The Dixieland Museum, New Orleans

Evaluating Corrosion Protection Systems: Hot-dip Galvanized Steel Recommendations

Lead Architect: Justina Starrad

Project Background

The firm has been commissioned to memorialize New Orleans jazz music with a performing arts center dubbed Dixieland Museum. We are in the early stages of pre-design, researching the existing site and conditions to make some determinations about specific location and materiality before sketching ideas. This document serves to evaluate corrosion protection systems for the New Orleans coastal marine environment. In the document, I compare protection systems and highlight my recommendation to achieve the attractive exterior finish the firm is known for without compromising on corrosion resistance. I include a case study of the Salvador Dalí Museum to highlight a project of a similar typology and materiality in a similar coastal environment.

Civic Buildings are the soul of the city; pumping arts and culture through the streets to create vibrant urban landscapes. And the new Dixieland Museum will be no different.

So how do we make it iconic?

Hot-dip galvanized (HDG) steel is the only choice.

The Site

New Orleans is one of my favorite cities; the richness of the food, liveliness of the music, the friendly people. The culture is palpable here. These factors make it the perfect site for a performing arts center that will continue to nourish and catalyze the development of the arts. However, the location of the city along the Gulf Coast poses several challenges architecturally. The weather service estimates that a hurricane will make landfall within 50 miles of New Orleans approximately once every decade[16]. The shallow, sloping Gulf of Mexico shelf creates a storm surge condition along the coast. This issue is further exacerbated by the rapid loss of wetlands which previously protected the coast against rising water levels. We have all seen the devastating impacts of Hurricane Katrina on both the livelihood and built environment of the city, so materiality of new construction is highly important.

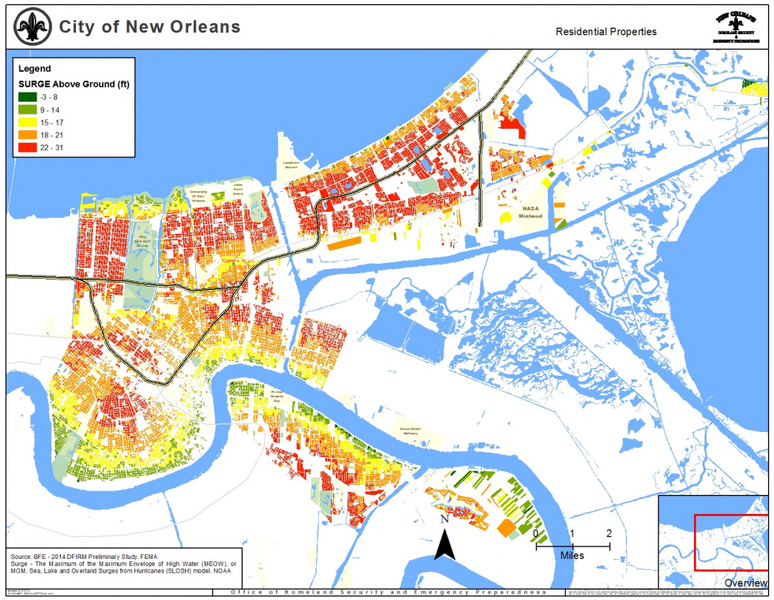

Fig. 1 Map of New Orleans highlighting areas of storm surge

Corrosion occurs when moisture and oxygen react electrochemically with iron to produce rust, Overtime, the rust decreases the structural integrity of steel leading to the eventual collapse of the structure. Fig. 1 highlights areas of storm surge 22 - 31 feet above ground in red. This is almost all of the downtown urban area. With brackish Gulf water thrashing against the coast during storm surge, it is more than necessary that the material proposed is not only aesthetically pleasing but highly resistant to salt water corrosion.

Evaluating Corrosion Protection Systems

There are several cost effective corrosion protection systems that can be used for this building based on their durability. In our earlier meetings, we discussed the options for corrosion resistance and settled on choosing either hot-dip galvanized (HDG) steel or zinc-rich paint. Through my research, I believe that HDG steel is the material for the job. I included this graphic from the American Galvanizers Association website (Fig. 2) because it is a great comparison of the two systems and highlights that HDG is the clear winner. It is almost 4 times more durable than zinc-rich paint in any environment, exceeds the ASTM A 123 minimum coating standards, is at least 50 cents cheaper per square foot and most importantly, ensures no base steel corrosion due to its hard alloy layers. I am recommending HDG steel for the facade system.

