

# Myths about Structure Critical Corrosion

## It is Destroying Steel Infrastructure from the Inside Out

By

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This corrosion article will explore the risks of painting steel bridges and infrastructures without resolving structural critical corrosion issues that are destroying structural integrity from the inside out.

Bridges consist of 3 main parts (ie: the substructure, the superstructure and the deck). This article focuses on structure critical corrosion found within the steel structure critical joints, connections and bearings. This electro chemical fouled corrosion will distort *structure critical connections* and *freeze bridge bearings* thru corrosion induced expansion and out of plain bending.

Heavy corrosion can cause structure components and *bridge bearings* to lose their ability to support and control movement. Important characteristics that guarantee the continued movement of our manufactured goods, exports and people across our nation. Without their predesigned range of movement the structure loses its ability to distribute those stresses induced by either thermal expansion, contraction or activities such as loads moving across the bridge. When structures are new, energy from moving loads are absorbed by the structure. In aged structures, however, corrosion build within the connection areas can adversely affect the strength of the structure and load distribution in ways which could contribute to reduced load ratings, structure failure or even collapse.



Corrosion Frozen Crevice Corroded Bearing

Crevice Corroded and Pack Rusted Connection

Structure Critical Corrosion forms in micro-void areas found between steel connections, at weld joints, between bearing surfaces, and wherever stress movements cause breaches to the existing

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coating, allowing contaminants to enter between two steel surfaces. Once the corrosion process begins, the oxygen starved acidic area between the two plates become anodic, the area becomes hungry for negative ions further accelerating the corrosion reaction. Other affected areas include design detail surfaces where debris can gather which often also leads to the cutting-off of oxygen.

In Detail “Metallic corrosion can produce very corrosive micro environments through the chemical change of water into acid, called hydrolysis. This phenomenon is particularly noticeable when the environment is confined such as in most forms of localized corrosion (pitting, crevices, environmental cracking).”

“Crevice corrosion is a localized form of corrosion, under the influence of crevice geometries’ .- Stagnant solutions play an important role in setting up of highly corrosive micro-environments inside such crevices. A metallic material tends to assume a more anodic character in the stagnant crevice solution compared with the bulk surface (exposed to the bulk environment).

As in a pitting corrosion attack, coating systems which rely on passive surface films for corrosion resistance can be particularly vulnerable to this mode of corrosion. The highly corrosive micro-environment of crevices tends to be similar to the micro-environment which exists at the base of corrosion pits. Crevice corrosion is usually a result of a differential oxygen concentration cell, in which the mouth of the crevice is richer in oxygen than the metal interface within the crevice, which therefore becomes anodic and dissolves. Subsequent pH shifts within the crevice may lead to even more intensified attack associated with the induction (initiation) and propagation phases of the corrosion cycle.

The chemical change in question is true of most metals, since the metallic ions produced by the corrosion processes are not soluble in their ionic forms. These ions will then react and form more stable species such as oxides and hydroxides. In aerated environments iron oxidizes to ferric ions that subsequently react with water.” <sup>(1)</sup>

In the final stage of development of crevice corrosion a few more accelerating factors fully develop:

1. The metal ions produced by the anodic corrosion reaction readily hydrolyze giving off protons (acid) and forming corrosion products. The pH in a crevice can reach very acidic values, sometimes equivalent to pure acids.
2. The acidification of the local environment can produce a serious increase in the corrosion rate of most metals.
3. The corrosion products seal and further accelerate corrosion in the crevice environment. (If the crevice is sealed with a coating or caulking without the use of a salt remover and an active penetrant to neutralize the active corrosion producing chemistry within the crevice the same results will occur.)
4. The accumulation of positive charge in the crevice becomes a strong attractor to negative ions in the environment, such as chlorides nitrates or sulfates that when reacted can be corrosive in their own right.”<sup>(1)</sup>



SSPC SP 10, 3 coat Organic ZEU System  
(left) Inorganic (Right) after 1 year

Crevice corroded and Pack Rusted Connection  
SSPC SP10 with Failing Caulking

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**A major reason a lot of specifiers believe you cannot do anything about crevice corrosion and pack rust is** Sand blasting does not remove existing corrosion product within confined areas found between connected steel members. SSPC-SP10 “Near White Blast” or SSPC-SP6 “Commercial Blast” standards are impossible to attain inside crevice corroded joints and connections. **[This surface preparation is usually required for hard film and sacrificial film forming paints.]**

These already active corrosion cells contains salt, water, a small amount of oxygen and depending on the salt, hydrochloric, nitric or sulfuric acid. This reacted contamination will facilitate the corrosion of the steel inside the connection. As the reaction progresses it further reduces the steel section inside the connection while expanding the area between the plates. The corrosion by product (Magnetite or  $Fe_3O_4$ ) expands at a rate of 10 to 1 (ie. 1 mil of steel section loss will produce 10 mils of corrosion product). This expansion bends plates and members out of plain, break fasteners and can freeze bearings.

