

A Note from CFSIC

Background and Qualifications of Kevin E Miller

Kevin Miller has been employed in the concrete industry for the past 30 years. Kevin, well-versed and educated in concrete technology, troubleshooting concrete defects, and designing concrete mixtures for commercial and residential applications, is an industry veteran. Additionally, during his seven-year term as President of the Connecticut Ready Mix Concrete Association, he witnessed and was instrumental in supporting legislative changes and the incorporation of stricter quarry inspections to assure the long-term durability of concrete used in roads, bridges, and highways as well as in other commercial and residential uses. Kevin continues to remain active in the industry as a consultant on Government projects and as a troubleshooter on residential and commercial concrete issues. CFSIC has engaged with Kevin to create the only comprehensive concrete failure training course available in the state of Connecticut. He continues to serve as consultant and advisor to CFSIC.

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Superintendent, CFSIC