Hot-Dip Galvanized Steel vs. Zinc-Rich Paint

Galvanized sign structure

Hot-Dip Galvanized Steel	Characteristic	Inorganic Zinc-Rich Paint (ZRP)
> 100 years[b] > 90 years > 70 years > 50 years	**Service Life/Durability**[a] Rural Urban Industrial Marine	27 years[c] 17 years 12 years 12 years
Exceeds ASTM A 123 minimum (> 3.9 mils for 1/4" thick steel) Exterior & Interior Edge & Corner thickness ≥ flat surfaces	**Coating** Thickness Coverage Consistency	Variable - may not meet required minimum due to applicator skill Exterior surfaces only Edge & Corner thickness < flat surfaces
Direct[d] / Indirect $1.76/ft² / $0 $1.76/ft² / $0 $1.76/ft² / $0 $1.76/ft² / $0	**Life-Cycle Cost**[e] Rural Urban Industrial Marine	Direct[c] / Indirect[f] $1.27/ft² / $ 6.35 - $12.70/ft² $1.74/ft² / $ 8.70 - $17.40/ft² $2.27/ft² / $11.35 - $22.70/ft² $2.27/ft² / $11.35- $22.70/ft²
Yes - 100% zinc metal Zinc metal is anodic to steel	**Cathodic Protection**	Maybe - Zinc % may be too low for conductivity/Binding materials may not be conductive, minimizing cathodic protection
No base steel corrosion	**2000 Hour Immersion Test**	Paint absorbed water & underfilm corrosion of the substrate steel occurred
No effect on performance	**Ultraviolet Ray Exposure**	No severe degradation
Alloy layers are harder than base steel DPN hardness ranging from 179 - 250	**Abrasion Resistance**	Moderate; DPN hardness approximately 33% less than HDG
-100 C to 350 C	**Performance Range Temperature**	Deterioration at 250 C
Documented, timed, scientific sequence Observable completion of metallurgical reaction	**Application** Surface Preparation Procedure	Function of human expertise, intolerant of improper cleaning/profiling Constant agitation of mixture, regulation thickness & drying time per pass
24/7/365 - all weather	**Application**	Requires specific temperature & humidity conditions
~ 3600 psi	**Bond Strength to Steel**	~ 600 psi
90' - 120' long by 6' - 8' wide/deep	**Size Range of Products**	Unlimited

[a] To 5% rust on substrate steel
[b] Zinc Coating Life Predictor, Zhang, 2001
[c] NACE Paper 06318, Helsel, Melampy, Wissmar, 2006
[d] Galvanizing Industry Survey, 2006
[e] 50-year life, 3% inflation, 7% interest rate, 100,000 sq. ft./typical mix of structural products
[f] Federal Highway Administration, RD-D1-156, Vermani

Corroding painted pole

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Fig. 2 Table comparing HDG steel and zinc-rich paint

How does HDG steel provide corrosion resistance?

Hot-dip galvanizing is the process by which steel is coated with a protective zinc layer to prevent corrosion. This increases the resistance of the steel to corrosion. Carbon pumps rebuilt in New Orleans following Katrina started to rust after only 5 years due to the brackish water flowing through the canal. They were meant to last 35[10]. If HDG had been used, these pipes would have lasted for decades. To prevent oxidation, the steel is first degreased to remove organic contaminants, acid pickled to remove rust then fluxed. When immersed in the kettle, the iron in the steel reacts metallurgically with the molten zinc to form a uniform corrosion resistant coating.

Appearance of HDG

I know that much of the resistance to HDG in comparison to zinc-rich paint is the lack of uniformity of the material after fabrication. The initial appearance of the HDG steel may be of various shades of grey due to differences in texture caused by cooling rate, stresses from fabrication or the composition of the steel. However, this has no impact on the material's ability to prevent corrosion. After approximately 6 months, or within 2 years[3], the HDG steel will develop a uniform matte grey patina due to weathering. Although this initial inconsistent appearance does not fit the aesthetic we are going for, there are several steps that we can take to rectify this issue. To ensure the desired finish, we must clearly and directly communicate our aesthetic requirements to the galvanizers.

