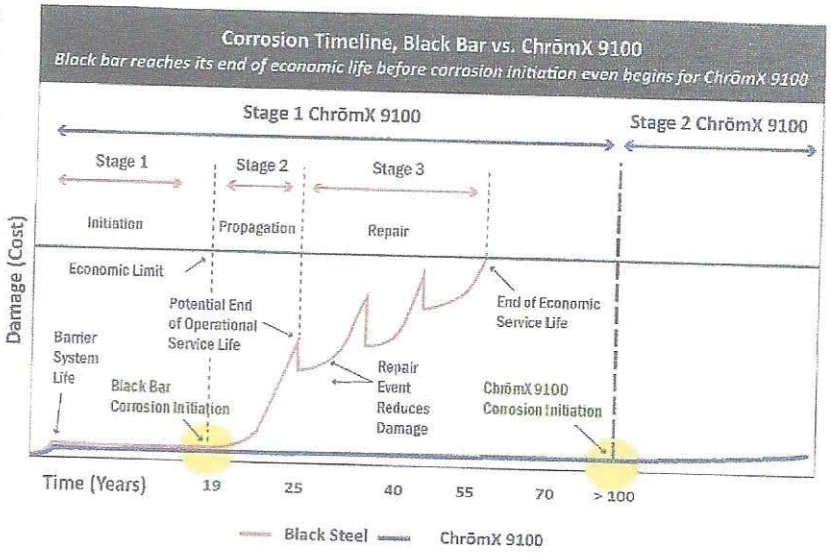
# Service Life and Lower Life Cycle Costs

## With ChrōmX Concrete Reinforcing Steels

**ChrōmX** concrete reinforcing steels provide high strength with varying levels of corrosion resistance, so designers can utilize the high strength efficiencies and best match the corrosion protection requirements of the structure.

The service life (the time to first repair) is driven by the corrosion of the reinforcing steel. Reinforcing steel corrosion begins when the chloride concentration at the steel surface reaches the critical chloride threshold (CT) value of that steel. The corrosion continues at the corrosion rate (CR) of the steel, eventually causing cracking and spalling of the concrete and deterioration of the structure.




### Estimated Chloride Threshold Used in Modeling Service Life


The CT of **ChrōmX 9100** is 4X that of Black Bar and twice that of **ChrōmX 4100**. In addition, both **ChrōmX 9100** and **4100** have a CR value of 1/3 that of Black Bar. These higher CT and lower CR values are the reason the ChrōmX products extend the structure's service life, saving repair and maintenance costs, resulting in lower life cycle costs compared to other steel reinforcing products.

**Chart Notes:**

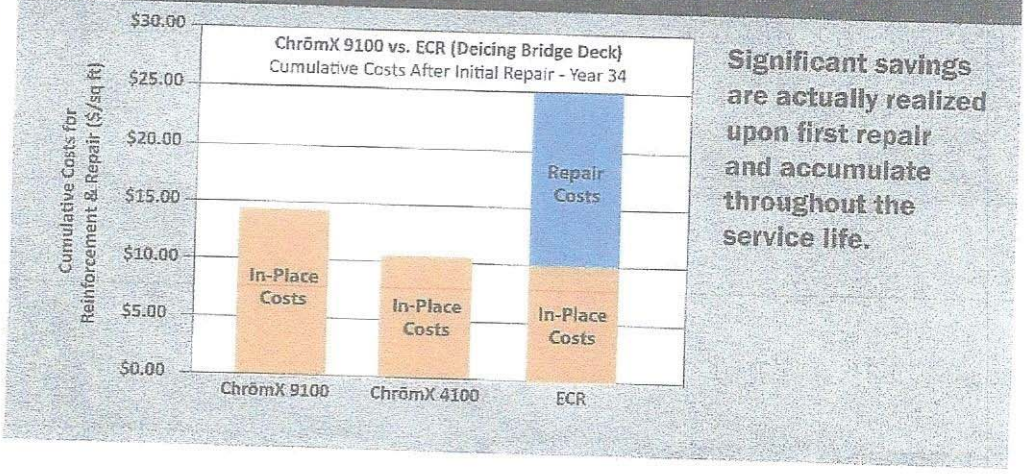
[1] Darwin, David et al, *Critical Chloride Corrosion Threshold for Galvanized Reinforcing Bar*, The University of Kansas Center for Research, Inc. (Dec 2007).

[2] ECR Chloride Threshold set at black bar's CT. Perfectly applied epoxy-coating performs well in laboratory tests, but field studies prove that the coating does not survive field handling and installation, and therefore provides little to no protection.

[3] ChrōmX 4100 comparison figure based on Tourney Consulting Group, LLC, *Reinforcing Steel Comparative Durability Case Studies and 100 Year Service Life Cost Analysis Report*, Tourney Consulting Group, LLC (2016).

