Evaluation of Steel Corrosion Protection Systems: Minimizing Economic, Social, and Environmental Effects

Why Do We Care About Corrosion?

Finding corrosion on a structure is worse than finding a pimple on your face on the day of an important presentation. In addition to being unsightly, corrosion is a threat to the integrity and safety of the structure. Corrosion constitutes a breakdown that is inconvenient, time consuming, and carries an enormous economic impact. In 2016, corrosion cost the US $557 billion in direct costs.[1] Indirect costs, which can be up to 11 times greater than direct costs,[2] are difficult to measure since they include a huge range of things like risks of injuries to the workers doing the repairs, impacts to the drivers in the area of the repair, and impacts to the community while repairs are underway.

If corrosion is ignored, there's the potential for a catastrophic event. In India, in 1984, corrosion of a tank holding methyl isocyanate allowed water to seep in. [3] The water combined with the methyl isocyanate, causing a chemical reaction that forced lethal gas to exit through the safety valve. Tragically, 8,000 people were killed. In 1997, corrosion caused a balcony to fall at the University of Virginia. One person was killed, and another 18 people were injured.[4] Corrosion can kill.

---

[1] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[2] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[3] Cowlishaw, Samuel. "Five Disasters Caused by Corrosion." *PCI Magazine*, 13 Jan. 2022, https://www.pcimag.com/articles/109648-five-disasters-caused-by-corrosion. Accessed 24 Mar. 2023.
[4] Cowlishaw, Samuel. "Five Disasters Caused by Corrosion." *PCI Magazine*, 13 Jan. 2022, https://www.pcimag.com/articles/109648-five-disasters-caused-by-corrosion. Accessed 24 Mar. 2023

What are the Ways to Prevent Corrosion?

Corrosion prevention is understandably a top priority. There are a variety of ways to prevent corrosion, but this report will convince you that hot-dip galvanized steel is the ideal corrosion protection system for your future projects. Compared to paint, hot-dip galvanized steel is the better choice. Hot-dip galvanized steel fulfills your needs for corrosion protection while at the same time prioritizing sustainability.

What are the Factors to Consider when Evaluating the Sustainability of Steel Corrosion Protection Systems?

Price. Your customers are looking for value. In order to evaluate a project's value, the customer needs information about the cost of construction, how long the structure will last, and what the estimated costs will be to maintain it during the structure's lifetime.

Customers are used to considering the up-front costs of a project. I live in a poor town where for years the city council and mayor have made decisions to use the cheapest materials and process that gets the job done without considering long-term costs. The current mayor is changing people's minds about the wisdom of that approach, showing everyone that ongoing costs to maintain and patch the infrastructure is more expensive in the long run than opting for a quality job from the beginning. The total price equals upfront costs plus ongoing costs.

Your customers need information about the upfront costs and the ongoing costs. After seeing the numbers, they will likely opt for hot-dip galvanized steel. Consider that your next project includes the construction of a balcony and your customers are debating between painted balconies and hot-dip galvanized balconies. You give them the numbers. Based on previous

projects,[5] it would cost $1.10 per square foot for the installation of the hot-dip galvanized balcony and no maintenance would be needed for the 60 year lifespan of the balcony. It would cost significantly more for the painted balcony - $4.83 per square foot for the installation of the plus $29.31 per square foot for maintenance over the 60 years. Crunching the numbers, you show the customers that the hot-dip galvanized steel balcony is 96% cheaper. Depending upon the size of the balconies and the total number of balconies being built, the difference can quickly add up to thousands of dollars of savings.

To make it easier to estimate how much the customers can save by using hot-dip galvanized stee, you can use the American Galvanizers Association's online calculator, which is posted at lccc.galvanizeit.org.

Social Impact. Choosing the hot-dip galvanized balcony over the painted balcony is more than just about price. It also has an impact socially. When community buildings and structures are in good repair as they would always be with the hot-dip galvanized balconies, there's a domino effect, in that others are encouraged to invest in properties, both residential and commercial. People want to live and shop in the desirable neighborhood. More shops open, triggering economic growth, and increasing the community's tax base, which generates more money to put into community building/structures.

Additionally, when communities invest in structures with lower maintenance needs, they free up money for other needs or wants. Using hot-dip galvanized steel allows community leaders to budget better. They won't have to worry about setting aside money for repainting the steel. There

[5] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.

no longer would be the potential that labor costs for maintenance could soar for some reason, leaving a community with not enough money to do future maintenance, as would exist were the community structures to be made of painted steel. Lack of maintenance to painted steel would leave structures in bad repair, leading to community eyesores and/or safety risks.