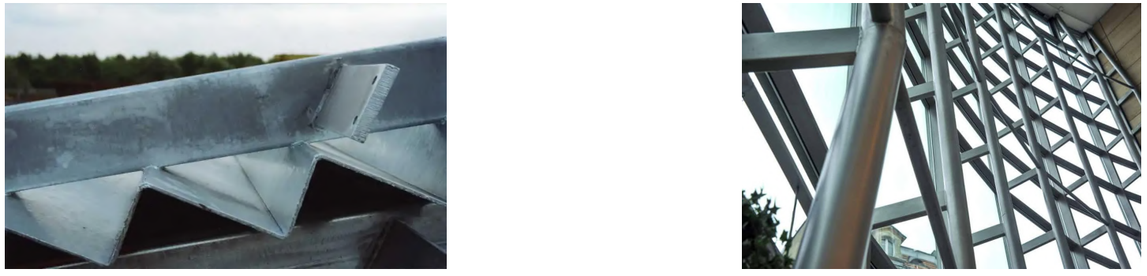

Fig. 3 Initial HDG steel appearance (left) vs. HDG steel with developed patina (right)

Plan of Action for Fabricators/Galvanizers (based on AGA recommendations for uniformity[3]):

1. Recommend the steel used be less than 2 to 3 inches to prevent thick, brittle coating which exposes the steel to corrosion.

2. Suggest an ideal makeup of a less reactive steel to promote strong adhesion and deliver a more uniform initial surface condition.
   - Silicon: < 0.04% or 0.15% - 0.22%
   - Phosphorus < 0.04%
   - Carbon < 0.25%
   - Manganese < 1.35%

3. The design engineer should ensure that all pieces are less than the size of the kettle (approximately 40') so that the objects can be fully immersed for a smooth finish.

4. Consult directly with the galvanizer to optimize venting/drainage hole placement, quantity, and size in relation to the designated lift points.

5. Consult with the welding team to ensure uniform metal use (e.g. spacers) and to seal overlapping joints to avoid galvanic corrosion and moisture rust.

6. Ask for mill markings to be smoothed before HDG for a uniform appearance.

7. Opt for commercial blasting before HDG which roughens the surface for a uniform look.

8. Request surface smoothing after HDG to increase uniformity of the material.

I am also recommending that all design engineers on this project read "The AGA Design Guide: The Design of Products to be Hot-Dip Galvanized After Fabrication"[4] to familiarize themselves with best practices for the process before we begin to generate ideas.

Maintaining the appearance of HDG steel

Though HDG is highly damage resistant, small voids or defects in the coating can occur during galvanizing or handling. ASTM A780 describes that these imperfections can be repaired with zinc-based solder, zinc-rich paint or zinc metallizing to fit the aesthetic. Scratchings or markings to the malleable outermost zinc layer caused by rough handling will weather overtime. These imperfections are superficial, and do not affect the corrosion resistance ability of the material. This is important because the museum will be a highly trafficked space, so the HDG steel may undergo some damage overtime from normal wear and tear. Periodic maintenance will be necessary to ensure the building remains aesthetically pleasing as it was designed and built. In this coastal marine environment, hot-dip galvanized steel is the best corrosion protection system to withstand the rigor.

My Design Recommendations

New Orleans' history of traditional wrought iron work in balconies and ornamental gates around the city makes the use of HDG steel the perfect decorative exterior steel façade. The tradition derives from Spanish architecture, and "The more ornate work is often floral or leafy, adorned with French fleur-de-lis and coquilles, or shells (associated with Saint Jacques and religious pilgrims), also abound."[9] Wrought iron differs from galvanized steel in that it is malleable with a high elasticity and tensile strength to be shaped into intricate details. However, this also means that is highly corrosive and rust is often a problem that arises as wrought iron ages. Using a perforated paneling system, as in Via 57 in New York City, the HDG steel can be made to honor the traditional wrought iron work of New Orleans in a way that is modern and aesthetically pleasing while being resistant to corrosion.