***On average, rebar accounts for approximately only 1% - 4% of the total cost of construction, yet this relatively small cost item ultimately determines the operational service life of the multi-million dollar structure.***

### Savings Realized Upon First Repair

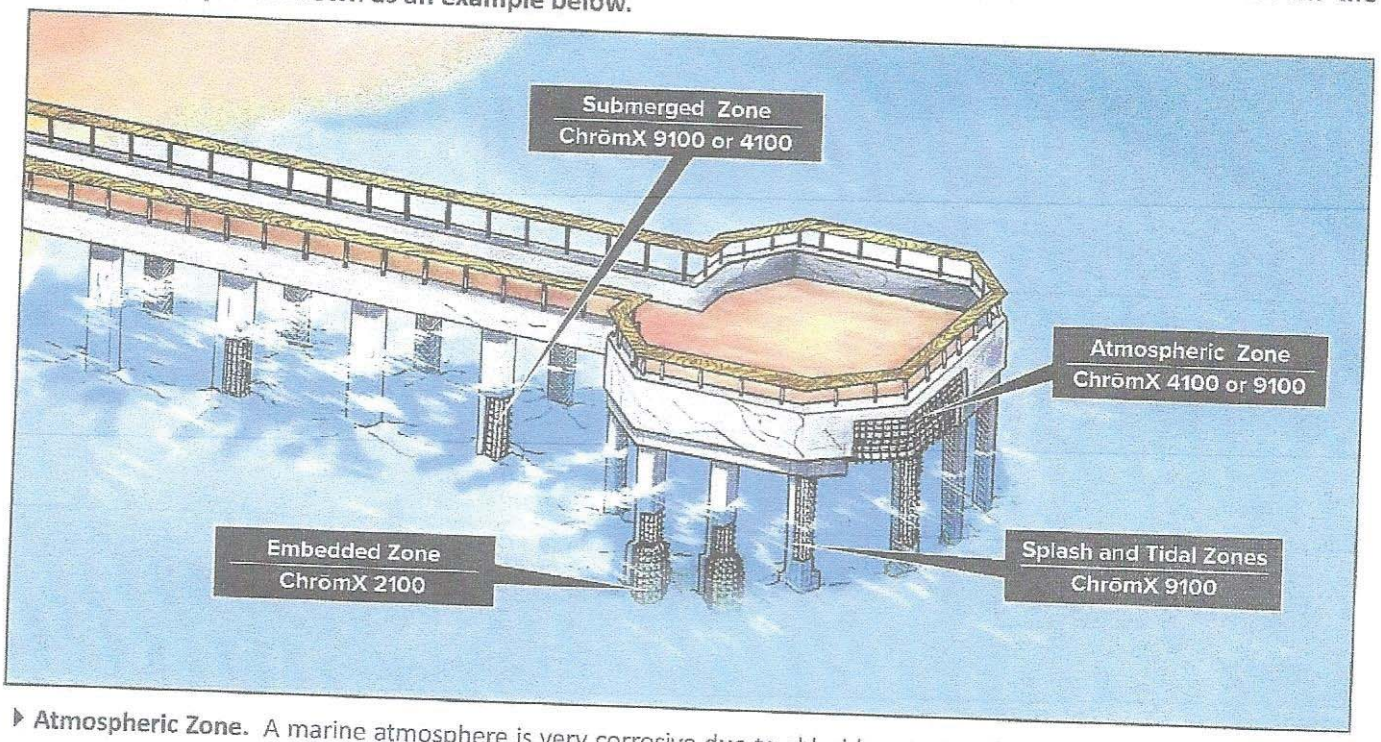



**Significant savings are actually realized upon first repair and accumulate throughout the service life.**

# Service Life Designs

## With the full ChrōmX product line

**Areas of the same marine structure have different corrosion protection requirements. The full ChrōmX product line (9100, 4100 and 2100) allows all designers to mix and match, and select the product that best fits the application. A pier is shown as an example below.**




- **Atmospheric Zone.** A marine atmosphere is very corrosive due to chloride exposure from salt spray, salt fog and salt mist. For atmospheric pier members in marine environments designers should consider using ChrōmX 4100 or 9100 depending on the target service life for the structure.
- **Splash and Tidal Zones.** The splash and tidal zones are generally severe corrosive environments due to repeated wet and dry saltwater exposures, requiring ChrōmX 9100's corrosion protection.
- **Submerged Zone.** While actually less corrosive than the splash zone, designers should consider ChrōmX 9100 or 4100 for the submerged zone.
- **Embedded Zone.** There is usually lower corrosion potential in the embedded zone depending on the composition and contents of the soil, therefore ChrōmX 2100 may be a good choice.

### Case Study Corrosion Service Life for Various Reinforcing Steels in Low Permeability Marine Piles

| Reinforcing Bar | Est. Initial Cost ($/lb)* | Service Life Years (2.0" cover)** | Service Life Years (2.5" cover) |
|---|---|---|---|
| Black Bar | $0.61 | 26 | 37 |
| Epoxy Coated | $0.84 | 35 | 46 |
| Galvanized | $1.14 | 64 | 89 |
| ChrōmX 4100 | $0.81 | 56 | 76 |
| ChrōmX 4100 w/ CNI | $0.86 | 94 | >100 |
| ChrōmX 9100 | $1.21 | >100 | >100 |
| Stainless (UNS S32304) | $2.11 | >100 | >100 |

* Estimate initial cost per pound installed including materials, fabrication and placement estimated costs as of date of publication. Adding 2 gallons of calcium nitrite (CNI) as a concrete additive at an estimated cost of $12.00 per cubic yard of concrete has been shown to further enhance ChrōmX 4100's corrosion performance. With a ratio of rebar to concrete for a typical marine pile ranging from 160 to 240 lbs. of rebar per cubic yard, the additional CNI cost would range from $0.05 to $0.075 per lb of rebar.

** Service lives estimated based on CT values determined in Critical Chloride Corrosion Threshold for Galvanized Reinforcing Bars, David Darwin, et al, Univ. of Kansas Center for Research, Inc. (Dec. 2007), as well as CT and CR values and Stadium Modeling for marine piles using 2.0 and 2.5 inches of Pile Mix LP concrete cover according to Reinforcing Steel Comparative Durability Case Studies and 100 Year Service Life Cost Analysis Report, Tourney Consulting Group, LLC (2016).