In general, people can feel good about the safety of hot-dip galvanized structures. Hot-dip galvanized structures are more likely to survive an earthquake and other natural disasters.[6] Hot-dip galvanized transmission and distribution poles are more likely to come through a hurricane unscathed.[7]

The residents' quality of life is better and there is more community pride when buildings aren't suffering from a lack of maintenance. San Diego residents, for example, feel a sense of pride when they see their Central Library's breathtaking hot-dip galvanized steel façade. It's beautiful and will stay beautiful for many, many years and no one has to worry about maintenance during that time, as they would if it had been painted instead.

Not having to do maintenance for many years is a great asset for the community. Maintenance is annoying to people in the area. It can necessitate road closures, create safety hazards on the side of the road, and block access to buildings/structures. It also can be dangerous for the people doing the maintenance. In Vancouver, BC, the Capilano Suspension Bridge Park was built using

---

[6] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.
[7] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.

hot-dip galvanized steel, a smart choice since this eliminates the need for people to risk their lives to do maintenance on a bridge that is 90 meters above a river, along a cliff.[8]

Environmental Impact. Structures built incorrectly or with subpar materials have the potential to unleash severe impacts on the environment, either at the time of construction or demolition. Sometimes, contractors use materials that are harmful to people or to nature. It's important to mitigate the potential for pollution. Using hot-dip galvanized steel is one method that can allay your and your customers' fears of pollution. When examining the acidification potential, galvanized steel came in at under 4000 g SO_2 compared to painted steel at 8000 g SO_2.[9] The potential for inadvertent acidification is important because acidification damages ecosystems.[10] Additionally, the photochemical ozone creation potential was under 3,000 for galvanized steel but was nearly 13,000 for the painted steel.[11] Photochemical ozone creation is a legitimate concern because it's hazardous both to human life and to plant life.[12]

Zinc, the material that makes up the coating of hot-dip galvanized steel, exists already in our environment and in the products we use. There are 5.8 million tons of zinc cycling through the environment.[13] Besides being in the air we breathe, the water we drink, and in the soil, it's also

[8] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.
[9] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.
[10] Pawłowski, Lucjan. "Acidification: Its Impact on the Environment and Mitigation Strategies. *Ecological Engineering.* vol. 8 (4) 1997, 271-288.
[11] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.
[12] Carter, William, et al. "Environmental Chamber Study of Maximum Incremental Reactivities of Volatile Organic Compounds*." Atmospheric Environment*, vol. 29 (18) Sep. 1999, 2499-2511.
[13] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.

found in many household goods including sunscreen, cold medicine, and cosmetics.[14] Your customers can feel good about using a substance that not only are we exposed to already but is actually vital to life.

The materials themselves are not the only consideration. There's also the issue of pollution in the form of energy loss. The burning of fossil fuels to produce the energy to power human activities including construction, creates CO_2 emissions. These emissions are up by almost 50% compared to pre-industrial times.[15] The unfortunate and dangerous result of these CO_2 emissions is an increase of almost 2 degrees Fahrenheit.[16] As far back as 1956, scientists knew that CO_2 from human activities was driving climate change.[17] Excessive climate change could cause a catastrophic chain of events, including weather-related crises and widespread diseases, which would threaten our health and overall well-being.[18] We would have to suffer through more pandemics and more natural disasters, while watching sadly as habitats disappear and animals go extinct. There are 150,000 species currently at risk of becoming extinct.[19]

It's critical that we minimize the amount of energy expended for construction and maintenance. That's why projects using hot-dip galvanized steel are ideal, as they require zero maintenance for

---

[14] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[15] Letcher, Trevor M. "Introduction with a Focus on Atmospheric Carbon Dioxide and Climate Change." *Future Energy*. 2020. 3-17.
[16] Shukla, Priyadarshi R., et al. "IPCC, 2019: Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems." 2019.
[17] Plass, Gilbert N. "The Carbon Dioxide Theory of Climatic Change." Tellus vol. 8 (2), 1956 140-154. https://www.tandfonline.com/doi/abs/10.3402/tellusa.v8i2.8969.
[18] Goshua, Anna, et al. "Addressing Climate Change and its Effects on Human Health: A Call to Action for Medical Schools. *Academic Medicine* vol. 96 (3) 2021 324-328.
[19] Whittle, Patrick. "These 700 New Species are Facing Extinction." *PBS* 9 Dec. 2022, These 700 new species are facing extinction | PBS NewsHour Accessed 16 Jan. 2022.