Caulking or sealing up the exterior of actively corroding connections, seals in the corrosion causing chemistries and accelerates the development of protons (which in turn creates more acid) only to attract yet more contaminants to the anodic areas inside the connection.

It is possible to neutralize these corrosion cells. It is a 2 step process.

Step 1: Forget trying to achieve SP6 or SP10 inside the connection this only plugs up the connection with abrasive making the situation worse. Instead focus on ridding the connection of existing salts, water, oxygen, and hydrochloric, nitric or sulfuric acids by flushing with High Pressure water and a salt removal chemistry.

Step 2: Use an active penetrant to neutralize remaining acids, displace moisture, and scavenge oxygen from within the crevice corrosion cell.

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#### **CREVICE CORROSION AND PACK RUST CAN LEAD TO SERIOUS STRUCTURAL PROBLEMS**

Unchecked structural critical crevice corrosion and pack rust is a serious national issue. Where present it can seriously affect the load carrying capacity and structural stability of bridges and structures. In addition if left unchecked reduced steel section (particularly in connection areas) and the resulting distorted members will seriously affect the structure's strength and ability to absorb and distribute load stress. This type of deterioration can cost millions to repair if left unchecked.

**COULD CREVICE CORROSION AND PACK RUST CONTRIBUTE TO THE COLLAPSE OF A BRIDGE?** Most definitely, yes - particularly from the standpoint that it has been found (from analysis of structural failures) that in almost all cases failures are the result of a combination of effects. Many a recorded instance exists where crevice corrosion and pack rust has distorted steel members (see above), overstressed fasteners and corrosion frozen bearings leading to increased structure vulnerability to overweight vehicles, wind loads, incorrect construction procedures, cold temperatures, seismic events and vehicular impacts.

Some Bridge Preservation, Myths and Risks.

**Myth:** “Nothing can be done to stop Crevice Corrosion and Pack Rust” This is only true when applying traditional barrier or sacrificial barrier coatings and their required surface preparations. The only way to stop crevice corrosion and pack-rust inside structure critical areas is to chemically neutralize these inaccessible corrosion hot spots with a process and active chemistry which neutralizes the corrosion causing chemical reactions.

**Myth:** Sandblasting is the standard steel surface preparation method. It is impossible to remove corrosion from within structure critical joints and connections with abrasive blasting. The media are incapable of breaking down the black oxide in the connection. In addition abrasive materials will only plug up the voids and make it more difficult, even impossible to flush out the salts, neutralize acids and remove loose matter. The bulk of the salts can only be removed using a salt mitigation chemistry and high pressure water for flushing. These methods have proven effective at neutralizing the corrosive chemistries found inside inaccessible connections. An imperfect procedure made perfect with the use of base neutralizing chemistry can ensure these corrosion hot-spots become chemically inactive.

**Myth:** Over-coating paint systems do not last. This is true if the overcoating system applied generates too much surface energy affecting the adhesion of the remaining coating system over which it is applied. Field history has proven that structure critical corrosion can be chemically neutralized and that a compatible low surface energy overcoat system are proven to provide decade's long overcoat system durability.

**Conclusion:** Steel bridge and infrastructure designs compensate for thermal expansion, contraction and create load carrying capabilities. This only happens if the original load distribution functions are maintained so the stresses are absorbed properly. Increases in vehicular activity and truck weights, even though all designs add in safety margins, corrosion induced stresses can eat into these margins allowing for less serviceability than originally anticipated.

When bridge bearings become corrosion frozen, stresses are introduced into the structure which can cause premature metal fatigue. Crevice corrosion and pack rust caused by road salts, sea salts or acid rain from industry causes decreased safety margins by compromising steel joints and connections ability to move as designed. Additional concerns when increased loads eat into design safety margins are most worrisome where connections are crevice corroded and pack-rusted introducing stresses and out of plain bending in some of the most structure critical areas. With abrasive blasting of structures proving to be ineffective at neutralizing this corrosion process, the only currently known way to neutralize crevice corrosion and pack rust is through application of active chemistries already field proven to neutralize corrosion within structure critical connections.