Corrosion Part II

Mitigation Methods

by Rich Davis, Editor In Chief

In Corrosion Part I, we talked about just how fast steel corrodes when buried in soil. There is no argument about whether or not steel actually corrodes. We cannot stop corrosion; we can merely hope to slow the process and contain it.

That being said, how can we mitigate corrosion and its deleterious effects on helical piers? There are three primary methods to help mitigate the corrosion process.

1. *Protective Layer* – a technique used to coat the steel and separate it from environmental effects. Above ground this can be achieved by simply painting the steel. This isn't a permanent solution, but so long as there is complete coverage (i.e. no bare steel), the corrosion effect will be impeded. As for below grade, throwing a coat of Glidden on a helical pier will be entirely ineffective because the abrasion encountered during installation will leave sections of the pier void of paint, thus subjecting the entire pier to corrosion. We'll talk more about this later.
2. *Cathodic Protection* - provide an alternative, sacrificial metal to encounter the corrosion in lieu of the steel. Not all metals corrode. For those that do, corrosion occurs at different rates and propensities. Generally speaking, metals with a higher electrical potential will corrode before metals with lower electrical potential. Since corrosion is an electro-chemical reaction, we can connect different metals together via direct contact or through an electric current and control which metals corrode and at what rates. This process is defined as a sacrificial anode. For example, bare steel, helical piers are installed into the ground and connected together with copper wires. The copper wire is also connected to a cinder block size chunk of zinc or magnesium. Because all components are connected electrically, the alternative metals (zinc or magnesium) with a higher electrical potential will corrode entirely before the bare steel begins to corrode. This process can be a bit costly and requires periodic maintenance over the years. Due to the expense and maintenance requirements, it is more common to attach or coat the sacrificial anode (typically zinc) directly to the steel through either galvanization (dipping the steel into molten zinc) or powder coating (spraying the steel with a cold zinc or epoxy products).

3. *More Steel* - we know how fast steel corrodes. Calculating how much bare steel will be left in the ground after a period of years is simply a function of corrosion rates and surface area. Helical Pier manufacturers can simply install bare steel piers with thicker walls or thicker central shafts. These piers will realize more corrosion over time than steel that has cathodic protection, hence the need for more steel.

It should be noted that so long as the pier will still carry the design loads at the end of its service life, the technique(s) used to achieve this becomes a function of cost, efficacy, and resistance to installation abrasion. There are trade-offs for each of these and that's what we'll talk about now.

First let's discuss the *More Steel* technique. As mentioned earlier, we can calculate how much steel we will lose to corrosion over time. A simple solution would be to just put more & thicker steel in the ground right? Not so fast. More steel means more cost. The price of steel has more then doubled in the past four years. Simply using more of it is costly and must be weighed against the cost and effectiveness of other alternatives.

Pros of just using more steel

- One really positive thing about the "more steel" approach is there are no issues with installation abrasion whatsoever.
- Simplification of the manufacturing process; with no coatings or other metals involved, it is just fabricate and deliver.
- Only subject to price volatility of one metal - steel.

Cons of just using more steel

- Because thorough soils properties are many times unavailable, the risk of placing unprotected steel into highly corrosive soils increases the risk. In situations like this, engineers will be more conservative by potentially applying higher safety factors resulting in – even more (unprotected) steel.
- There is a general perception by engineers and others that unprotected steel corrodes much faster than it really does. Educating engineers about this fact who are used to seeing and specifying galvanized steel can be an exhausting process.
- Only subject to price volatility of one metal - steel.

Next, let's talk about *Cathodic Protection*. As discussed earlier, this type of protection can be implemented by direct contact or through electrical current. In the case of helical piers, either method is applicable, but neither one is necessarily cost effective. Connecting a series of helical piers with wires and then attaching a sacrificial anode (zinc, magnesium, aluminum) to them is definitely more complicated than simply installing piers and walking away. An easier and more cost effective way to provide *cathodic protection* is by attaching the sacrificial anode directly to the pier itself. This can be done in a couple of ways. One is by spraying it on, and the other is by dipping the steel pier into molten zinc in a process called hot-dip galvanizing. Let's look at the pros and cons of each of these three methods of *cathodic protection*.