70 years.[20] That means that there is no additional energy waste after construction. Other coating systems like painted steel need energy intensive maintenance every 15 years.[21] When comparing the hot-dip galvanized balconies and the painted balconies, the energy for building the hot-dip galvanized balcony was 23,700 MJ with no additional MJ for maintenance during the 60-year lifetime of the balconies. [22] The energy for building the painted balcony required 64,700 MJ of energy for construction and maintenance over the lifetime of the balconies. Incredibly, the hot-dip galvanized balcony used 37% of the energy needed for the painted steel balcony, making it the more environmentally friendly choice. The global warming potential for the painted balcony was twice that of the galvanized system – 2,000 kg CO_2 vs less than 1000 kg CO_2.[23]

Construction and demolition also generate a lot of waste. The EPA kept track of the construction-related waste in 2018 and estimated a whopping 600 million tons of trash came from construction/demolition.[24] When your customers choose hot-dip galvanizing steel, they can be reassured that they are minimizing the amount of waste their projects generate. Excess hot-dip galvanized steel is easily reused or recyclable. When a bridge made of hot-dip galvanized steel in Massachusetts was no longer needed after 15 years, it was given to Haiti to be reused there.[25] If there isn't a way or desire to reuse hot-dip galvanized steel projects after they are no longer

---

[20] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[21] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[22] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[23] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.
[24] "Construction and Demolition Debris: Material-Specific Data" *EPA.* Construction and Demolition Debris: Material-Specific Data | US EPA. Accessed 20 Mar. 2023.
[25] "Introduction." *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.

wanted, the materials are 100% recyclable, which means that when they are recycled, they can stay zinc and steel and be just as amazing as they were when they were first used.[26] Zinc and steel aren't just recyclable in theory. Steel is recycled 70% of the time, making it the most recycled material in the world.[27] Zinc is also commonly recycled at 30%.[28] Hot-dip projects that use other coating systems are not so easily recycled. The nonrecyclable coatings are blasted off and the coatings become waste. Only the steel is recycled.

The ability to recycle the coating and the steel, along with the abundance of these materials, is at the heart of what makes hot-dip galvanized steel sustainable. We aren't using up rare materials and harming future generations. Zinc and steel are both available and easily obtainable from the Earth's crust. Zinc is the 24th most abundant element in the Earth's crust and iron ore, the main ingredient of steel, is the 4th most abundant.[29] Future generations will have the same access to hot-dip galvanized steel.

What's the Bottom Line?

You should choose hot-dip galvanization over other steel corrosion protection systems. Hot-dip galvanization minimizes the economic, social, and environmental impact of construction and demolition.

---

[26] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[27] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[28] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.
[29] "Hot-Dip Galvanizing for Sustainable Design." *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.

References

Carter, William, et al. “Environmental Chamber Study of Maximum Incremental Reactivities of Volatile Organic Compounds.” *Atmospheric Environment*, vol. 29 (18) Sep. 1999, 2499-2511.

“Construction and Demolition Debris: Material-Specific Data” *EPA.* Construction and Demolition Debris: Material-Specific Data | US EPA. Accessed 20 Mar. 2023.

Cowlishaw, Samuel. “Five Disasters Caused by Corrosion.” *PCI Magazine*, 13 Jan. 2022, https://www.pcimag.com/articles/109648-five-disasters-caused-by-corrosion. Accessed 24 Mar. 2023.

Goshua, Anna, et al. "Addressing Climate Change and its Effects on Human Health: A Call to Action for Medical Schools. *Academic Medicine* vol. 96 (3) 2021 324-328.

“Hot-Dip Galvanizing for Sustainable Design.” *American Galvanizers Association*, https://galvanizeit.org/education-and-resources/publications/hot-dip-galvanizing-for-sustainable-design. Accessed 20 Mar. 2023.

“Introduction.” *American Galvanizers Association*, https://galvanizeit.org/sustainable-development-hot-dip-galvanizing-online-seminar/introduction. Accessed 20 Mar. 2023.

Letcher, Trevor M. "Introduction with a Focus on Atmospheric Carbon Dioxide and Climate Change." *Future Energy*. 2020. 3-17.

Pawłowski, Lucjan. “Acidification: Its Impact on the Environment and Mitigation Strategies. *Ecological Engineering.* vol. 8 (4) 1997, 271-288.

Plass, Gilbert N. "The Carbon Dioxide Theory of Climatic Change." Tellus vol. 8 (2), 1956 140-154. https://www.tandfonline.com/doi/abs/10.3402/tellusa.v8i2.8969.

Shukla, Priyadarshi R., et al. "IPCC, 2019: Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems." 2019.

Whittle, Patrick. “These 700 New Species are Facing Extinction.” *PBS* 9 Dec. 2022, These 700 new species are facing extinction | PBS NewsHour Accessed 16 Jan. 2022.