**Question:**

Think about a specific market (e.g. utility, bridge/highway, buildings, etc.) where you notice corrosion taking place. Which of these markets do you feel would benefit the most from utilizing more hot-dip galvanized steel? Provide justification for your position.

**Answer:**

As an aspiring architect, I seek to design spaces that are sustainable and inspiring, while meeting a growing need for built space. By 2060, the amount of global built space is expected to grow by 230 billion m,2 essentially doubling the existing building stock.1 Beyond the new construction, many existing buildings will undergo major renovation or replacement. For my future architectural projects, I will aim to reduce each building or space’s initial greenhouse gas emissions (known as “embodied carbon”) and prepare each design for a “long life, loose fit.” A “long life” requires a durable underlying structure, while a “loose fit” requires a flexible design that allows for multiple uses throughout a building’s lifespan. Increased material use of hot-dip galvanized steel will contribute to “long life” building lifespans, helping to meet voluntary or mandatory sustainability targets.

Existing buildings sometimes are demolished less than 25 years after completion of construction, and 31% of demolished buildings are demolished due to poor physical condition (in a survey of 227 residential and commercial buildings in North America).2 Focusing on reducing future environmental and economic impacts, architects are realizing that new buildings should be built to a design service life of at least 100 years – the structure of the Bullitt Center in Seattle was built to a building lifespan of 250 years.3 It is challenging to design a structure and specify materials that will last 250 years. Under conditions of salty air, continuous moisture, or chemical exposure, steel can corrode much sooner than these desired service lifespans of 250 or 100 years. Despite the corrosion risks, steel is still desirable for architectural use; it can have positive environmental aspects such as high recycled content, efficient construction assembly rate, and light weight composition. By using galvanized steel in reinforced concrete, high moisture environments, and exterior environments, architects can limit some of the corrosion concerns while taking advantage of the positive characteristics of steel.

After undergoing the hot-dip galvanization process, steel emerges protected by an external layer of zinc over intermediate layers of iron-zinc alloy.4 Galvanized steel is more resistant to corrosion and abrasion than unprotected steel. Galvanized steel exposed to the exterior should last at least 75 years without notable damage, and enclosed galvanized steel can last much longer.5

In reinforced concrete, hot-dip galvanized steel reinforcement bar offers exceptional corrosion resistance compared to regular “black” bar or even epoxy-coated bars, improving the serviceability and durability of reinforced concrete. Corrosion of rebar in concrete eventually leads to swelling of the bars, cracking and compromising the structural integrity of reinforced concrete and possibly of whole buildings.4 Notable areas of special concern for rebar corrosion are roofs, exterior walls, and balconies. Drainage problems can cause the infiltration of moisture into the concrete, and the resulting rebar corrosion can cause costly reinforced concrete failures.6 Hot-dip galvanized steel rebar tolerates a higher chloride concentration or carbonation amount than black bar prior to corrosion commencing.4 Although epoxy-coated rebars were initially advertised to have superior performance to galvanized rebar, recent field-tested studies in the United States have indicated that bridges using galvanized rebar are maintaining structural integrity longer than bridges with epoxy-coated rebar.7  Additionally, epoxy-coated rebar can be easily damaged during construction and any hole in the coating can allow corrosion to start under the coating.7

High moisture or submerged environments such as waterparks, pools, and coastal facilities should use galvanized steel to limit corrosion that accelerates with chlorine or salt in the air.8  Because chlorine can still damage hot-dip galvanized steel, galvanized steel in these environments often receives a top coat of paint, creating what is known as a “duplex system.”8 In a duplex system, corrosion protection can last from 1.5 to 2.3 times the combined lifetimes of both paint and galvanization systems when each is used on their own.5 As long as the paint protection is replaced when damaged, the galvanized steel underneath could last indefinitely.8 In areas at risk for coastal flooding, galvanization provides extra protection in case of extreme weather events.

Even where moisture is less of a concern, other exterior applications should consider galvanized steel. A recent trend in commercial and residential architecture is towards outdoor living environments that blur the line between indoors and outdoors. These settings are defined with open structures that provide shade, light, heat, and electrical access.9 Hot-dip galvanized steel is one of the best material choices for these structures, where it can be paired with fabric and glass panels. Although wood has an inherent aesthetic appeal, the required treatments and finishes for high-performance exterior use require frequent reapplication and maintenance; whereas a galvanized structure should be relatively maintenance-free.

Another exterior architectural use of steel is in carports and parking garages. Galvanized steel for these structures will protect against corrosion from rain. Galvanized steel has a high abrasion resistance which limits damage from car collisions with the parking structure.

Galvanized steel elements can also enhance façades and building forms. Aluminum façade systems are lightweight and common, but they can easily be damaged and corrode under the right conditions. Galvanized steel panel systems offer more robust protection from impact damage and scratches. When left unpainted, the soft reflectivity of the galvanized surface may be desired, as with the landmark VIA 57 building by Bijarke Ingels in New York City, which uses galvanized steel panels on its stunning façade.5 Unpainted surfaces avoid the negative environmental impacts associated with paint production and volatile organic compound emissions. Galvanized steel can be used for exterior structural expression as well, such as on the Harley Davidson museum in Wisconsin, which has exposed galvanized steel beams and columns.5

Although galvanized steel may initially cost more than non-galvanized steel, the economic and environmental cost of not making long-lived and low maintenance buildings is greater. The initial cost of galvanized steel is the total life cycle cost if no maintenance is needed.5 The environmental cost of demolishing and replacing a building with steel rebar or structure corrosion failures is enormous, certainly much more than any additional initial cost of galvanized steel. Choosing galvanized steel for long-life concrete rebar, high moisture environments, and exterior environments is a smart decision for long-term sustainability of the built environment.

Sources

1 International Energy Agency. 2017. *Energy Technology Perspectives 2017: Catalysing Energy Technology Transformations*. *International Energy Agency (IEA) Publications*. <https://doi.org/10.1787/energy_tech-2014-en>.

2 O'Connor, Jennifer. “Survey on Actual Service Lives for North American Buildings .” In *Survey on Actual Service Lives for North American Buildings*. Las Vegas, 2004.

3 “An Environmental Model for the Next 250 Years: Seattle's Bullitt Center.” *Urban Land Magazine,* March 18, 2015. https://urbanland.uli.org/news/an-environmental-model-for-the-next-250-years-seattles-bullitt-center/.

4 Yeomans, Stephen Ross. “Galvanized Steel in Concrete: An Overview.” In *Galvanized Steel in Concrete*, 2004.

5 “Galvanized Buildings and Architecture.” Centenial, CO: American Galvanizers Association, 2000. https://galvanizeit.org/uploads/publications/Galvanized\_Buildings\_and\_Architecture.pdf

6 “Why Reinforced Concrete Buildings Fail.” FCAP. Accessed December 29, 2019. https://www.fcapgroup.com/flcaj/flcaj-articles/why-reinforced-concrete-buildings-fail/.

7 “Field Handling Guide: Hot-Dip Galvanizing versus Fusion Bonded Epoxy.” Centennial, CO: A merican Galvanizers Association, 2000.

8 Fossa, Alana. “HDG for Waterparks, Pools, and Aquatic Facilities.” American Galvanizers Association, December 29, 2019. https://galvanizeit.org/knowledgebase/article/hdg-for-waterparks-pools-and-aquatic-facilities.

9 “The Top Landscape Trends of 2018.” *Building Design Construction*, February 12, 2018. https://www.bdcnetwork.com/top-landscape-trends-2018.