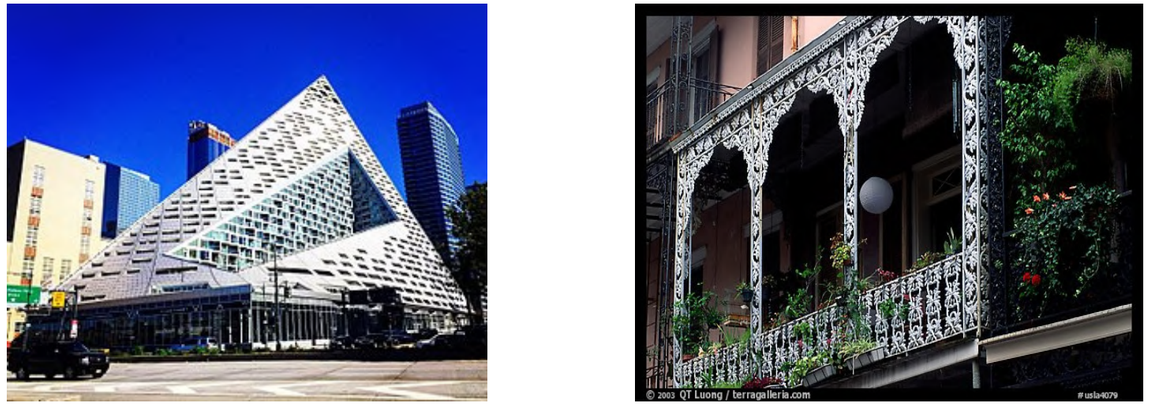

Fig. 4 Via 57 in New York City (left) vs. New Orleans traditional wrought iron work (right)

I propose implementing a duplex system with a proprietary colorant to mimic the age and history of wrought iron. This involves the addition of paint or powder to HDG steel to achieve a desired color. This duplex system also improves the longevity of the material by 1.5 to 2.3 times.[3]

Civic architecture often becomes an icon or beacon of the city and a representation of the arts and culture scene. Therefore, it is essential to create architecture that invokes a response of awe or inspiration. Reinventing a traditional façade with HDG steel in this way will do just that.

CASE STUDY

Salvador Dalí Museum, St. Petersburg Florida
Designer: Yann Weymouth, HOK
Year: 2011
Size: 68,000 sq. ft.
Typology: Cultural Building

Fig. 5 Salvador Dal Museum, St. Petersburg Florida

Designed by Yann Weymouth of HOK, the museum displays the largest collection of Dalí's work outside of Europe with a 2,140 piece permanent collection. Over 3 stories, 1062 individual 4 mm glass panes create a geodesic structure at 75 feet dubbed "Enigma" and at 45 feet, called "Igloo". The dome-like form oozes from an interior rectangular box made of 18-inch-thick unfinished concrete walls. Wymouth highlights that this move is deliberate to "contrast between the rational world of the conscious and the more intuitive, surprising natural world .. a constant theme in Dalí's work."[4] In the interior, a poured-in-place helical staircase again reinforces Dalí's work; this time reminiscent of his fascination with spirals and the shape of the DNA molecule.

Location Context

Situated on St. Petersburg downtown waterfront, The Salvador Dalí Museum borders the Tampa Bay. According to accuweather, the St. Petersburg area is one of the top 5 US cities most vulnerable to hurricanes.[12] Although the city has not been impacted by direct landfall since the 1921 Tampa Bay Hurricane, there have been at least 68 tropical storms within 60 miles since that year.[12] The shallow depth and the U-shape of the coastline means storm surge is concentrated and intensified in the city of St. Petersburg. And since the Downtown Area where the Museum is located has predominantly impermeable surfaces, the issue of inundation is further exacerbated. In 1950, for example, Hurricane Easy made landfall in Cedar Key, about 130 miles north of Tampa Bay. However, this still resulted in a rise in the Tampa Bay tide to 6.5 feet and a resulting $3.3 million in damages.[8]

Appearance

From the entrance, this building provides museum goers with an attractive façade. The decorative steel exterior is not only intriguing, but represents the surrealist nature and themes of Dalís work. Supporting the glass panels is a steel system which has been rendered corrosion resistant by way of a duplex system. The duplex system also serves to unify the color of the glass and steel so it is viewed as one element that juxtaposes the inner rectangular form.

Fig. 6 Detailed look at the HDG steel support system

Corrosion Resistance

The museum is designed to withstand a Category 5 hurricane storm surge and 165 mph winds. Due to the prevalence of these surges, the art itself is displayed within the internal concrete structure. The duplex system fortifies the already highly resistant hot-dip galvanizing. The hollow steel tubing that forms the structure is protected from the inside out as zinc coats the interior during the galvanizing process.

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