Pros of protecting bare steel through wire connected sacrificial anode

- Manufacturing process is simplified since bare steel piers are used.
- In highly corrosive settings, actual corrosion rates can be monitored and additional anodes can be used over time.
- If anode metals are cheap, this method can be very cost effective despite the additional effort of connecting the piers with wires.
- No installation abrasion worries because the steel is bare.

Cons of protecting bare steel through wire connected sacrificial anode

- Additional costs of connecting piers via wire.
- Maintenance expense of ongoing monitoring of anodes.
- Price volatility of anode metals costs can be significant.

Pros of direct spraying of Helical Piers with sacrificial anode

- Install and walk away.
- Cold zinc spraying is "relatively" inexpensive, not to mention the fact that is an easier process than galvanization.

Cons of direct spraying of Helical Piers with sacrificial anode

- Installation abrasion can strip the coating off the pier - particularly in abrasive soils.
- The cost of zinc has tripled in the past two years.
- It requires an additional manufacturing step.

Pros of Hot-Dip Galvanization as a sacrificial anode

- Install and walk away.
- Little abrasion from installation. When steel is dipped into molten zinc a layer of zinc oxide is formed in between the zinc and the steel. Zinc oxide is highly abrasion resistant (more than bare steel itself). The zinc itself may suffer some abrasion, but not as significantly as cold sprayed applications. Also, the zinc oxide layer acts as a sacrificial anode as well.
- Galvanization is the status quo.

Cons of Hot-Dip Galvanization as a sacrificial anode

- The cost of zinc has tripled in the past tow years.
- Additional manufacturing step.

Lastly, we'll talk about the *Protective Layer*. This isn't difficult to achieve above ground, but the rigors of helical pier installation make the *protective layer* a challenge. Some companies have dabbled with epoxy coatings, creosote, coal-tar, and other coatings in an effort to shield the steel from the corrosive effects of the surrounding soils. The problem is none of them can remain perfectly intact (remember, they must remain 100% intact below ground or they don't work) as a result of the installation process. Hot dip galvanizing also creates a protective layer. As mentioned above, a zinc oxide layer is created through the hot dip process. This layer not only provides *cathodic protection*, but also creates a *protective layer* between the steel and the soil.

Pros of Protective Layers

- Can be less expensive and easier to apply than hot dip galvanization.

Cons of Protective Layers

- Installation abrasion all but rules these coatings out as an effective solution.

Pros of Hot Dip Galvanization as a protective layer

- The zinc oxide layer is highly abrasion resistant and stays intact during installation. Proof of this was offered by Secure Piers. Before beginning a noise barrier project in , the DOT requested to examine a pier for abrasion damage. A pier was installed into 50/3 granular soils with gravel and then removed and a cross section taken to the lab. It was determined that abrasion had reduced the lifespan of the pier by 2 years based on a 75 year design life. Needless to say, the soil conditions for this test were as severe as most any you could expect for a helical pier, and the results were acceptable to the DOT.
- Hot dipping process protects both the outside and the inside of round shaft helical piers.

Cons of Hot Dip Galvanization as a protective layer

- The cost of zinc has tripled in the past two years.

Overall, hot dip galvanizing offers both cathodic protection as well as a protective layer against the surrounding soils. As for preserving the state of the steel below ground, there is no better option. The problem is the price of zinc. It has gone up 3X in just two short years. One has to hope that supply will catch up with demand and prices will moderate – but no one can count on this to happen. On the flip side and with zinc prices currently going through the roof, turning to the *more steel* option looks more and more appealing all the time. There is obviously a price point for each manufacturer where zinc prices get too high, and it becomes more cost effective to just put more steel in the ground. Of course this assumes that steel prices will be less volatile than zinc. Using *more steel* or *hot-dip galvanized steel* can both be acceptable solutions for engineers. Until or unless a new solution is introduced, for now the future of protecting helical piers from corrosion appears to rest the price of metals.