Nordmeyer, LLC

213 County Road 575
Castroville, TX 78009-2120
herbnordmeyer@gmail.com
210-573-2030
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# Deterioration of Rebar

*This explanation will probably make the eyes of most readers glaze over, but if you are working in an area with moderate or high chlorides, it is mandatory you address the problem.*

## The Basics

Non-reinforced concrete is high in compressive strength, but low in tensile strength. Reinforcing is added to concrete to increase the tensile strength. The most common method used is to add steel rebar. In most situations this is adequate. The two most common problems with the use of steel rebar is when chlorides are present, as when salt (sodium chloride) is added to a roadway for deicing, and when water can get to the rebar.

## The Chemistry

When chlorides are in contact with steel, and there is enough moisture present for a chemical reaction to take place (enough moisture to dissolve some of the sodium chloride), several chemical reactions take place. First, when the salt dissolves in the water, the ability of the water to carry an electrical current is increased. This increases the ability of the oxygen that is dissolved in the water to react with iron which is in the steel rebar. In the process, ferrous oxide, ferric oxide, ferrous chloride, and ferric chloride can be formed. The oxidation state of the iron (ferric or ferrous) and whether a chloride or an oxide are formed are not germane to this issue, since each of those chemical compounds increases the volume of the iron in the steel which was the precursor for those compounds.

## The Physics

When the rebar expands as these compounds are formed, stress is developed until that stress is greater than the tensile strength of the concrete. This causes the concrete to crack. The cracking of the concrete allows more water and oxygen to come in contact with the rebar and the chlorides which are present. This accelerates the process.

The stresses the concrete has been under usually weaken the concrete in areas around any of the cracks which occur.

As the chemical reactions continue, the tensile strength of the rebar decreases. This causes the tensile strength of the concrete to decrease.

When a concrete beam or slab is suspended between multiple supports, it flexes very slightly. At a point between any two supports, the bottom side of the beam is under tension and the upper side is under compression. Above any of the supports, the top of the beam is under tension and the bottom of the beam is under compression.

As a result, a flat concrete roof will often crack above any supports and will sag between those supports. The cracking above the supports increases the moisture entering the roof and accelerates the deterioration.

## Accelerants

In the Gonaives, Haiti, region where I work, there are several other factors which contribute to the problem:

- The water used for mixing much of the concrete is often brackish. This provides the chlorides to increase the oxidation of the steel.
- Much of the aggregate used contains clay. Tests I have conducted have shown up to 29% clay in concrete sand on our jobs. The presence of clay requires more water to be added to make the concrete, stucco, or mortar workable. The increased amount of water needed increases the amount of chlorides which are available to catalyze the oxidation reaction.
- The concrete is often porous due to aggregates used which are not well graded to increase the density of the concrete mass.
- The concrete is often not well consolidated, leaving air pockets in the concrete as reservoirs of oxygen and water.
- The clay in the concrete acts as a reservoir for the chlorides, so the chlorides can initiate a chemical reaction whenever the moisture content of the concrete is conducive to the oxidation reaction.

## Conclusion

Chlorides do not directly harm the Portland cement paste or the hardened Portland cement paste. Chlorides catalyze the oxidation of chemical element iron, which is a major component of steel rebar, and metal lath. The oxidation process weakens and/or destroys the tensile strength of reinforced concrete and stucco. Expansion of the metal components can, and often does crack the concrete or stucco and thus accelerate the deterioration.

Avoid chlorides